AN EXAMINATION OF STANDARDS OF FUNCTIONAL REQUIREMENTS, PERFORMANCE AND FINISH IN HOUSING

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SUMMARY

With the object of establishing a framework within which the standard of building may be judged, statutory requirements and recommended standards covering all facets of the construction of housing are reviewed. Grades of finish of external and internal surfaces are defined by detailed specifications. Previous research relevant to building standards in housing is evaluated. Then in the light of this study, standards in a sample of recently constructed dwellings in 18 local authority areas in the West Midlands are examined. It is assumed that statutory requirements are met and the examination concentrates on what reputable bodies consider desirable.

In the sample of dwellings examined, slightly more than half are taken from those built by local authorities, most of the remainder are speculatively built but there is a sprinkling of other classes. Opinions of householders and tenants, obtained from interviews with occupiers of 200 of these dwellings, are compared where appropriate with the observed standard.

For different standards the quantity of information available varies, for some about 180 dwellings of different design are considered, for others up to more than 300 are used. When the data permits, inferences are made about the population from which the sample is drawn and the level of significance is established for differences in standards in the different types and classes of dwelling.

The examination not only demonstrates the standard of recently constructed housing but also presents a basis for further recommendations where current provisions are judged to be inadequate.

QUOTATION

Well building hath three conditions:

Commodity, Firmness, and Delight.

Sir Henry Wotton.

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Lastly, I must thank the people of the West Midlands who kindly allowed me to subject their homes to close scrutiny and who freely answered my questions.

CHAPTER 1

AIMS AND METHODS

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A I M S A N D M E T H O D S

INTRODUCTION AND AIMS

Despite frequent allegations of jerry-building and exhortations to house-builders to improve their workmanship, there has been little attempt to determine precisely what standard of building is being achieved in housing. Concern about poor workmanship has arisen from complaints by purchasers, supported by general observation, and not from any systematic investigation. What research has been done has been restricted almost entirely to local authority housing and has been largely concerned with the habits and opinions of tenants. Apart from space heating, actual building standards have scarcely been looked at, even in local authority housing.

The aims of the research project described here were to illustrate current standards of construction and services in housing in the West Midlands in both the public and private sector and to see how the two sectors compared. Because no work on residential buildings could ignore the feelings of the people whose homes they were, the views of householders were obtained. It was realised that most people would know only the standard of building to which they had become accustomed, but nevertheless it was thought beneficial that the yardsticks of technical measurement should be checked against the needs and opinions of occupants.

The plan of this thesis, after the description of methods used, places standards of functional requirements first, followed by performance standards and then standards of finish. The first two parts are sub-divided into chapters dealing with different aspects of building. The last part contains only one chapter. All chapters follow the same broad outline and cover relevant specifications of standards, previous research (if any), the examination of dwellings and results, a conclusion and suggestions for further work. The thesis ends with a general view of the principal shortcomings revealed and suggestions for their improvement.

METHOD OF INVESTIGATION

Statutory requirements and recommendations by British official and semi-official bodies were reviewed to determine desirable standards. Where, as with surface finishes, no recognised standard had been defined methods of measurement to illustrate levels attained were developed. It was assumed that building inspectors would ensure that statutory requirements were met, and the official and semi-official recommendations were used as the basis of a list of items to be examined and questions to put to occupiers, which was formulated (see Appendix II).

To gain experience before working in occupied dwellings and to see what quality of finish builders considered worthy of display to prospective buyers, six showhouses were examined with the permission of the firms who had built them. The check list was revised and the investigation of dwellings in the sample commenced in July 1967; it finished after 208 dwellings in 183 buildings had been examined, in November 1968. Details of the method of examination are given where appropriate in following chapters. The equipment that was carried is shown in Plate 1.1.

After a dwelling had been examined a questionnaire was sent to speculative builders and local authority architects, when necessary, to obtain information not apparent from a visual inspection or not previously obtained. A copy of the form used is included in Appendix II together with a copy of the covering letter to builders. Architects were written to individually as they had usually been met personally before their dwellings were examined. Exactly half of the 52 speculative builders concerned completed and returned the questionnaire, 20 did not, six were either out of business or could not be traced.

Speculative dwellings were sketched and dimensions taken during their examination. With most municipal dwellings the fieldwork was lightened by drawings supplied by architects.

After the necessary calculations relating to thermal insulation, cost of external re-decoration and other items had been made the information in respect of each dwelling was transferred to punched cards by a trained operator. Nearly 1000 cards were necessary to contain the information. They were later sorted and counted as necessary on the University's ICT 302 Sorter. Most of the data so obtained is presented later in the form of frequency tables.

DEFINITIONS

To enable one descriptive word to be used instead of several, where there is a great deal of repetition certain words have been used in a limited or special sense.

Standard is used to mean degree of excellence. Standards examined are classed as functional requirements, performances, and surface finishes. There is no clear distinction between function and performance: in the recorded results a line has been drawn between functional requirements which are presented purely descriptively, and performances which are described with the aid of numerical specifications. Standards of finish are confined to the quality of visible surfaces.

Municipal is used with reference to dwellings to describe those erected by local authorities for letting.

Speculative is used to describe dwellings built by private developers and offered to purchasers as a complete package.

Occupier This means the head of a household or his wife (remarks attributed to occupiers came usually from the wives). Where it is necessary to distinguish between owner occupiers and tenants of rented dwellings the word "occupier" is sometimes used for householders of speculative buildings only. It will be clear from the text when the sense is restricted in this way.

Intermediate Used in connection with terraced houses it means a house which is not at one or other of the ends of the terrace.

THE SAMPLE

So that as much information as possible could be obtained only dwellings of different design were examined, therefore, in as much as design features are concerned, the sample is of designs and not of total dwellings erected. Even so, it is felt that for items concerned with standards of workmanship the sample will be representative of all dwellings as an attempt was made to relate the number of dwellings examined to those erected in different districts, and to obtain a dispersion of location as wide as possible.

Locations of the 183 buildings which were visited are shown in Fig. 1.1. The 18 local authority districts embraced comprise the heavily built-up conurbation of Birmingham and the Black Country, plus the rural area to the north and west, with a total population of about 2.6 million. Unless they were detached houses or bungalows, the selected buildings contained more than one dwelling, but except for blocks of flats, where whenever possible dwellings located in different parts of the building were looked at, only one dwelling was examined.

The dwellings had been occupied for a period between 6 months and 24 months at the time of examination. Restriction to this period was intended to ensure that the building had been finally completed by the builder but not re-decorated by the occupier: with a few exceptions this proved to be the case. The dates of occupation are shown in Fig. 1.2 Prior to their examination it was expected that the bulk of the buildings would be first occupied in the year 1966 and it was endeavoured to arrange that the number of buildings visited in each district was proportional to the number whose erection was completed in that year.[1] With municipal dwellings this proved to be difficult, particularly in the case of the larger authorities, because there were not always sufficient different

LOCATION OF BUILDINGS EXAMINED

Fig 1·1

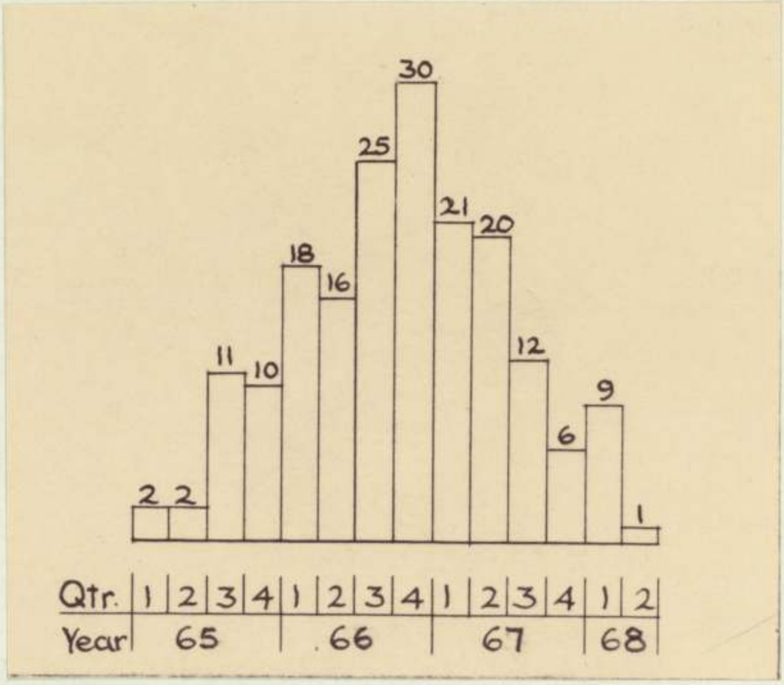

Fig. 1.2 Dates of occupation of dwellings examined

designs available. With speculative dwellings, different designs were more plentiful, and for each district the agreement between the percentage of total dwellings completed and the number of dwellings examined is quite close, as shown in Table. 1.1. Besides the dwellings included in the Table, one block of flats erected in Walsall by a Housing Association was examined. Regrettably municipal dwellings in Birmingham could not be included because the City Architect's Department found itself unable to co-operate in the research. One municipal dwelling in the City was examined in error, having been mistaken for a speculative house.

TABLE 1.1

Comparison of dwellings completed in 1966 and buildings examined

District		Number of Dwellings				Percentage of Total Dwellings			
		Local Authorities		Private		Local Authorities		Private	
		Completed	Examined	Completed	Examined	Completed	Examined	Completed	Examined
Aldridge-Brownhills	U.D	166	6	492	5	2.9	6.7	6.8	5.5
Birmingham	C.B		(1)	1518	20			21.0	22.0
Bridgnorth	M.B	Nil	Nil	169	4			2.3	4.4
Bridgnorth	R.D	12	2	79	Nil	0.2	2.2	1.3	
Cannock	R.D	159	4	634	8	2.8	4.5	8.8	8.8
Cannock	U.D	193	3	345	4	3.4	3.3	4.8	4.4
Dudley	C.B	622	16	578	9	11.0	17.8	8.0	9.9
Halesowen	M.B	54	4	411	7	1.0	4.5	5.7	7.7
Lichfield	M.B	95	2	104	2	1.8	2.2	1.4	2.2
Lichfield	R.D	22	4	246	2	0.4	4.5	3.4	2.2
Seisdon	R.D	8	1	316	2	0.1	1.1	4.4	2.2
Shifnal	R.D	28	3	135	1	0.5	3.3	1.9	1.1
Stourbridge	M.B	209	4	545	3	3.7	4.5	7.5	3.3
Sutton Coldfield	M.B.	138	4	201	3	2.4	4.5	2.8	3.3
Walsall	C.B	808	6	390	5	14.3	6.7	5.4	5.5
Warley	C.B	712	8	48	1	12.6	8.9	0.7	1.1
West Bromwich	C.B	1598	8	545	7	28.3	8.9	7.5	7.7
Wolverhampton	C.B	842	15	490	8	14.9	16.7	6.8	8.8
Total		5666	90	7246	91				

The method of selection adopted, once the site of a development had been located, was to approach the occupier of the first dwelling where someone was at home and ask for their co-operation, if they were unable to help the next dwelling showing signs of life was visited and so on. When people agreed to help, their name was taken and they were later written to so that they would know what was expected of them and be assured that it was a bona fide investigation. A copy of the standard letter used is given in Appendix II. Additional letters were sent to houses where people had not previously been approached so that time wasting might be avoided by having a reserve ready if required.

To locate municipal dwellings, the Architect's department in the district concerned was asked to provide particulars of dwellings completed in the selected period. Drawings and other details were obtained, where available, and then sites were visited with authorisation from the Housing Manager. With speculative dwellings, sites were located with the help of the local Planning Officer. The aim was to look at 100 municipal dwellings and 100 speculative dwellings but only 91 municipal designs were found in spite of endeavours to include all designs of dwelling and not just those for which the architects had drawings available. This was made more difficult by the alterations of boundaries of local authority areas which had taken place in April 1966. Towards the end of the fieldwork difficulty was also experienced in finding different designs and locations of speculative dwellings. Originally if a development contained more than one design of dwelling usually only one was examined unless the sites available were insufficient to give the required number, when two or more would be chosen. It would have been possible to have increased the total of speculative designs examined but only by going over the same ground again or enlarging the area covered. With both classes of dwelling it was necessary, on the whole, to take what was made available by the people whose co-operation was essential, ideas of selection by random numbers or similar methods would not have worked out in practice.

Of the municipal dwellings examined, 85 were erected by 43 different main contractors. The nine other municipal dwellings in the survey were located in Wolverhampton, where the Architect's department provided drawings only, and it was not possible to find out the names of all of the contractors they had employed. The 84 speculative dwellings (including six showhouses) which were examined, were erected by 52 different builders. The Housing Association flats previously mentioned and five privately rented dwellings all had different builders. Two self-built houses complete the number in the survey: these were each built by an association of prospective occupiers as a spare time project. Nine firms built both municipal and speculative dwellings, so excluding the self-building associations the total of different builders is 92. Dwellings erected by the same builder were often well separated by both dates of erection, and location.

The dwellings examined were located in buildings which comprised 117 houses (21 detached, 69 semi-detached, 27 terraced), 17 bungalows, 43 blocks of flats (including 11 multi-storey blocks all 10 or more storeys high, and three old persons grouped flatlets) and six blocks of maisonettes. Nineteen municipal buildings and four speculative were of non-traditional construction (including no-fines concrete). Other ways of classifying the many different types and classes of dwelling have been used as required in the chapters that follow. Particulars of floor area are given in Chapter 11.

The top selling price of any of the speculative dwellings was £8,750 for a freehold detached house with four bedrooms, bathroom and separate shower, whole-house central heating and double garage, completed in January 1968. A fuller account of prices is given in Chapter 18.

STATISTICAL METHODS

To order data collected during the investigation or computed from observations made, measured variables in various samples are arranged in classes of a convenient size and the count of the number of individuals falling into each class is tabulated as a frequency distribution. Where it is felt that it would make the distribution more descriptive or help the comparison of data from different groups, percentage frequencies are also given. Cumulative frequency distributions are used, occasionally, when it is desired to show the count of individuals falling in all categories below (or above) and including a specified one.

When measurement has been on a ratio or interval scale, average values have been indicated by the arithmetic mean. The variability of distributions has been shown by their variance and standard deviation. Relative variability of groups has been compared by means of Pearson's coefficient of variation.

Where assumptions regarding the appropriateness of the data are thought to be tenable, and are supported by tests showing that samples from two groups of dwellings could both have come from populations with the same variance, the null hypothesis that there is no significant difference between the means of the two samples is tested. The level of significance, i.e. the probability that a statistical test will yield a value under which the null hypothesis will be rejected when in fact it is true, has generally been specified as 0.05, but in all cases the probability level actually associated with the findings has been given.

For certain statistics, interval estimates of parameter values, or confidence limits, are made. The level of confidence adopted is 95%, and the assumption that the data were drawn from normally distributed populations is first tested.

When measurement is on an ordinal scale and, hence, parametric tests cannot be employed, the chi-square test has been used to determine the significance of differences between groups.

In one instance, where other methods would not be appropriate, use has been made of a rank test where the intensity of the correlation between the order of the individuals, according to first one quality and then a second quality, is measured.

As the tests take into account the size of the sample in the estimation of probability levels and confidence limits, they provide a firm mathematical base to assist the formation of conclusions about trends and relationships indicated by observations, even when the sample is small.

P A R T 1

<u>F U N C T I O N A L R E Q U I R E M E N T S</u>

CHAPTER 2

STRENGTH AND STABILITY

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STRENGTH AND STABILITY

SUMMARY

General standards of strength and stability required of dwellings are reviewed then faults observed in a visual inspection of 183 buildings are described.

INTRODUCTION

It is common to consider the strength of a structure or structural element to be its capacity to carry load, whether this be limited by overstressing of the material or instability. If a distinction is to be made between strength and stability, then strength refers essentially to the capacity of a material to withstand stress, and stability refers to the ability of a structure or structural element to resist large overall deformation[(1)]. Dimensional changes which do not affect overall stability such as small movements due to changes in temperature or moisture content are not considered here under this heading.

STATUTORY REQUIREMENTS

The Building Regulations 1965

Structural Stability

Foundation Regulations, D3

"The foundations of a building shall -

(a) safely sustain and transmit to the ground the combined dead load and imposed load in such a manner as not to cause any settlement or other movement which would impair the stability of, or cause damage to, the whole or any part of the building or of any adjoining building or works; and

(b) be taken down to such a depth, or be so constructed, as to safeguard the building against damage by swelling, shrinking or freezing of the subsoil; and

(c) be capable of adequately resisting any attack by sulphates or any other deterious matter present in the subsoil."

Structure above foundations, Regulation D8

"The structure of a building above the foundations shall safely sustain and transmit to the foundations the combined dead load and imposed load without such deflection or deformation as will impair the stability of, or cause damage to, the whole or part of the building."

Floors

Minimum imposed loads as specified in Schedule 5 may be summarised as follows:

(a)	(b)
Houses having not more than three storeys and the upper floors of maisonettes, in either case designed for occupation by one family. (Class 1) 30 lb/ft^2 of floor area	Residential buildings other than under (a). (Class 2) 40 lb/ft^2 of floor area.

Subject to a minimum load when the floor consists of floorboards or floor slabs with or without joints, ribs or beams not more than 3 ft apart between centres of:

(a)	(b)
240 lb/ft width	340 lb/ft width

uniformly distributed over the span.

Also, subject to a minimum load when the floor consists of a floor slab with beams or ribs more than 3 ft apart between centres of

(a)	(b)
1920 lb	2560 lb

uniformly distributed over the span on any beam.

The floor loadings specified are large enough to allow for high loading on part of the floor with such items as a heavy safe or bookcase. The smaller the floor area the larger the average imposed load due to such items, hence a floor with beams not more than 3 ft apart and a span of less than 8 ft is treated as though the span were 8 ft, and a slab with beams more than 3 ft apart is assumed to have an area of at least 64 ft^2 when calculating the minimum load.

Stairways and Landings

The minimum imposed loads on stairways and landings vary according to the class of floor with which they are used. The requirements of Schedule 5 for residential buildings are as follows:

(a)	(b)
With Class 1 Floor	With Class 2 Floor
30 lb/ft^2	60 lb/ft^2

Subject to any structurally independent step supporting a load of 300 lb concentrated in a position to cause the greatest stress.

Parapets, balustrades and railings

Schedule 5 requires that parapets, balustrades and railings should be able to resist an imposed lateral load applied horizontally at coping or handrail level and at right-angles thereto as follows:

(a) On a stairway, landing or balcony leading to a Class 1 floor, or on a stairway or landing leading to a Class 2 floor within a maisonette or house designed for occupation by one family, or on a private balcony having an area not exceeding 30 ft^2 and connecting with a Class 2 floor: 25 lb/ft run.

(b) In any other residential building: 50 lb/ft run.

Where the wind loads, calculated in accordance with the regulations exceed the above loads, then the greater load is adopted.

Roofs

The requirements of Schedule 5 for roofs and their supports are that they should be able to carry the following imposed loads, other than wind loads, over the area measured on plan.

(a)	(b)
Roofs with access for repair and maintenance only,	Roofs with general access
(i) for pitches not exceeding 30°: 15 lb/ft^2	30 lb/ft^2, 240 lb/ft width, 1920 lb roof slab as Class 1 floors.

(a) Cont.

(ii) for pitches greater than 30°: 15 lb/ft^2 less 1 lb for every 3° by which the pitch exceeds 30°.

Wind Loads

The Building Regulations require wind loads to be calculated in accordance with the recommendations of CP3: Chapter V (1952) "Loading"(2) with special provision for the overhang of roofs but recent failures in buildings incorporating new forms of design and construction coupled with an advance in knowledge of wind loading have revealed the need for revision of the code and this is currently taking place. Digests recently published by the Building Research Station(3) set out procedures now recommended for calculating wind loads on buildings.

In the case of houses no calculations of wind pressure are likely to be necessary for the building as a whole as CP3: Chapter V states:

"Where adequate stiffening is provided by walls, or by floors and walls, calculations for the effects of wind except in regard to wall panels and foundations need not be made on a building or part of a building of which the height (h) does not exceed twice the effective depth."

House foundations will generally be constructed in accordance with the deemed-to-satisfy provisions of Clause D7 of the Building Regulations which includes dimensions for concrete strip foundations on different subsoils and with wall loadings up to 2 tons per lineal foot. Individual wall panels, wall sheeting and their fastenings will have to be designed to resist local effects of wind.

RECOMMENDED STANDARDS

The recommendations of CP3: Chapter V 1952 are in general agreement with the Building Regulations, except that in the code the minimum imposed load of 30 lbf/ft^2 of floor area is limited to dwelling houses of not more than two storeys designed for one occupation.

Strength is well covered by the Building Regulations and there is little to add to ensure an adequate standard beyond (i) stiffness requirements (ii) provision for loads, incidental to maintenance of roofs. Both these are covered by National Building Studies, Special Report No. 1 Structural Requirements for Houses[(4)].

The stiffness requirements are: "the floors must not bend so much as to crack ceilings beneath, nor must a house sway noticeably on a windy day".

Stiffness tests are proposed in which test loads 1½ times the specified superimposed load or wind load are applied and maintained for at least 12 hours in the case of vertical loading and 3 hours in the case of lateral loads.

The requirements to provide for loads incidental to maintenance are that all roof coverings should be capable of carrying the following loads:

Where the slope is such that the workmen could stand directly on any point.	200 lbf concentrated at any point.
Where the slope is such that the workmen would have to use a ladder or similar support laid on the covering.	100 lbf concentrated at any point.

CP3: Chapter V:1952 has a slightly different requirement with respect to loads incidental to maintenance and defines the concentration of the load. The relevant passage is as follows:

"... all roof coverings (other than glass) at a slope of less than 45° should be capable of carrying a load of 200 lbf concentrated on an area 5 in square at normal stresses."

EXAMINATION OF DWELLINGS AND DEFINITIONS

The examination was confined to looking for signs of movement in structural elements. Movement usually showed itself by cracks in the structure. When these were found they were classified as slight, moderate or severe. Cracking caused by shrinkage of plaster or small dimensional changes in timber was excluded. Slight cracking is defined as that which if it occurred in brickwork would be unlikely to receive treatment, similar cracking internally would be stopped up on re-decorating. Moderate cracking would be re-pointed or otherwise stopped up (an example of moderate cracking is shown in Plate 2.1). Severe cracking would require action beyond mere stopping up.

RESULTS

No severe cracking or other serious structural defect was observed in any of the 183 dwellings visited. The case of moderate cracking illustrated in Plate 2.1 occurred in a showhouse and was the worst of its type. There were also seven other cases of cracking in walls of speculative dwellings and three in municipal dwellings, all of them slight to moderate and thought to be due to differential settlement.

Shrinkage of the blocks used for the inner leaf was thought to be the cause of another example of cracking observed in the wall of a speculative house. Extensive cracking of plaster in a maisonette was probably due to movement of the woodwool slabs which backed up infill panels under the windows and to which the plaster adhered.

In roofs faults observed occurred in municipal dwellings. In one case the fault was sagging of rafters in an old person's bungalow; not all rafters were affected, the sagging appeared as a wave in the roof, possibly due to warping of one or two rafters. Another example concerned two houses with dormer windows, in each there was a crack in the sloping ceiling at the side of the window running down the ceiling and on to the

CHAPTER 3

RESISTANCE TO MOISTURE PENETRATION AND FORMATION OF CONDENSATION

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RESISTANCE TO MOISTURE PENETRATION AND FORMATION OF CONDENSATION

SUMMARY

The frequency and causes of moisture penetration in 183 dwellings are given. Causes and prevention of condensation are discussed. Occupiers opinion of whether condensation is troublesome and precautions they took to prevent it are given. Symptoms and probable causes of condensation in the observed dwellings are described.

PART I - MOISTURE PENETRATION

INTRODUCTION

The ideal with respect to resistance to moisture penetration is succinctly expressed in the Technical Appendices of the Housing Manual 1949; "A house should be so constructed that rain, snow or damp cannot penetrate to the interior above the damp proof course". The entry of rain or snow would be obvious but the meaning of damp needs consideration.

Moisture vapour is always present in the air and even in a "dry" building porous materials will contain moisture. The amount will vary with the material - timber is capable of absorbing about a quarter of its weight of water (to fibre saturation point) without becoming noticeably wet. Within a building, timber may have a moisture content of nearly 20%, other materials, in equilibrium with the humidity of the air will hold much less moisture, plaster for example, is unlikely to have a moisture content of more than 1%.*

Small amounts of moisture which do little harm to the materials holding them are not usually regarded as dampness. The term is usually reserved for conditions under which moisture is present in sufficient quantity either to become directly perceptible to the senses of sight or touch or to cause deterioration in the decoration and eventually in the fabric of the building(1).

When attempts are made to measure the water present in the structure of a building it is usually only possible to obtain a value for the moisture content at or near the surface. Moisture meters for timber are intended to be used for measurements during seasoning but they may be used on fixed timber providing that the insertion of prongs into the timber is acceptable. A method of determining the dryness of a sub-floor has been developed(2). It consists of a paper hygrometer in a well-insulated box Which is sealed to the floor for 4 hours or more and gives a reading of the humidity of the entrapped air.

Generally recommendations specify the exclusion of dampness without definition of the term. The Building Regulations 1965, in general, require the construction to be such as to prevent moisture being transmitted to any part of the building which would be adversely affected. The Scottish

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* As in this case, moisture content is usually expressed in terms of the dry weight of the material.

Regulations, which are less limited in application, require in addition the harmful effect of moisture from rain or snow on the health of persons to be prevented.

STATUTORY REQUIREMENTS

The Building Regulations 1965

Preparation of site - Regulation C2

Either the subsoil must be effectively drained or else other steps must be taken as necessary to protect the building against damage from moisture. If the building requires an existing subsoil drain to be severed, precautions must be taken to ensure that this does not result in the site becoming damp.

Protection of floors next to the ground - Regulation C3

Floors must be constructed so that they are not adversely affected by dampness or water vapour from the ground and so that they prevent the passage of moisture from the ground to the upper surface of the floor.

Protection of walls against moisture - Regulation C6

Walls, piers, columns and chimneys must not transmit moisture from the ground to the inside of the building or to any material used in the construction of the building which is liable to be adversely affected by moisture.

Weather resistance of external walls and roofs - Regulations C8 and C10

Moisture due to snow or rain must not be transmitted to the inside of a building or any part of it liable to be adversely affected by moisture.

RECOMMENDED STANDARDS

No precise performance standards can be set and there is little that can be added to the recommendation quoted at the beginning of this chapter, however, requirements might be summarised as follows:

<u>Moisture should not penetrate the structure in sufficient quantity either to become directly perceptible to the sense of sight or touch or to cause deterioration in the decoration or fabric of the dwelling.</u>

Walls are only wetted by rain when the rain is blown on to them by wind. The wetting of a wall and the likelihood, therefore, of penetration depends not only on rainfall but also on the direction and severity of the wind. Some buildings will obviously be more exposed than others and some walls will face the prevailing winds. The standard of weather-tightness of walls might be considered with this in mind.

In the West Midlands the index of driving rain ((annual rainfall mm x average wind speed m/sec) ÷ 1000) is between 3 and 4 m^2/sec(3) and most rain falls when the wind blows from the south or south-west. This represents a moderate condition of exposure to driving rain under the method of grading suggested in Building Research Station Digest 23 (second series).

The grades of exposure are:

(i) sheltered - where the index is 3 m^2/sec or less

(ii) moderate - where the index is between 3 and 7 m^2/sec

(iii) severe - where the index is 7 m^2/sec or more

The grades are modified for areas within 5 miles of the sea or large estuaries.

Further modification of the grading will be necessary for local circumstances such as high ground, high buildings, buildings protected by trees, etc. but as a general rule it may be advisable in the West Midlands to pay particular attention to the weather-tightness of walls facing south and south-west.

EXAMINATION OF DWELLINGS

A watch was kept for signs of rising damp or water penetration and when any was seen an attempt was made to ascertain the cause. Particular care was necessary to be sure that apparent dampness was caused by moisture penetration. New brickwork may contain as much as 30 gallons of water per cubic yard[(4)], new plaster and concrete will also contain a large amount of water, this will take a long time to dry out and some deterioration of the decoration is to be expected in the first year of the life of the building[(1) (5)].

RESULTS

Dampness identified as being caused by water penetration occurred in 19 dwellings, 10% of those examined. The cause of the dampness where this could be ascertained with some degree of certainty is given in Table 3.1.

TABLE 3.1

Damp penetration observed in 183 dwellings[(a)]

Class of dwelling	Freq.	Cause
		External Walls
Mun.	1	Probably mortar droppings on wall ties.
"	2	Rainwater from front entrance canopy running down wall.
"	1	Multi-storey block. Water probably running down cavity wall from roof.
"	1	Surface water from sloping ground getting above d.p.c.
Spec. cert'd	2	Cavity tray. (One rectified by formation of weep holes, other by taking down wall and re-building).
Spec. not cert'd	2	Probably lack of vertical d.p.c. at window reveals
"	1	9 in solid brick walls
		Internal Walls
Mun.	1	Probably part of d.p.c. omitted
		Roofs
Mun.	1	Flat roof. Cause unknown
Spec. not cert'd	1	Faulty flashing around dormer window
"	1	6 in of ridge tiling missing.
		Floors
Mun.	2	Surface water runs into house
		Soil Pipes
Mun.	2	Faulty jointing of plastic pipes
Privately rented	1	Faulty jointing of plastic pipes (replaced by copper pipe).

(a) Municipal 91, Speculative (with N.H.B.R.C. certificate) 42, Speculative (no certificate) 30, Speculative (not known whether certificate issued) 6, Speculative (showhouses) 6, Others 8.

In three cases the trouble had been rectified but only after some delay and, particularly in the case of the soil pipe in the privately rented dwelling, after the occupiers had been seriously inconvenienced. In another case, again an internal soil pipe, an attempt had been made to put it right but was unsuccessful.

In addition to those described in Table 3.1, there were two more cases where surface water collecting around the house looked troublesome but had not caused signs of dampness at the time of examination.

CONCLUSION

The trouble experienced by occupiers with surface water and probably also that with the canopies may be attributed to faulty design. The other faults were caused by bad workmanship.

Although the frequencies at which the faults occurred in the different classes are insufficient for firm conclusions to be drawn the number of faults in municipal dwellings and in speculative dwellings without N.H.B.R.C. certificates gives cause to suspect that these faults are most likely to be found in dwellings of these two classes.

PART II - CONDENSATION

INTRODUCTION

When air is cooled to its dew point condensation occurs. In buildings the temperature of the inner surface of walls, floors and ceilings will be at a temperature intermediate between that of the inside and outside air under steady-state conditions and condensation will occur when the inside air is sufficiently cooled by contact with the external structure. With the exception of glass surfaces the temperature of inside surfaces is unlikely to be low enough to cause condensation on the surface under normal conditions.

When humidity is high, as it is at times in kitchens and bathrooms, condensation will readily occur on the enclosing surfaces of the room. It may also occur on surfaces when steady state conditions do not prevail as, for example, in unheated rooms when a sudden temperature rise gives warm air in the rooms while the walls remain cold because of their thermal time lag, or when radiation to the night sky leads to rapid cooling of the structure.

Interstitial condensation is more likely than surface condensation. As the temperature gradient within a wall drops between inside and outside temperatures the dew point of the inside air is likely to be reached, whether this will cause condensation within the wall depends on the resistance of the construction to the passage of water vapour. If some vapour is excluded the dew point will be lowered and freedom from interstitial condensation will be obtained as long as the dew point remains below the wall temperature.

Vapour resistance will be more important in some forms of construction than others, the porous walls of traditionally built houses will hold interstitial condensed moisture without harm for a short period and allow it to evaporate when conditions are favourable but with non-traditional multi-layer construction, or constructions containing an impervious layer, water may collect in sufficient quantity to cause trouble.

As the thermal insulating properties of a wall are lowered when water replaces air within its structure, the first interstitial condensation will tend to lead to more until under adverse conditions the wall is saturated through to the inside surface, where the trouble becomes apparent and decoration is affected.

RECOMMENDED STANDARDS

With resistance to condensation dependent upon the heating and ventilation of the building, the thermal insulation of the walls, floors and roofs, the thermal conductivity of surfaces and the vapour resistance of the construction, standards of resistance cannot be defined without reference to other standards.

In respect of heating and condensation the Egerton Report[(6)] states: "It is desirable to provide against excessive chilling of the structure of the house, which causes condensation of moisture on walls, furnishings and household linen. Such condensation most frequently occurs when the outside temperature and humidity rise suddenly after a spell of cold weather. It is probable that a considerable amount of the trouble may be avoided if the temperature inside the house is prevented from falling below about 45^{o} to $50^{o}F$". Building Research Station Digest No. 132 (first series)[7] says "Even a low level of background heating to keep the temperature of the house slightly above that of the outside air, will be sufficient to avoid condensation." The Parker Morris Report confines itself to condensation in kitchens and states: " .. this is a widespread and serious problem, or at best one that is never far from being serious at certain times of the year if the kitchen is unheated. Our recommendations on heating will help in this direction, but when water vapour is produced in quantity condensation is only to be expected unless special precautions are taken."

Adequate ventilation is especially necessary in rooms where moisture vapour is produced. Digest No. 132 states "As much as possible of the moisture vapour produced in the house should be removed by way of flues or vents. Of particular importance is the provision of:

Clothes drying facilities, making sure that the moist air is not fed back into the dwelling.

A hood over the cooker, vented to the open air.

A flue or vent pipe to provide permanent ventilation in main rooms where it is likely that "flueless" combustion appliances will be used for space heating.

An opening top light or ventilator to the kitchen, higher than the top of the door."

The last provision is one mentioned in the Parker Morris Report which says: "Easily controllable fanlight or similar windows are of course always necessary in a kitchen where mechanical ventilation is not provided."

The requirement of the Building Regulations with regard to the thermal insulation of walls, i.e. that the thermal transmittance should not exceed 0.3 Btu/ft^{2}h degF ensures a minimum standard in this respect but does not cover glazed windows - the source of most surface condensation. Double glazing, which has a U-value of 0.60 to 0.50, would lessen condensation but in the Parker Morris Report this is considered too expensive for general adoption in local authority housing having regard to other needs.

Low thermal conductivity of surfaces is particularly important in the prevention of condensation in intermittently heated dwellings, for example, in a house unoccupied during the day where rapid warming of the air within the rooms takes place in the evening accompanied by a rise in humidity due to cooking and the presence of occupants. A surface material with a good thermal insulation value or a lightweight lining of low thermal capacity, which will warm up quickly is required. Digest No. 132 points out the advantages of the suspended timber ground floor over a solid floor in this respect and states that to avoid temporary condensation on a solid floor it is necessary to have an insulating finish such as timber or cork. For walls an insulating plaster finish or a lightweight lining, such as plasterboard, is recommended. The need for insulating material on ceilings formed by the underside of flat roofs of dense concrete is stressed.

CLASSIFICATION OF SEVERITY OF CONDENSATION CONDITIONS

An approximate classification of surface condensation is given in Building Research Station Digest No. 58 for the purpose of discussing conditions likely to be encountered on walls and ceilings. The classification is as follows:

1. Bad. Conditions in which condensation occurs without intervals sufficiently long for any appreciable drying to occur. Wall and ceiling surfaces may run with moisture continuously.

2. Severe. Condensation is heavy, but a period of condensation is followed by a drying interval sufficiently long and effective to prevent a build-up of moisture.

3. Moderate. Condensation occurs for short periods on most days but the surface dries quickly and remains dry in between those periods.

4. Mild. Condensation occurs for short periods but much less frequently than in (3) and for the rest of the time the surface is dry.

PREVIOUS WORK

Recently efforts have been concentrated on making the causes of condensation known to a wider public rather than on research. Troubles with condensation in dwellings of non-traditional construction might have been avoided if the designers had been more aware of this simple natural phenomenon. In his work on condensation in sheeted roofs Professor Pratt (1958)[9] had demonstrated the difficulties faced by lightweight construction and shown how the temperature of sheeted roofs might be several degrees cooler than outdoor air on a cold night when the sky was clear. Troubles with heavy large-panel constructions were investigated by Ball (1964)[10] who looked at the causes of interstitial condensation in such buildings.

RESULTS

Condensation did not seem to be the occupiers most serious cause for complaint in any of the dwellings visited and no examples were observed which were as bad as those that have been reported in the press. There were not, for example, any cases which could be classified as bad under the B.R.S. Digest No. 58 classification. Many occupiers said that condensation was less trouble than it had been when they first moved in, showing that humidity had been reduced as the building dried out.

Occupiers opinion of what constitutes "troublesome" condensation would, of course, be expected to vary considerably and it would not be wise to place too much reliance on the figures given in Table 3.2 in spite of the agreement they show in some cases in the expressed opinions of occupiers of municipal dwellings and the occupiers of speculative dwellings.

TABLE 3.2

Rooms in which condensation is troublesome
in dwellings of different design

Rooms	Municipal	Speculative	Others	All
Number of dwellings	91	78	8	177
Kitchen	34 (37%)	28 (36%)	5	67 (38%
Bathroom	15 (17%)	4 (5%)		19 (11%)
Other rooms	27 (30%)	19 (24%)	4	50 (28%)

Apart from the work of one architect who put air bricks in the wall adjacent to that containing the windows in all his houses there were only two municipal designs where cross ventilation could be obtained in the kitchen. There were rather more in speculative dwellings where cross ventilation could be obtained in 10 out of 84 designs.

The lack of extract fans and the difficulty experienced in obtaining a reasonable amount of ventilation with large top hung casement or pivot-hung windows without fanlights are described in Chapter 13 . Only two occupiers had had extractor fans fitted in their kitchens after moving in to the house, one of these was in conjunction with a hood. Some people had to have their back door open to get rid of steam. In one house with large windows glazed to the floor, in the kitchen-dining room a glazed door formed the only opening light and it was necessary to open this to prevent condensation. It was open for this reason at the time of inspection on a quite cold day in March.

Tenants were asked what precautions they took to prevent condensation. Any that were taken were mostly limited to the kitchen - usually this did not go beyond opening the window. One housewife said she put the heater on blow. An old age pensioner used "anti-mist" on the kitchen window, and as previously mentioned, some people opened the door.

Large windows in living rooms, glazed down to floor level, were a frequent cause of complaint. Many people said that condensate made the carpet wet. In some dwellings the carpets were turned back, in others towels were used to soak up the moisture.

Where windows were not fitted with window boards, or the boards were narrow, as in timber-framed walls where the window frame was flush with the inside of the wall, instead of the condensate collecting on the window board as would normally happen, it ran down the wall and marked the decoration. The same trouble occurred in kitchens when a sloping, tiled inner sill was provided.

A lady in a block of flats, where another tenant said condensate ran down the living room walls, said that she had also experienced an extensive amount of condensation in her flat and she "had lived in a pre-fab and knew what condensation was". The block was of traditional construction and the reason for the trouble was not apparent.

In another block of flats condensation was troublesome in drying cupboards and bathrooms as well as elsewhere indicating that the ventilation system was probably at fault. Eighteen of the blocks of flats visited had drying cupboards and this was the only one not working efficiently, although there were other flats where the tenants did not use the cupboards. They said that they preferred to dry their washing 'naturally'.

In spite of reported difficulties with condensation in non-traditional housing, in only one building of this type was condensation sufficiently bad to affect the decoration. It occurred at the corners of rooms, i.e. at the joint of the large pre-cast concrete panels of which the multi-storey block of flats where this happened was constructed. The flats superintendent said that only tenants with babies who had napkins to wash had this trouble. The panels were of sandwich construction with cellular polystyrene between inner and outer concrete slabs.

In only one case was a concrete roof the apparent cause of condensation, the roof was insulated with 1 in cellular polystyrene under the screed and the trouble occurred at the joint between wall and ceiling.

CONCLUSIONS

Although it is obvious that condensation is likely to be particularly troublesome in kitchens little is done to provide convenient means of ventilation. Insufficient thought is given to the collection and removal of condensate, notably where windows are glazed to floor level. Cold bridges are still occurring in constructions of a non-traditional type.

CHAPTER 4

FIRE RESISTANCE

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FIRE RESISTANCE

SUMMARY

The extensive statutory requirements and recommendations are reviewed. A few items not covered by legislation are examined in 183 dwellings of different design.

INTRODUCTION

The reports of the Joint Committee on Fire Grading of Buildings[(1)] together with the records of work carried out by the Building Research Station and the Fire Research Organisation published as National Building Studies form the basis of recommendations and regulations relating to fire resistance. When they reported in 1946 the Fire Grading Committee felt that traditional construction gave small houses a fire-resistance generally in excess of what was needed, except in the case of joisted floors. The ample fire resistance of brickwork did not need to be repeated in houses of alternative construction, and, therefore, the recommendations of the Committee were for much lower grades of fire resistance than given by brick walls.

In respect of floors, the Committee felt that the type of floor generally accepted in house construction had not presented any serious hazard in a long period of use and suggested that a grade of less than ½ hour fire resistance would be acceptable. This view is reflected in the current Building Regulations.

Blocks of flats, being divided into many small compartments, are of a form of construction well suited to limit the spread of fire. The Building Regulations ensure that compartment walls and floors have sufficient fire resistance and that openings in floors for staircases, lifts, etc. are connected by protected shafts. Means of escape are the concern of the Fire Authority of the area where the Building is erected. Plans are vetted to ensure that occupants should be able to reach safety in the event of a fire and that in high residential buildings the design and construction ensures that the occupants of floors above a dwelling which is on fire, may if they choose, remain safely on their own floor.

FIRE TESTS AND DEFINITIONS

Properties of materials and structures which are relevant when considering the fire protection of the building in which they are to be used are tested as specified in BS.476:Part 1[2]. Three properties are defined, they are: (i) combustibility, (ii) surface spread of flame, (iii) fire resistance of structures. Part 3[3] of the same standard describes a test for external roof surfaces.

The combustibility test of materials entails the heating of six small specimens (2 in x $1\frac{1}{2}$ in x $1\frac{1}{2}$ in) at 750°C in an electrically heated furnace. While the specimens are heating a pilot gas flame is kept burning. If any one of the specimens (i) flames (ii) produces vapours which are ignited by the pilot flame, or (iii) causes the temperature of the furnace to be raised 50°C or more above 750°C then the material is considered combustible.

In the surface spread of flame test for materials, six specimens, each 9 in x 36 in in area, are tested one at a time. After the edges have been treated with sodium silicate composition a specimen is fixed in a framework projecting in front of a gas-fired radiant panel. The heat radiated is carefully controlled so that the temperature is 500°C at the end of the specimen nearer the panel, diminishing over a specified range at given distances. Immediately the specimen is exposed to the heat, a vertical luminous gas flame is applied to its hottest end for one minute. The flame spreads along the surface and ultimately dies out. Observations are made of the time of the spread of flame for measured distances. Curves of time and distance are plotted for each specimen and what is known as the effective spread of flame is calculated from a root-mean-square type of formula. A surface is placed in one of four classes of flame spread: Class 1, Very low, 2. Low, 3. Medium, 4. Rapid. A further class, Class 0, has been defined in the Building Regulations. This class of material is either (i) non-combustible throughout, or (ii) has a non-combustible base with a thin combustible surface, or (iii) has a combustible base and a non-combustible surface. The spread of flame rating of the combined projects must not be lower than Class 1.

Structural elements, together with partitions, doors, shutters and glazing are tested by loading the element with the design load and heating it in a furnace under strict control of the rate at which the furnace temperature is built up. The test result is the time which the element complies with the following requirements: (i) it does not collapse, and if its function is to separate spaces (ii) flame does not pass through it, and (iii) the temperature of the unexposed face does not increase, on average, by more than 139 degC (250 degF), or at any point, by more than 180 degC, nor reach a value higher than 221°C (430°F) whichever is the lesser value. The latter requirement may be waived for doors, shutters, glazing and the like against which it is not intended that combustible material should be placed in service. The grade of fire resistance of an element is the longest of the periods given below in which no failure occurs:

½, 1, 2, 3, 4, 6 hour(s).

The capacity of a roof to resist fire when the external surface is exposed to radiation and flame is tested as specified in Part 3 of BS.476. Roofs are graded according to the time for which they resist penetration by fire, and the distance of spread of flame, on their external surface. The grades are designated by two letters, the first referring to penetration and the second to spread of flame, the letters ranging from A to D in each case. A preliminary ignition test is also made. This is done before the penetration and spread of flame tests. A gas flame is applied for one minute and unless the specimen is so affected by this that it is obvious that it would not pass the principal tests these are carried out using an apparatus which radiates heat on to the external roof surface. Reference to the duration of burning and spread of flame in the preliminary test is made in the Building Regulations.

STATUTORY REQUIREMENTS

The Building Regulations 1965

Buildings are placed into various purpose groups depending upon the use of the building. The purpose groups have been devised to take account of both damage hazard and personal hazard. The damage hazard is related to the fire load, that is, the number of heat units (Btu) which would be liberated for each unit of floor area (ft^2) by the complete combustion of the structure and contents. In this respect residential buildings are in the lowest category. Personal hazard is also low in residential buildings but a particular risk attaches to buildings of the institutional type where children or old people sleep.

Small houses are in Purpose Group I, Institutional Buildings in Purpose Group II and other types of residential buildings in Purpose Group III.

Purpose Group I: Small Residential

A building in this group is defined as a private dwelling house (not including a flat or maisonette) not comprising more than (i) a ground storey (ii) one upper storey, and (iii) a basement storey or basement storeys.

In general ½ hour minimum fire resistance is required for all elements of structure (Reg.E5) but this does not apply to external walls which are non-loadbearing and which in accordance with the regulations may be an unprotected area*. In a house having a maximum length of side of 40 ft, the whole area of the side wall may be unprotected providing it is 16 ft from the boundary; for walls at lesser distances (up to 3 ft) the unprotected area is reduced (Sched.9). Walls which

* An unprotected area is a window, door or other opening, an external wall with combustible cladding more than 1/32 in. thick, and any external wall not having the fire resistance specified in Regulation E.5.

are not part of an unprotected area and are on or within 3 ft of the boundary of a site must be fire resistant from both inside and outside (Reg. E6) and cladding less than 3 ft from the boundary must be non-combustible (Reg. E7). For external walls over 3 ft from the boundary the requirement of $\frac{1}{2}$ hour fire resistance is qualified in that with respect to insulation the period is 15 minutes. Separating walls between houses must have one hour fire resistance (Reg. E5).

The upper floors of two-storey houses must be capable of resisting the fire test from the underside for 30 minutes in respect of freedom from collapse but only 15 minutes resistance is required in respect of insulation and passage of flame (Reg. E6(7)).

Roofs are not regarded as elements of structure unless they are structural members without which the building would be in danger of collapse. The roof of a house in a continuous terrace of more than two and the roof of a house within 20 ft of the boundary must resist penetration of fire for one hour. Such a roof must not be covered with thatch or wood shingles nor must it continue to burn for five minutes after the withdrawal of the flame, or spread more than 15 in. across the region of burning in the preliminary test[3]. For houses more than 20ft from the boundary the regulations are relaxed until at 75 ft roofs which are penetrated in the preliminary test are allowed (Reg. E15).

Internal wall surfaces of small residential buildings must be constructed so that the surfaces are of very low flame spread classified as Class 1 in accordance with BS.476:Part 1, except that walls of rooms of less than 40 ft^2 floor area and parts of walls not exceeding half the floor area of the room or 200 ft^2 may be of Class 3, that is, surfaces of medium flame spread. All ceilings must be at least Class 3 (Reg. E14)*.

If a garage is attached to or forms part of a house, any wall between the garage and house must have a fire-resistance of ½ hour. If there is a doorway in this wall it must have a threshold 4 in high and be fitted with a self-closing door of ½ hour fire resistance. A floor above the garage must also have at least ½ hour fire resistance (Reg. E16).

Purpose Group III: Other Residential

Private dwellings other than two-storey houses are in this group, it therefore covers three-storey houses, flats and maisonettes.

The requirements given above for small houses (Group I), unless specifically limited to this type of dwelling, are applicable also to buildings of Group III.

In buildings of this group, any wall or floor separating a flat or maisonette from any other part of the same building must be constructed as a compartment wall or compartment floor. The compartment walls need not have more than one hour fire resistance unless the wall is load bearing, forms part of a protected shaft or separates the flat or maisonette from part of the building which is of a different purpose group requiring a fire resistance of 1½ hours or more.

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*As the regulation refers only to materials of construction it does not appear to apply to wallpaper or certain other materials applied after completion of the structure.

Other elements of structure above ground are required to have a minimum fire resistance of $\frac{1}{2}$ hour when the height of the building does not exceed 25 ft, one hour up to 90 ft and $1\frac{1}{2}$ hours above 90 ft. For heights of 25 ft to 50 ft, the period is reduced to $\frac{1}{2}$ hour in respect of floors which are not compartment floors except as to beams which support any part of the floor contributing to the structural support of the building as a whole.

Structural elements below ground are, in general, required to have a fire resistance $\frac{1}{2}$ hour greater than elements above ground (Reg. E5).

External walls over 25 ft high may not include combustible material, except certain internal linings and certain external claddings. Compartment walls or compartment floors must be constructed of non-combustible materials apart from the floor finish and certain wall and ceiling finishes (Reg. E7).

Where openings are necessary in compartment floors to allow persons, things or air to pass, they must be protected by shafts running from floor to floor. Walls and other elements covered by the regulation mentioned above will normally enclose much of the shaft, any other structure necessary is subject to similar requirements (Reg. E10).

Doors in protected shafts and in walls separating flats or maisonettes from space in common use must have a fire resistance of $\frac{1}{2}$ hour. They must be self-closing; rising butt hinges may be used but hinges or their bushes may not be of nylon or other plastic materials (Reg. E11).

Stairways and landings, other than those in maisonettes or above ground in flats not more than 25 ft high, must be of non-combustible material. The requirement does not extend to surface coverings which may be of combustible materials (Reg. E12).

Surfaces of rooms other than small rooms of 40 ft^2 maximum floor area must be of Class I in respect of spread of flame. In circulation spaces and protected shafts the more stringent Class 0 is required (Reg. E14).

If a block of flats or maisonettes has a capacity of over 50,000 ft^3 the requirements with regard to roofs are the same as those given above for houses in continuous terraces. Smaller blocks are subject to the same restrictions as other houses (Reg. E15).

The regulations relating to Chimneys, Flues and Hearths are concerned with solid fuel, oil burning and gas heating appliances together with incinerators, other than electric incinerators. The appliances are divided into two sections: high rating and low rating. A further division into Class I and Class II is made of low-rating appliances. The classification is given in Table 4.1.

General functional requirements (Reg. L2) for chimneys, flue pipes, constructional hearths and fireplaces serving any appliance are that the construction should be of non-combustible materials of such nature, quality and thickness as not to be unduly affected by heat, condensate or products of combustion and so constructed and of such thickness, or in the case of flue pipes, so placed or shielded, as to prevent the ignition of any part of the building. Chimneys and flue pipes must be so constructed as to prevent any products of combustion escaping internally into the building.

TABLE 4.1

Classification of Appliances

	Low Rating		High Rating
	Class I	Class II	
Solid fuel or oil burning appliance output rating (Btu/h)	Not exceeding 150,000		Exceeding 150,000
Gas appliance input rating (Btu/h)		Not exceeding 150,000	Exceeding 150,000
Incinerator refuse combustion chamber (ft^2)	1 - 3	Not exceeding 1	Exceeding 3

Outlets of flues must discharge without offering danger to health or creating a nuisance. Flue pipes must discharge either into a chimney or the external air, they must be properly supported and so placed or shielded that there is neither undue risk of accidental damage nor undue danger to persons.

Detailed provisions are made (Reg. L3 - L21) with the object of ensuring that in the case of Class I and Class II appliances the functional requirements are met. One of the reasons for lack of detailed provision for the larger appliances is the absence of a suitable Code of Practice on the subject[4].

Heat Producing Appliances and Incinerators

The installation of coal-burning appliances is prohibited except for convertable grates when the dwellings are not in smokeless zones (Reg. M2). The relevant parts of a building must be suitably constructed before appliances of the type described in Table 4.1 can be installed and the appliance itself must be fitted to comply with regulations which cover (i) for high rating appliances, primarily its discharge into a flue and provision for the introduction of sufficient combustion air, (ii) for Class I and Class II appliances, the provision of hearths, and means of ensuring protection of the structure by placing the appliance a sufficient distance from combustible matter. In addition, the regulations cover the discharge into flues, and in the case of certain oil burning and gas appliances the discharge into rooms. For room sealed gas appliances, discharge directly to the external air or into an appliance ventilation duct are permitted under certain conditions (Reg. M3 - M10.)

RECOMMENDED STANDARDS

The structural fire precautions recommended in C3: Chapter IV:1948 Precautions Against Fire (Houses and Flats of not more than two storeys)[5] have been superseded by the Building Regulations. It is understood that codes are in preparation on the subject of means of escape from buildings below 80 ft in height. Probably the code relating to two-storey houses and flats will also be revised; in the meantime two recommendations are worthy of note:

(i) One window in each habitable room of upper storeys should have an opening light through which the occupants can escape or be rescued. The minimum dimensions of the clear opening should be not less than 2 ft 9 in by 1 ft 5 in.

(ii) No staircase should ignite or collapse more readily than a timber staircase having $\frac{7}{8}$ in treads supported by 1 in timbers (finished thickness). Each room, unless it is provided with an alternative exit to ground level, should have access to the staircase which does not involve passing through another room.

Fire precautions in tall blocks of flats are dealt with in CP3: Chapter IV 1962: Precautions Against Fire. Part 1 "Fire precautions in flats and maisonettes over 80 ft in height"[(5)]. Eighty foot was selected because dwellings above that height are beyond the reach of rescue or fire fighting from a mobile ladder outside the building. The recommendations made apply to all floors of a building and not only to those floors which are in excess of 80 ft from the ground.

Analysing the problem, the code states that the only sound basis for designing means of escape from fire is to attempt to locate the position of all possible sources of outbreak of fire and to predict the courses which might thereafter be followed by the fire as it develops or, more particularly, the routes which smoke and hot gases are likely to take.

Fires originating in dwellings occur chiefly in kitchens and living rooms and may develop to serious proportions while occupants are asleep in their bedrooms. Recommendations are made on methods of providing safety in flats either by ensuring that escape from any bedroom via the entrance hall of the flat will not be cut off by fire or smoke or by providing an alternative exit from the bedroom. For maisonettes an alternative exit from the floor is considered essential.

Outside the dwelling, the aims of the recommendations are:

(i) to ensure that a fire which starts in any one dwelling will not obstruct the escape of the occupants of any other dwelling on the same floor,

(ii) to remove sufficiently the risk that smoke or fire might enter a staircase at any point and render it impassable above that point.

(iii) to ensure that the escape route from the bottom of the staircase to the outside air is adequately protected.

Further recommendations from CP3 are summarised below:

(I) Engineering Services

(i) Protected circuits for staircase and corridor lighting.

(ii) Staircase lighting circuit direct from main switchboard; no switches on landings.

(iii) Gas and electricity meters in separate cupboards, preferably not in the entrance hall of a dwelling, but if so positioned contained in metal cupboards.

(iv) Meters outside dwellings placed in cupboards of non-combustible construction with strong lockable metal doors. If meters are insert in corridor partitions the construction at the back should have the same fire resistance as the partition.

(II) Fire Brigade Facilities

The following provisions to be made to assist the fire services in applying water to the fire as soon as possible.

(i) Access for fire appliances.

(ii) External hydrants, within confines of site, if necessary.

(iii) Internal hydrants: "dry risers" may be used for buildings not more than 200 ft high: in buildings of greater height they should be wet. Outlets should be provided on every floor as near as possible to a main staircase or fire lift and not more than 200 ft from any part of the building.

(iv) A sufficient number of lifts should be arranged as fire lifts to ensure that every flat or maisonette has direct access to at least one lift. (Under certain circumstances the fire lift need not serve the top floor of a building).

(III) Advice to Tenants

Advice on how to avoid fires, the need for ensuring that fire resisting doors are kept closed, and other precautions should be promulgated for the benefit of tenants.

RESULTS

As fire resistance is a functional requirement well covered by legislation it was assumed that a satisfactory standard of fire resisting construction in the buildings visited was assured. On the whole statutory requirements and recommended standards appeared to be met apart from three items, the first the recommendation that habitable rooms of upper storeys should have an opening light large enough for occupants to escape through. The number of dwellings of different design which contained rooms with opening lights big enough to provide a clear opening of at least 2 ft 9 in by 1 ft 5 in is given in Table 4.2.

TABLE 4.2

Dwellings with openings large enough to permit escape from all habitable rooms of upper storeys

Item	Municipal	Speculative	Other	All
Dwellings examined	91	84	8	183
Those with opening lights of required size	81	58	6	145

The lack of opening lights of the required size in speculative dwellings was largely due to the use in bedrooms of wooden windows 4 ft by 4 ft or 4 ft by 3 ft 6 in in area. These windows had a large panel of direct glazing with a fanlight above. The size of the fanlight was about 10 in by the width of the window and, therefore, neither large enough nor suitably positioned to allow a person to escape or be rescued through it. Other windows had casement lights undersized in one or both dimensions.

The second recommendation which did not appear to have been observed was the promulgation of advice on fire precautions in flats. Occupiers of flats were asked if they had received advice on fire precautions and what to do if there was a fire. The number who said that they had received at least some advice is shown in Table 4.3. It is, of course, probable that some of the others had forgotten or that they had not read instructions given to them when they moved in but nevertheless at the time when they were interviewed they did not know what action they should take in the event of a fire.

TABLE 4.3

Tenants in flats and advice given on fire precautions

Item	Municipal	Other	All
Those who had received advice	7	1	8
Those who said they had not	32	3	35
	39	4	43

The third recommendation which was frequently not observed was that gas and electricity meters should be in separate cupboards. The recommendation was made specifically for flats but as it was felt that it was desirable in all types of dwelling, all types were checked. Details of meter positions are given in Table 4.4. Although 183 buildings were visited the check was unfortunately overlooked in 9 municipal dwellings.

Two examples where fire-resisting doors at the entrances of flats were likely to be ineffective were observed. One fitted so badly that it was possible to see daylight through the joint on the hanging side even though the necessary 1 in deep rebates in the frame had been provided. The occupier said it had been worse but the door had been re-hung. In another flat, the jamb of the door frame had been fitted to the reveal of the opening after plastering, subsequently the jamb warped and pulled away so that there was a gap between the back of the jamb and the reveal.

TABLE 4.4

Gas and electricity meters in separate cupboards or well apart

Item	Municipal	Speculative	Other	All
Meters separate	45	50	7	102
Meters together	32	28	1	61
One meter only	5	6		11
	82	84	8	174

CONCLUSIONS

It is a matter of some concern that most people living in flats do not know what action they should take if a fire breaks out. The deficiencies found in size of openings that will allow escape and the undesirable juxtaposition of gas and electricity meters although probably less serious are also matters that could be easily avoided.

CHAPTER 5

DURABILITY AND MAINTENANCE

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D U R A B I L I T Y   A N D   M A I N T E N A N C E

SUMMARY

After defining durability and maintenance and discussing standards the cost of re-decoration of 127 houses and bungalows of different design is assessed. Factors of design and materials affecting durability in these and 56 other dwellings are investigated.

INTRODUCTION

Durability

If technological advance can overtake demand then present day housing will not have to last as long as formerly. In 1958 one-quarter of the houses in the United Kingdom had an estimated age of more than 85 years[(1)]. It is unlikely now that for municipal housing a life beyond the 60 year length of loans to local authorities is considered at the design stage. The private developer is probably not concerned beyond the length of the building society loan needed by his customers. In any case the life of a dwelling cannot easily be predicted; it has been said that from a practical point of view the life of a building ends when the amount of alteration required to bring it to modern standards of amenity is more costly than demolition and renewal[(2)]. Want of foreknowledge of what will constitute a "modern standard of amenity" in the future and the probability that sub-standard housing will continue to be occupied means that the 60 year lifetime is probably as good a period as any to adopt for housing.

Little guidance regarding the life expected from housing is to be obtained from CP3[3] in this publication it is stated that buildings as a whole may generally be regarded as having a life of at least (a) 100 years, (b) 40 years, (c) 10 years, or (d) less than 10 years. It is also stated that the foundations and structural walls, floors and roof of a building should normally be designed to have a satisfactory life*, at least equivalent to the designed life of the building.

Maintenance

All buildings start to deteriorate from the moment they are completed and need maintenance to keep them in good condition. Dr. Parker has stated that the need for maintenance may be regarded as the inverse of durability[4]. B.S. 3811[5] defines maintenance as work undertaken in order to keep or restore every facility, i.e. every part of a site, building and its content, to any acceptable standard. Although about 30% of the total output of the building industry is on maintenance work and about 40% of this is on housing, insufficient housing maintenance is being done. That it would be in the national interest to reduce maintenance on housing constructed in the future is beyond doubt.

The cases of deterioration of materials used in buildings and their installations (as listed in CP3:Chapter IX) include the following:

(a) Atmospheric and climatic action.

(b) Wetting and drying effects.

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* The satisfactory life of a building or its component parts or installations is defined as the period during which no excessive expenditure on maintenance or repair is required.

(c) Soil and ground water action.

(d) Rodent, insect, bacterial, fungal and plant action.

(e) Water supply (effect on installations).

(f) Electrolytic action.

(g) Contact or association of incompatible materials.

(h) Specific chemical action or chemical changes in materials.

(i) Wear.

(j) Impact and vibration.

(k) Action of cleaning and cleansing agents.

(l) Action of domestic or industrial wastes.

(m) Accidental causes, including fire, lightening and floods.

Obviously design should be such that deterioration due to these causes, and thus maintenance also, should be minimised.

Work such as cleaning, polishing, attendance on heating plant, and cutting lawns is sometimes included under the heading of maintenance but it is intended here to consider only items where renewal is necessary. Re-decoration - the renewal of a surface - is included.

STATUTORY REQUIREMENTS

Local authorities have power under the Public Health Act 1936, Section 53 of controlling the use of materials which are, in the absence of special care, liable to rapid deterioration, or otherwise unsuitable for use in the construction of permanent building.

The Building Regulations 1965

Fitness of Materials (Regulation B.1)

Materials used in a building are required to be:

(i) of a suitable nature and quality in relation to the purposes for and conditions in which they are used;

(ii) adequately mixed or prepared; and

(iii) applied, used or fixed so as adequately to perform the functions for which they are designed.

The above regulation is related to British Standards and Codes of Practice by a deemed-to-satisfy clause (Reg. B2) which provides that compliance with the relevant British Standard or Code of Practice shall be deemed to be sufficient compliance with the regulation if the material or method used is appropriate to the purpose for and conditions in which it is used.

Short-lived or otherwise unsuitable materials (Regulation B3)

This regulation draws attention to the section of the Public Health Act mentioned above and lists materials deemed to be unsuitable for the weather-resisting part of an external wall or roof.

RECOMMENDED STANDARDS

Limited knowledge of maintenance costs and useful life of buildings means that recommendations regarding durability are not specific. A general recommendation which receives support is that it pays to spend £1 on first cost to reduce annual cost by a shilling(6). This is arrived at by assuming a building lifetime of 60 years over which period the annual charge on a loan is little more than the rate of interest: £1 at a long term interest rate of 5% would, therefore, be charged at one shilling per annum.

Depreciation of money by the time the maintenance is incurred will mean the cost has risen. It is argued that it is, therefore, worthwhile spending more on initial cost to reduce maintenance cost. The point of view that this is a fallacious argument because the costs of maintenance are met from current revenue which is itself measured in terms of the value of money then current[7] ignores the fact that interest charges are also met from current revenue. Another factor to be considered about initial cost and annual cost is that whereas productivity on new work has increased and is likely to continue to increase, the increase in productivity on maintenance has been negligible. Continuation of this trend would favour a greater initial cost.

From some buildings, taxation relief encourages periodic maintenance expenditure rather than capital expenditure but this does not apply to public or private housing.

PREVIOUS WORK

Reiners (1955) analysed data on the maintenance of local authority housing and considered the relation of maintenance to initial cost of the various elements involved. After external painting, where maintenance cost was 100% that of initial cost, came water service 84%, then heating, cooling and lighting 33%. Further studies at the Building Research

Station showed that about one-third of maintenance costs were on the structure (including doors and windows) about one-third on decorations and about one-third on services. Reiners[8] and Chaplin[9] concluded that structural aspects of houses showed little justification for an increase in initial capital costs but that some advantage might be gained by improving the specification of the plumbing and heating installations together with a reduction of those areas requiring frequent internal re-decoration or the use of alternative materials.

Clapp (1963)[10] made cost comparisons of maintenance in local authority housing and found an overall average cost for maintenance in 1959-60 of £13.18.0d. per house.

One of the difficulties in making comparisons of cost, that of having to deal with different methods of classification was recognised by a working party in 1964[11] who produced a standard classification of maintenance operations.

A study of the availability of data on maintenance and operating costs of buildings has recently been undertaken by Bath University of Technology.

EXAMINATION OF DWELLINGS

The cost of re-decorating the exterior is an important part of total maintenance cost, accordingly in houses and bungalows decorated items were measured and the cost of renewal estimated. With terraced dwellings, rather than distinguish between end houses and intermediate houses the average cost of a dwelling in the terrace was taken. No estimate was attempted with flats and maisonettes because it proved impracticable to estimate the cost per dwelling without first estimating the cost of the whole block and that additional task was too great to be encompassed within this work.

Rates for re-decoration were taken from Hutchins' Priced Schedules[12], Schedule 10, Repairs and Alterations. Those used are given below*:

Wash down, touch up and apply two coats oil colour to general wood surfaces	9s. 4d. yd^2
Ditto on window frames and sashes (measured over glass)	9s. 0d. yd^2
Ditto on wood fascia 7 in girth	2s. 5d. yd.
Ditto on boarded soffit 10 in girth	3s. 6d. yd.

Analogous rates were used for other items, for example, doors were priced as follows:

Glazed doors and frames	as windows
Plain door and frame (approx. 2 ft 6 in by 6 ft 6 in)	£1.15s.0d. each
Garage doors and frames (pair of folding doors or one up-and-over door)	£4. 0s.0d. each

In addition to re-decoration other items which it was thought might lead to maintenance costs were observed.

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* Mr. G. Chrystal-Smith, Editor of Hutchins' Priced Schedules, suggests that to up-date these rates to August 1969, including the recent increase in S.E.T. it will be necessary to add 12½%.

RESULTS

Exterior re-decoration costs were influenced by the area of windows and doors, panels and other features of painted wood, the number of external walls (on which features could be displayed), and the size of the building. The variation in cost was found to be very wide varying from £11 for a terraced house, where special consideration had been given to re-decoration costs, to £54 for a detached house with garage, glazed screen at front entrance and lavish fascias and soffits.

To enable comparisons to be made it was obviously necessary to classify houses into different types: this still left the variable of size so to remove this re-decoration costs were expressed as the price per 100 ft^2 of floor area. The floor area taken was measured within the external walls and included the garage if one was provided. Before dividing into the cost the floor area was rounded off upwards to the next 100 ft^2.

To see whether expressing re-decoration costs as cost per 100 ft^2 floor area reduced the variation shown in figures for cost per house, Pearson's coefficient of variation was used to compare the relative variability of the two costs.

The coefficient of variation is defined as $V = \frac{100s}{\bar{x}}$

where: s = standard deviation of sample

$\bar{x}$ = mean of sample.

For re-decoration costs per house, statistics of the sample of all houses classified in Table 5.1 were $s = £8.43$, $\bar{x} = £25.5$, $V = 33\%$, for re-decoration costs per 100 ft^2 floor area, $s = £0.7$, $\bar{x} = £2.5$, $V = 28\%$, thus the relative variability was reduced by relating costs to floor area. It may, therefore, be assumed that the variation in re-decoration costs shown in Table 5.1 is due to characteristics of design aside from size.

No house examined had painted rainwater goods, mostly these were of plastic, but there were a few of asbestos-cement. Some houses had soffits of asbestos-cement left unpainted; probably on re-decoration these would be painted but this was not considered when estimating costs. There were some houses with flush eaves and hence no soffit at all, on the other hand almost every house with a verge also had a painted barge board.

As Table 5.1 shows the addition of a garage raised the cost of re-decoration disproportionately to the additional area. Garages detached from the house usually had a fascia about 6 in deep, all round and this with the garage doors, a window and perhaps another door necessitated a lot of painting. When the garage was an integral part of the house this seemed to encourage the use of wide fascias, boarding and other features painted with white paint. Terraced houses constituted an exception. The two classes into which they have been divided have a similar distribution with the same mean and standard deviation and may thus be regarded as coming from the same population. When these houses were split into municipal and speculative as well as being classed as with or without garages, the numbers were too small for statistical analysis. However, neither the examination that had been made of the dwellings nor the estimates available

TABLE 5.1

Cost of exterior re-decoration, per 100 ft^2 of floor area, for houses

Cost £	Detached, with garage Speculative	Semi-det. with garage Speculative	Semi-det. no garage Municipal	Semi-det. no garage Speculative	Terraced with garage Speculative and Municipal	Terraced, no garage Speculative and Municipal	All houses
1.2 - 1.4			1		1	1	3
1.5 - 1.7			4	2	1	2	9
1.8 - 2.0		1	7	2	5	4	19
2.1 - 2.3	1	7	5	4	1	3	21
2.4 - 2.6	2	10	4	2	3	2	23
2.7 - 2.9	3	6	2	1	2		14
3.0 - 3.2	2	2				1	5
3.3 - 3.5	3	2	2				7
3.6 - 3.8	4		1				5
3.9 - 4.1	2						2
4.2 - 4.4	1		2				3
4.5 - 4.7							
4.8 - 5.0	1						1
	19	28	28	11	13	13	112
Statistics							
Mean £	3.4	2.6	2.4	2.1	2.1	2.1	2.5
Standard deviation £	0.7	0.4	0.8	0.3	0.5	0.5	0.7

gave reason for supposing that there would be a marked difference in costs between municipal and speculative houses and the two classes were combined.

Speculative houses without garages showed less variation than other types, to some extent this could be due to the small numbers available for analysis but the same relatively limited variation will be shown to exist when ratios of external surfaces to floor areas are examined in Chapter 11. This indicates greater uniformity of design in this class of dwelling than in others.

Municipal houses although without garages often had outhouses with doors, windows, and fascias to include in the estimate of re-decoration costs.

A few houses did not fit into any of the classifications used - a municipal semi-detached house with a garage, for example. Bungalows were also too few in number for classification to be useful. They were in addition very varied in cost of re-decoration. However, the average cost and an idea of the distribution as shown in Table 5.2 are of some value in showing what level of re-decoration will be required. Old persons semi-detached and terraced bungalows formed the largest group: their costs ranged over the whole scale of Table 5.2. Other types included were speculative detached and semi-detached, some with and some without garages.

Because wooden windows rot and steel windows rust the type of window in the dwellings examined was determined. The protection of steel windows has been improved and in future they may not give the same trouble as they have in the past. Wooden windows in houses built to N.H.B.R.C. specifications

TABLE 5.2

Cost of exterior re-decoration, per 100 ft^2 of floor area, for bungalows

Cost (£)	Number of Bungalows
2.0 - 2.5	5
2.5 - 3.0	1
3.0 - 3.5	4
3.5 - 4.0	3
4.0 - 4.5	2
	15
Average cost £3.1	

will have to be treated against fungal attack, from 1st July, 1969.

It will be seen from Table 5.3 that few windows did not contain wood in their construction but, according to information received, in only three municipal dwellings and three speculative dwellings had wooden windows been treated with preservative. The figures may not be complete because with regard to 12 municipal dwellings, 37 speculative dwellings and one other dwelling it could not be ascertained whether or not windows had been treated.

Aluminium windows came in for criticism. One housewife said she found the frames difficult to keep clean because of the deposit which formed on them. In a flat which had been occupied for only 12 months the frames

TABLE 5.3

Material used for construction of windows

Material	Municipal	Speculative	Others	All
Wood	48	69	4	121
Steel	10			10
Aluminium	5			5
Steel with wood surround	28	15	4	47
	91	84	8	183

were badly corroded on the inside. In other flats of the same block "Brillo" pads had been used for cleaning, although the products of corrosion were removed the frames were pitted, particularly at the overlap between sliding sashes.

Information as to whether or not suspended ground floor timbers had been treated with preservative was thin. Certainly in all the seven municipal buildings with this type of floor the timbers had been treated, but for speculative buildings insufficient particulars could be obtained to show the general picture. The same applied to the use of treated timber in other positions but there was no evidence to show that it was much used except that the N.H.B.R.C. specification requires that the ends of joists built in to brickwork shall have preservative treatment and several builders said they did this.

The average durability of built-up bituminous felt roofing is 20 years[1]

Because its renewal will be necessary during the lifetime of the building the frequency of its use was obtained. It was found on garages, outbuildings, porches and the like in 89 out of 134 houses and bungalows. Of these 27 were municipal dwellings out of 49 municipal houses and bungalows inspected, 59 out of 81 were speculative dwellings and three out of four were other dwellings. In addition, in several flats felt was used for the main roof covering. In contrast with former practice corrugated asbestos-cement was found in only two dwellings.

Flush eaves are a current architectural fad. This deprives the wall of much protection and could affect the rate of deterioration of the walling material. Seven municipal houses and eleven out of 25 municipal flats and maisonettes, excluding multi-storey blocks, had flush eaves. In speculative housing there were just three houses and one block of flats so designed.

Whether or not a particular type of partition is sufficiently robust to last the life of a building without maintenance is perhaps a matter of opinion but doubts have been expressed as to whether partitions of two sheets of plasterboard with an egg-crate core are sufficiently robust. No evidence of damage to them during occupation of dwellings was observed. This type of partition or other partition no more robust was found in 13 out of 87 municipal dwellings, 24 out of 70 speculative, and one out of six other dwellings. In addition there were 20 dwellings where the type of partition was not identified.

CONCLUSIONS

The cost of re-decoration of the exterior of houses varies considerably, the most expensive being four times that of the cheapest for a comparable area. Even when classified into detached, semi-detached and terraced houses there is a wide difference in costs, particularly in municipal semi-detached houses. There is little attempt to keep re-decoration costs down, in fact in many houses prettying up the building with painted wood appeared to come before consideration of maintenance costs.

There was no evidence of the general use of preservative on external joinery or structural woodwork but this may be expected to improve as a result of the wider adoption of N.H.B.R.C. specifications and the implementation of the Building Regulations. Time will tell whether the widespread use of bituminous felt roof coverings is going to cause troublesome maintenance in the future; current problems with flat roofs indicate that it will. If plasterboard partitions do not prove durable their replacement will be another cost to be faced in a high proportion of dwellings.

SUGGESTIONS FOR FURTHER WORK

Work currently in hand into maintenance costs will probably cover municipal housing. It is suggested that the private sector should also be investigated. One item which could receive attention is the period within which re-decoration of house exteriors first becomes necessary, and the effect of its neglect on this and subsequent occasions. The effect of design fads, e.g. flush eaves, boarded gables, on maintenance costs and durability together with the durability of non-traditional materials are other rather obvious items for investigation.

CHAPTER 6

PRECAUTIONS AGAINST VERMIN INFESTATION

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PRECAUTIONS AGAINST VERMIN INFESTATION

SUMMARY

Recommendations with regard to proofing buildings against vermin are briefly reviewed. The absence of any signs of infestation in the dwellings inspected is reported.

INTRODUCTION

Present day methods of construction coupled with standards of cleanliness and hygiene now observed mean that vermin infestation is not likely to be a problem in dwellings recently erected, except perhaps for wood-destroying insects in country districts. The importance of keeping dwellings free from infestation is self-evident and for that reason the topic has been included here although it was not given special attention during the inspection of dwellings.

STATUTORY REQUIREMENTS

Local Authorities have power, under the Prevention of Damage by Pests Act, 1949, to require structural repairs or other works to be carried out to keep premises free from rats and mice. Presumably, if it was felt necessary, the powers could be applied to the construction of new buildings.

The Building Regulations 1965

Special treatment of softwood timber in certain areas (Regulation B4)

In parts of Surrey and Hampshire, centred roughly on Woking, where the house longhorn beetle has got a hold, softwood timber used in the construction of roofs must be treated with a preservative to prevent infestation by this pest.

Regulation K6

Windows and ventilators in larders must be fitted with fly-proof screens.

RECOMMENDED STANDARDS

It is suggested in CP3 Chapter X "Precautions against vermin and dirt"[1] that it is desirable to take precautions in the design and construction of a building to prevent infestation by vermin. The likelihood of infestation will have to justify any increased costs. Precautions that might be taken are described in a Technical Bulletin of the Ministry of Agriculture, Fisheries and Food[2]. Briefly, the recommendations applicable to housing are: foundations taken down 2 - 3 ft deep; cavity walls sealed at all points where mice could enter; eaves properly sealed; air bricks to have apertures with dimensions not exceeding ¼ in; door and window frames bedded solid; plasterwork taken into a rebate in the frames and continued behind skirtings.

The N.H.B.R.C. specification requires that where ventilation openings or other apertures occur they should be closed with suitable material to prevent the ingress of vermin or birds.

Wood destroying insects are more likely to cause trouble in country areas than in conurbation areas, and after a survey which showed the incidence of insect attack in local authority housing in areas of different character, it was said that there did not appear to be any economic justification for the general use of pre-treated timber in local authority housing in the conurbations but that it might be justified in other areas[3].

RESULTS

No sign of vermin was observed in any of the dwellings visited although it must be said that no special effort was made to see if any were present. Neither, because it was felt that the effort would be more usefully expended in other directions, was the construction checked to see if the recommendations given in this chapter had been carried out.

The use of timber preservative in the dwellings inspected has been described in the preceeding chapter. Although this preservative was primarily intended to give protection against decay fungii, it would presumably be of a type which would also give protection against wood-destroying insects, however no increased use was observed in country districts.

CHAPTER 7

S A F E T Y

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SAFETY

SUMMARY

Regulations and over 100 recommendations concerning design for safety are reviewed. The results are given of an investigation into the implementation of most of these recommendations in 183 designs of dwellings.

INTRODUCTION

Of recent years increasing attention has been given to accidents in the home and means of preventing them. If in addition to the statutory requirements, and rudimentary care now taken as the result of awareness of latent dangers, the special precautions recommended for old people, children, and disabled persons were incorporated in every home then the standard of safety would be raised for everyone and the home would be more suitable for the several categories of people who, at some time or other, will inevitably live there. Accidents attributable to faults in design or construction are not a great proportion of all accidents in domestic buildings but it is obviously desirable that they should be prevented if possible.

STATUTORY REQUIREMENTS

Together with health the Building Regulations are essentially concerned with safety. This is safety applied to buildings in general in that the regulations are largely confined to structural safety and precautions against fire in the structure. However, a few regulations are more directly related to the prevention of accidents to occupants, in particular those relating to stairs.

The Building Regulations 1965

Stairways (Regulations H1, H2, H3, H4)

Uniformity of rise and going. Were the rise or going irregular, people would be likely to stumble, therefore, between consecutive floors all steps and landings must have an equal rise; parallel steps must have an equal going, and tapered steps the greatest and least goings of consecutive steps uniform.*

Pitch. To ensure that stairs provide a safe descent, not too steep, the greatest pitch allowed for a stairway within a building occupied by one family only (a private stairway) is 42 degrees, for a common stairway it is 38 degrees. The pitch is also governed by the requirement that the sum of the going plus twice the rise must be not less than 22½ in and not more than 25 in. In addition, the rise is not to be more than 8 in in private stairways or more than 7½ in in common stairways.

Width of treads. A narrow tread affords insufficient width for placing the foot safely on descent, hence, a minimum going of 8½ in for private stairways and 9 in for common stairways is called for.

Where there are no risers the nosing of a tread or landing must overlap

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* In connection with the greatest going, there is an exception for private stairways between 2 ft 6 in and 3 ft 3 in wide.

the back edge of the tread below it by not less than $\frac{5}{8}$ in.

Tapered steps. Because of their varied going tapered steps are always a source of danger, particularly when they are used as winders.

In defining the requirements in respect of tapered steps, where the width of a stairway varies as, for example, at a quarter space of winders, the term notional width is used. This is the width (note: not the going) of the narrowest part of the tapered steps and is measured from the side of the stairway where the treads are narrower. It is what is normally regarded as the width of the stairs.

The sum of the going plus twice the rise of tapered steps is to be within the limits laid down for parallel steps, except where the angle of taper exceeds 10 degrees the maximum permitted is 28 in. It is calculated from measurements made $10\frac{1}{2}$ in in from the ends of the steps or, where applicable, $10\frac{1}{2}$ in from the extremities of the notional width.

For a private stairway between 2 ft 6 in and 3 ft 3 in wide the requirements in respect of proportioning tapered steps are relaxed providing the angle on plan is not less than 20 degrees, the going is at least 3 in throughout the width, and the rise not more than 8 in.

If the width of a stairway varied above and below winders or other tapered steps this could be a source of danger, therefore, the nosing of the lowest tapered step is required to be equal in width to the nosing of the next parallel step or landing above.

Length of flight   On common stairways the maximum number of steps permitted without the break of a landing is 16. There is no limitation on the number of steps in a flight of a private stairway, presumably because the number is not likely to exceed 16.

Headroom   A minimum headroom of 6 ft 6 in above the pitch line is required; clearance must be not less than 5 ft measured at right-angles to the pitch line. For pitches below 39°43' the headroom requirement is critical, above that pitch, the clearance is critical.

Guarding of stairways and landings
(Regulation H5)

To protect people from falling, a wall or securely fixed screen, balustrade or railing must be provided on each side of a stairway with an aggregate rise of more than 2 ft and on the side of a landing or similar space overlooking a stairwell. It must have a height of at least 2 ft 9 in measured vertically above the pitch line of the stairs, 3 ft above the floor of landings of private stairways and 3 ft 6 in above the floor of landings of common stairways.

To provide a grip, where the aggregate rise of a stairway is more than 2 ft, a continuous handrail, 2 ft 9 in to 3 ft 3 in above the pitch line, must be provided on each side of stairways 3 ft 6 in or more in width. Where the stairway is less than 3 ft 6 in wide the handrail need by on one side only.

Balustrades, parapets and railings on balconies and external areas
(Regulation H6)

Any balcony, platform, roof or other external area which is above ground storey level and likely to be used by people, other than for maintenance purposes, must be protected by a balustrade, parapet or railing not less than 3 ft 6 in in height and of such extent, construction and material as to afford reasonable safety for any person using the area.

RECOMMENDED STANDARDS

The Parker Morris Report included a checklist for testing safe design in the home. Further recommendations of note have been made by Anne Acland at the Royal College of Surgeons' Convention in 1963[(1)] and B.R.S. Digests 43[(2)] and 44[(3)] (second series). A later publication "Safety in the Home"[(4)] includes an Architects Safety Check List which contains most of the points covered by the prior publications (and a few extra), classified under headings of activities.

Except for some points concerning multi-storey buildings, Mrs. Acland's recommendations are most comprehensive. A few items are now covered by the Building Regulations, exempting these her check list is reproduced below in inverted commas. Where there are further recommendations from other sources these are given under the appropriate heading of the check list.

The Building Standards (Scotland) Regulations cover more aspects of safety than the English Regulations. There are requirements not only for stairs and balconies but for windows and electrical fittings in bathrooms. One regulation applies generally to prohibit projecting parts and parts capable of being opened in places where they might cause danger or obstruction (Regulation 175). Items from the Scottish regulations are included here where it is felt they are of interest or that adoption of them might be desirable.

Stairs, handrails

"Single steps should never be used on landings or elsewhere. If this is absolutely necessary, differentiate the change of level by a definite change of colour."

"No step should be less than 3 in in height."

"If winders are inevitable they should form the lowest steps of a flight. They are better avoided."

"Risers should be not more than 7½ in."

"A handrail should be provided on both sides whenever possible."

"The stairs should have good daylight and good artificial light, looking towards the stairs and not downwards, to avoid shadows."

"Two-way switches should be provided at top and bottom of stairs."

"No door should open on to the top of stairs or swing so as to obstruct the top or bottom of stairs or landing."

"Outside stairs or steps should be avoided wherever possible as they are very dangerous in wet or frosty weather. In any case they should have a non-slip surface, a handrail and an external light: maximum rise 7 in, minimum tread 9 in."

"Staircase surface non-slip, never polished wood."

Digest 44 points out that there should be no encroachment by steps on the circulation space at the top or bottom of stairs, and that children tend to use access stairs for play at blocks of flats, therefore, if a well is necessary it should be fitted with a storey- height balustrade. MHLG Design Bulletin No.13 states that gaps of less than 5 in between balusters or railings should be avoided, and that open risers have special hazards.

In the Building Standards (Scotland) Regulations no opening between two adjacent treads of a common stairway* giving access to dwellings may be of such a size as will permit the passage of a sphere of 4 in diameter (Regulation 180(7)). The same requirement applies to any opening in a balustrade or railing (Regulation 180(10)) (see also Balconies). In addition, the regulation requires a terminal landing with a length equal to the width of the stairway to be provided at each end of a common stairway, likewise where the landing or balcony of a private stair is open to the external air its length must be equal to the width of the stairway.

Balconies, terraces, flat roofs

The Parker Morris Committee made the following recommendations.

(i) Balcony fronts should be at least 3 ft 9 in high and designed so that a child can see out without having to climb on to any object or on the parapet.

(ii) There should be no horizontal bars or projections which might encourage children to climb.

(iii) If balcony fronts are formed of bars, the clear spacing between the bars should not exceed 3½ in.

(iv) The balcony should be so designed that it is possible for an occupier to fit a protective net easily.

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* The terms "common stairway" and "private stairway" are not used in the Scottish Regulations but they are used here where the stairways so described are broadly the same as those in the English Regulations.

In detailing the special precautions to be taken for children, Digest 44 suggests a further reduction in the space between members of balustrades to a maximum of $2\frac{3}{4}$ in so as to make it impossible for a child to put his head through.

There is little agreement on the maximum space desirable between bars, railings or balusters, those quoted by different authorities are summarised below:

B.R.S. Digest 44	$2\frac{3}{4}$ in
BS 1753: 1965[(5)]	$2\frac{3}{4}$ in min. up to 3 in
Homes for Today and Tomorrow	$3\frac{1}{2}$ in
Building Standards (Scotland)	4 in
M.H.L.G. Design Bulletin No.13	5 in

Windows

"Windows behind fixed obstructions, e.g. bath or sink, present a problem with regard to cleaning, and special opening gear may be necessary."

"On staircases windows should be placed so that they can be cleaned safely."

"Whether top or side-hung, or horizontally pivoted, ground floor windows should never open out on to a path. In such cases the path should be kept a little away from the house by means of a flower bed or patch of loose gravel."

"First floor windows should have sill height from floor 32 in minimum, have a secure fastening, and be easily cleaned from inside. Vertical safety bars may be advisable where there are children or old people."

"All windows with top vents must be checked for height. If they cannot be opened without standing on something, special opening gear must be fixed." MHLG Design Bulletin No.13 gives 6 ft 7 in as the absolute maximum height for hand operated controls and states that this should be reduced if there are fixed obstructions beneath the window.

Further recommendations on the height of windows are made in Digest 44 which states that in high blocks of flats and maisonettes no opening part of any window should be below 3 ft 9 in from the floor but that a fixed glazed area would be acceptable for a few inches. If the glass is lower, then fixed bars should be provided. The MHLG Bulletin states that if opening lights in any windows above ground floor are lower than 2 ft 8 in from the floor additional protection is needed. Above three storeys it is recommended that the minimum height should be increased to 3 ft 8 in.

Under the Scottish Regulations, where in the wall of an access passage to a house* there is a window with a glazed portion less than 3 ft 6 in above the floor, the window must be guarded by a secure railing or balustrade extending to a height of 4 ft above the floor (Regulation 179(7)).

A further recommendation (MHLG Design Bulletin No.13) applicable to staircase windows in blocks of flats is that if they are cleaned by contract they should have no opening lights lower than 3 ft 9 in from the floor and

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* The meaning of "house" is rather wider in Scotland and as used here includes flats.

should be fitted with budget locks, preferably with a visual indication as to whether the lock is open or shut. An extra precaution advised for high buildings with sheer wall faces is that windows (including high level glazed vents) should be reversible through approximately 180 deg. so that they can be cleaned entirely from inside.

Bars at least 3 ft above the sill are recommended in Digest 44 in order to make windows safe for children. Where bars are not fitted it is suggested that safety can be improved by locks or other devices to keep children from opening them or stops can be used to restrict opening to a few inches. This suggestion has been elaborated in MHLG Design Bulletin No. 13 to "fastenings to casement and pivot windows above ground level should limit the initial opening to 4 in and provide continuous control of the windows movement".

In Scotland it is mandatory to have every window, above the ground storey of a house, not being a roof light, so constructed as to enable the outside of the window to be cleaned safely from inside the house or from a balcony, platform or flat roof to which access can be obtained (Regulation 197). MHLG Design Bulletin No. 13 recommends that above three storeys windows should be designed so that they can be cleaned and re-glazed (though not necessarily repainted) from inside, unless there are balconies. It also advises that 1 ft 10 in is the maximum reach for cleaning windows through or across an adjacent opening and that side-hung casements should have easy clean hinges with a clearance of 3¾ in minimum. Further recommendations are that windows reversible for cleaning should have locking bolts to fix them in the fully reversed position and that independent fastenings at each side of such windows, far enough apart to be beyond a child's reach, should be considered.

Glass weight should, of course, be adequate. This can be assured by specifying it in accordance with CP 152[6].

Doors, thresholds

"Thresholds proud of ground level must be avoided whenever possible. Where it is absolutely necessary at an external door the threshold should form part of the doorstep where there is less likelihood of anyone tripping over it."

"Front and back doors should have mat wells. Door mat flush with floor."

"Double swing doors should be used only if they can be provided with a vertical glazed panel."

"No doors should open outwards on to circulation areas such as passages or staircases (see Stairs)."

Further recommendations with regard to doors, from Digest 44 are:

door and gate swings should not interfere with movement of people or other doors,

the method of movement of doors should be apparent,

glass or fully glazed doors must be clearly visible,

as a special precaution for old people lever handles should be of such a design as not to catch in clothes.

MHLG Design Bulletin No.13 advises that glazing in doors must be strong enough to withstand slamming. CP 152 Supplement No. 1[(7)] recommends toughened glass in the lower panels (not less than $\frac{1}{4}$ in thick for areas exceeding 2 ft^2) but allows that upper panels may be glazed in $\frac{1}{8}$ in annealed glass limited to 5 ft^2.

Floor finishes

"The problem here is to achieve a non-slip surface but this is very difficult. Any hard surface is slippery if polished."

"Rubber, cork, lino (unpolished) are least slippery."

"Avoid single or too shallow steps (see Stairs) and see that any difference in level is marked with a change of colour."

"The architect, of course, cannot control what is put on the floor once the house is finished, e.g. too much polish, or loose rugs, but the problem of the slippery floor is very important indeed."

Digest 44 points out that deterioration of floor finishes is a frequent cause of accidents, therefore, the durability of floor finishes should be taken into account. A higher standard of slip resistance for old people is also recommended.

Heating

"People nowadays refuse to accept a cold house. If built-in warmth is not provided in some form of installation (capable of heating the work/circulation area to 55°F, the living/dining area to 65°F, when outside temperature is 30°F) and if the house is not properly insulated, people will keep warm by means of portable oil stoves and electric fires with trailing flexes, and all their attendant dangers."

"Although the open fire has a traditional and obvious attraction, it is not an efficient source of heat and it is dangerous and dirty. The movement nowadays is towards some kind of central heating or to openable stoves. The open fire is on the way out and it is up to all concerned with home safety to give it a further push."

"If an open fire is used permanent fixing should be built in to accommodate a standard fireguard (British Standard 2788)[8]."

"If an open fire is used the hearth should conform strictly to the building regulations and should also have a raised edge."

"If an open fire is used the fuel store should be conveniently placed and the journey to it should not be too long or awkward."

"Electric and gas fires should be fixed, not portable and should be provided with guards."

"A fixed fire of whatever type should be placed in such a way that all furniture required can be placed at least 3 ft away from it. (For kitchen heating see 'Kitchens')."

The last item in the above list is amplified by Digest 43 - no fixed heating appliance which attains a high temperature should be placed in such a position that congestion of persons or furniture around it is likely. Another recommendation in the Digest is that closed stoves should have a hearth projecting at least 12 in in front of them. The Building Regulations (M4(3)(a)) require only 9 in unless the appliance is an open fire or a stove which can, when opened, be operated as an open fire in which case 12 in is required. In Scotland permanent fixings for a fireguard <u>must</u> be provided where there is a fireplace opening capable of containing an open fire (Regulation 82).

Electrical, gas, telephone, miscellaneous

"It goes without saying that gas and electrical regulations should be strictly followed."

Electrical:

"At least fifteen socket outlets per house should be provided. Fewer than this leads to trailing flexes and overworked adapter-plugs."

"Meter cupboards and fuseboards should be within reach so that step ladders are not needed."

"All socket outlets should be at 3 ft 6 in height." (This may well lead to danger if leads were stretched).

"Enough well considered lighting should be provided everywhere." Illuminated switches in circulation areas are desirable (MHLG Design Bulletin No.13)

Storage:

Adequate storage is necessary so that things can be put out of the way. Where there are children, special storage should be provided for sharp tools, poisonous or corrosive chemicals, etc. (Digest 44).

"Apparatus such as thermostats should be checked for safety and anything doubtful queried with manufacturers. (See also 'Kitchens' and 'Bathrooms')."

Gas:

"Gas taps should be of a type which cannot be turned on by mistake."

"Meter positions as for 'Electrical'."

Telephone:

"Should not be put at the bottom of a flight of stairs nor behind a door."

Fire extinguishers:

"A definite place should be provided for at least one, to encourage installation. Preferably at top of stairs."

Kitchens

"Accidents in the kitchen mostly concern the cooker, the electrical installation, and out-of-reach storage."

"The cooker should be planned as part of a continuous range of equipment with no unused floor space beside, to discourage children from climbing up and to lessen risk of projecting saucepan handles. It should not, therefore, be next to door or window or under window. Draughts and curtains can cause fires, or blow out low flames in gas cookers, leading to an explosion."

"If there is a ceiling airer it must not be over the cooker."

"Working surfaces should all be planned at one height and in one continuous range, reducing the need to lift or carry hot liquids."

"There must be adequate storage space at normal height of reach for everything in daily use."

"Entrance door and cupboard door swings must be considered carefully and sliding doors substituted if necessary.

"There must be really good daylight and artificial light, carefully placed to light the various working points."

"Some warmth must be provided apart from the cooker - possibly radiator or overhead infra-red heater. This is often neglected in a kitchen with the resultant temptation to use portable heater."

"Floor surface must be non-slip."

"Sockets outlets should not be placed so that flexes can trail across the cooker or too near the sink."

"A larder should not be allowed to obstruct the flow of work in the kitchen.

"A lockable cupboard should be provided for household cleaners and polishes."

Digest 44 suggests that as a special precaution for children doors of walk-in larders should be openable from inside.

Additional points, from Digest 43, are that the kitchen should be planned to give a sequence of work surface - cooker - work surface - sink - work surface, that doorways should be placed so as not to cause cross circulation which may lead to collisions, and that there should be an efficient and economical means of heating water which will not tempt housewives to boil kettles for heating water for washing; also there should be adequate space provided in a kitchen (or separate utility room) for the necessary washing and drying equipment. The NHBRC require dwellings constructed to their specification from July 1969 onwards to comply with certain provisions relating to kitchen layout, these include a space not less than 1 ft wide for a work surface on each side of the sink and the cooker.

Two more recommendations, made by MHLG Design Bulletin No. 13, are that ventilation to laundering space should be adjustable and adequate and that the route to the clothes line should be direct and free from unnecessary change of level.

There are no recommendations in respect of automatic washing machines but now that they are quite common it would seem advisable that the necessary services for 'plumbing-in' the machines should be available if required.

Bathroom, cloakroom

"Floors should be non-slip."

"Either put a grab rail by the bath or position the basin in such a way that someone getting out can steady himself."*

"Hot water towel rails, which get much hotter than an ordinary radiator, ought to be a wall-fixed type and above the height of a small child's head - say 2 ft 6 in minimum from floor."

"Medicine cupboard should be lockable and out of children's reach".

"Electric light fitting should be enclosed type so that there is no temptation to plug in any heating device or hair dryer."

"All electrical regulations with regard to bathrooms should be strictly adhered to."

"An indicator bolt openable from both sides should be fitted in place of a locking device."

Pull switches in bathrooms and W.C. should be low enough for a child to reach (MHLG Design Bulletin No. 13).

Old people might need a hand hold or similar by the W.C. as well as the bath (Digest 44).

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* This does, of course, assume that the basin will be securely fixed.

If a safe heating appliance is not provided in the bathroom there should at least be wiring provision (Digest 43).

The Scottish Regulations cover light fittings or appliances in rooms containing baths or showers and amongst the requirements is the proviso that any part of a lamp-holder likely to be touched by a person replacing a lamp shall be constructed of or shrouded in insulating material and fitted with a protective shield.

Bedroom

"The planning should not be so cramped that furniture has to be too near the fire."

"A light switch should be provided by each bed. It is important to be able to light ahead whether going into a dark bedroom or out onto a dark landing."

"Enough storage space should be provided at the proper level."

Garages, outbuildings

"Garage should have some permanent ventilation."

"Garage should have a non-greasy floor."

"There should be easy room to turn the car outside the garage with safety."

"There should be an external light between garage and house with two-way switch at garage door and house door."

"Any porch, verandah, yard, etc. should have proper lighting and non-slippery surface."

"Ideally, entrance to fuel store and garage should be accessible under cover from house door."

"Water butts or garden tanks should be fitted with covers."

Workshops and garden sheds should have lockable doors (MHLG Design Bulletin No.13).

"Asbestos roofs on low outbuildings should be avoided if there is any risk of people climbing on to them. They are brittle and very dangerous."

"A light (switched at access) should be provided in the roof space and the trap door access made as safe as possible. A small portion of the space between the joists should be boarded, especially if inspection of tanks etc. is likely."

"Rooflights should be either of reinforced glass or unbreakable clear plastic."

Living room, dining room, hall, landing passages, paths

"Considerations of floor finish, change of level, circulation, fire prevention, storage, light and warmth considered under other headings all apply equally to these spaces."

Recommendations from MHLG Design Bulletin No. 13 are:

Paths should be kept away from buildings by a strip of material uncomfortable for walking.

Paths used at night should be lighted.

Fences and gates

Two recommendations from the MHLG Bulletin:

Fences and gates should be designed so that children under four years old find them difficult to climb and open.

Very low fences must be designed to be clearly visible.

PREVIOUS WORK

An analysis of records of domestic accidents made by the Building Research Station (1964)[2] showed that 8% were attributable to design faults, 25% to maintenance inadequacies and 63% to personal factors. The Royal Society for the Prevention of Accidents analyses causes of death in home accidents annually. The figures show that there are about 8000 deaths a year in homes and residential institutions, slightly more than half the deaths are caused by falls and most of them occur in people over 65 years of age.

A great deal of work has been done on kitchen planning such as that by Bateson and Whyte (1953)[9], and from this work have come recommendations on safety. Other recommendations have come from work on dwellings for old people by, for example, Hole and Allen (1962)[10], and from work on housing the disabled by Goldsmith (1965)[11] [12]. Acland (1963)[1] and (1967)[4] has pointed out faulty design features which are responsible for many accidents in dwellings.

EXAMINATION OF DWELLINGS

As many of the recommendations as it was felt would yield useful results and be possible to check were investigated. The results are given under similar or related headings to the relevant recommendation.

RESULTS

Stairs

The examination was confined to stairways within dwellings. Contrary to the practice otherwise followed in the survey of assuming that the Building Regulations had been complied with, the requirements in respect of headroom and clearance were checked (Table 7.1). There were two reasons for this, firstly some dwellings were constructed not under the Building Regulations but under the former Building Bye-laws with no requirements for minimum headroom or clearance, and secondly there was reason to believe that the requirements of the Building Regulations were not always met. The figures given in Table 7.1 bear this out although it must be emphasized that determining whether or not a dwelling was constructed under the Building Regulations was usually judged from the date of completion, the figures are, therefore, not completely reliable. However, the indication is that although builders have been dissuaded from the worse excesses by the introduction of the Regulations the standard in speculative buildings has not otherwise improved. In municipal dwellings the Regulations seem to have been more effective.

The figures for clearance, rather than headroom, are given because it was easier to measure clearance accurately. At the pitches used in housing it is not likely that figures for headroom would result in any increase in the numbers failing to meet the minimum requirements. The pitch itself is not likely to have been affected much by the introduction of the Regulations - only six stairs had a rise of more than the now permitted maximum of 8 in and only two had a going as small as $7\frac{1}{2}$ in, which with a nosing would not fall far short of the minimum 8½ in width of tread. Most stairs had a rise greater than the recommended maximum of 7½ in: 75% of stairs in municipal dwellings and 85% in speculative came into this category.

TABLE 7.1

Insufficient clearance on stairways[a]

Distance below 5 ft (in)	Municipal N=45(17)	Speculative N=74(43)	Other N=4(2)	All N=123(62)
More than 1	19 (4)	48 (27)	3 (2)	70 (33)
More than 2	16 (4)	36 (20	3 (2)	55 (26)
More than 3	9 (2)	27 (13)	2 (1)	38 (16)
More than 4	6 (1)	18 (7)	1 (-)	25 (8)
More than 5	4	10 (4)		14 (4)
More than 6	1	7 (3)		8 (3)
More than 7		4 (2)		4 (2)
More than 8		3 (-)		3 (-)
More than 9		1		1
More than 10		1		1
More than 11		1		1
More than 12				

(a) Figures in brackets refer to stairways in dwellings believed to have been constructed under the requirements of the Building Regulations 1965.

The number of stairways examined for other undesirable features of design was the same as that shown in Table 7.1. Of these, seven municipal, eight speculative and one other contained single steps, usually at the top of a flight. The danger of these was emphasised during the investigation when one of them, disguised by a patterned carpet was not noticed. and nearly led to an accident to the investigator

Four municipal and ten speculative had stairs with winders, one of them, in a municipal dwelling, had winders at both top and bottom of the flight, seven out of the other 13 sets of winders were at the top or in the middle of the flight. One speculative house with winders at the top of the stairs had a window over them, the top of which was 9 ft above the winders - a potential window cleaning hazard of the most obvious type. A municipal house with a window over the winders had the window too low: the sill was only 1ft 9 in above the winders. If anyone stumbles on those stairs the window is quite big enough for them to fall through.

Other windows over stairways were sometimes in a position which many people could not reach with safety, sometimes they were in a position which no-one could reach with safety. One window, a borrowed light in a bedroom, which lighted the stairway, was just under the first floor ceiling and at one point at least 12 ft above the stairs. The window was at the side of the stairway and when a ladder was used for cleaning the window its foot would need to rest on the stair treads.

Four houses, two municipal and two speculative had a handrail on each side of the stairway: the additional rail was over the lower few steps only, in two cases. In eight houses, six coming under the Building Regulations, a capping fixed on a solid balustrade was expected to serve as a handrail. The cappings varied between 5 in and 6½ in in width, too wide for a firm grip to be obtained on them. Often the capping stopped short at the ground floor ceiling leaving nothing at all to afford a grip at the top of the stairway. One particularly dangerous flight of stairs, the one with winders at top and bottom previously described, had no handrails: just a short length of capping about 2 ft long over the foot of the stairs.

When the balustrade was not flush but built up of bars or rails many stairways constituted a danger to children because of the wide spacing of the members. Even the widest of the maximum spacings recommended by the various authorities was exceeded in over 60% of cases (Table 7.2). What little protection to a small child was given in one house is shown in Plate 7.1. This sort of arrangement was not uncommon, the largest spacing recorded was 1 ft 9 in.

There were a few examples of stairs without risers, two municipal, four speculative and one other, all had a space between the treads of 6 in or more, the largest being 6¾ in. Usually this was the type of stair provided when the stairway rose out of the living room rather than the hall. One particularly fine example observed was a staircase of parana pine; with its open risers and the light widely spaced members of its balustrade it had an appearance of lightness which might have been lost if safety had been given more consideration - a challenge to designers.

TABLE 7.2

Spacing of members of balustrades

Spacing (in)	Municipal N = 14	Speculative N = 34	Other N = 3	All N = 51
More than $2\frac{3}{4}$ (BRS)	14	33	3	50
More than 3 (BS)	12	33	3	48
More than $3\frac{1}{2}$ (P-M)	8	32	3	43
More than 4 (Scot)	7	31	3	41
More than 5 (MHLG)	4	25	2	31
More than 6	4	21	2	27
More than 7	2	14	2	18
More than 8	2	13	2	17
More than 9	2	13	1	16
More than 10	2	13	1	16
More than 11	2	8		10

Doors sometimes opened close to the foot of the stairs, as when the stair rose from a small entrance lobby little wider than the stairs, but this did not seem to constitute a danger. When doors opened near the top of stairs they were potentially more dangerous. One example of this which may well lead to an accident was where a W.C. compartment was sited immediately opposite the head of a flight of stairs. The landing was less than 3 ft wide and when the W.C. door opened its edge was not far from the top riser of the stairs. It would be easy for anyone coming out of the W.C. to fall straight down the stairs: the occupier said she was afraid of this happening one night.

Deficiencies in natural lighting of stairways which were observed will be described in Chapter 15.

Balconies

Fifteen municipal flats with balconies were observed. Only five of the balconies had fronts 3 ft 9 in high or more as recommended by the Parker Morris Committee. Eleven fronts had open spaces between bars; although four exceeded $3\frac{1}{2}$ in the largest spacing was $4\frac{1}{2}$ in. One front had horizontal bars which, were it not for the fact that the flat where it occurred was for old persons, might have been regarded as encouragement to climb, nevertheless there remains the possibility of children visiting the flat.

Windows

The sill heights of windows in living rooms and bedrooms were measured in all dwellings where these rooms were found above ground floor level, except where a balcony ran outside the window. If one of the windows was at a lower level than the others in either the living room or one of the bedrooms then it was the height of the sill of that window which was taken. When a window had wired glass in its lower panes then this was treated for safety considerations as though it were part of the wall and the sill height measured to the member immediately above the wired glass.

The sill heights are given in Table 7.3. Because the various

TABLE 7.3

Window sill heights in rooms above ground floor level

Height ft in	Living Rooms	Bedrooms		
		Municipal	Speculative and others	All
Less than 5.0			84	158
Less than 4.4			83	157
Less than 4.2		74	83	157
Less than 4.0		74	82	156
Less than 3.10		74	81	155
Less than 3.8		73	78	151
Less than 3.6	42	63	67	130
Less than 3.4	40	53	62	115
Less than 3.2	37	49	49	98
Less than 3.0	22	34	30	64
Less than 2.10	18	18	23	41
Less than 2.8	12	13	15	28
Less than 2.6	6	6	4	10
Less than 2.4	4	4	3	7
Less than 2.2	3	2	3	5
Less than 2.0	2	2	2	4
Less than 1.10	2	1	2	3
Less than 1.8	1		1	1
Less than 1.6			1*	1

* This sill was at floor level

authorities differ in their views as to what constitutes a safe height, the Table has been arranged so that the number of dwellings with heights below any desired minimum can easily be read off. As there were only four living rooms in speculative dwellings to include, all living rooms have been given under one heading.

Some windows had a horizontal glazing bar about 9 in to 1 ft above the sill with a fixed pane of glass between bar and sill. This improved the safety somewhat but did not remove the danger to a child who climbed up on to the sill. Except for windows of this type, details of which are given in Table 7.4 it is safe to conclude that of the others at least one in practically every dwelling had a light which opened at sill level, the exceptions would be found in a few houses where bedroom windows had opening lights above the transoms only. When windows with a fixed light above the sill were used they were generally found in both living room and bedrooms.

TABLE 7.4

Windows with fixed light above sill

Height to opening light ft.in.	Height to sill ft.in.	No
3.2	2.2	1
3.6	2.6	3
4.0	2.9	2
4.0	3.3	2
4.3	2.11	1
	Total	9

The danger of falling through a window may be more apparent in high blocks but even so it is difficult to understand why the recommended minimum should be lower for windows below third floor level. If we conclude from the recommendations of the various bodies that the minimum sill height for all windows above ground floor levels should be 3 ft 6 in then it has been demonstrated that few dwellings are satisfactory in this respect. If the lowest of all the recommendations is taken, that is 2 ft 8 in then there are still dwellings which must be considered unsafe, the proportion is particularly high when living rooms are considered even when windows with a fixed light above the sill are deducted.

It was not necessary to be on an upper floor to find a dangerously low sill; the ground floor living room of a house where the ground sloped steeply from front to back had the bottom of an opening light but 10 in from the floor - and a 7 ft drop outside!

Devices to limit the opening of windows were found generally in multi-storey blocks of flats but in few other dwellings. One multi-storey block had windows with two opening lights, one horizontally pivoted, the other side-hung on hinges; the pivoted light was provided with a safety catch to limit its initial opening but no similar device was provided on the side-hung light. These windows were unsafe in other ways; a housewife whose flat contained them said that she could clean the outside of the windows from within the building but only if she stood on the sill to reach the top.

Tenants in many flats and maisonettes said that they could not get window cleaners to clean windows above the first floor. It was noticeable that even when windows were obviously intended to be cleaned from inside it was often not possible to reach some part of them without sitting on the sill or otherwise getting into a dangerous position. Dwellings where it appeared that the windows had been so constructed that it was possible to safely clean them from inside numbered 16 out of 169 designs of two-storeys or more, nine of these were in multi-storey blocks (out of eleven blocks examined) and only one was a speculative dwelling.

Doors and glazing

Glass is a potential danger to children when doors, screens and windows are glazed below lock rail level, i.e. about 2 ft 8 in. This was obvious from the several broken panes observed during the survey; some occupiers had replaced the glass of internal doors by hardwood or plywood because of the frequency with which it had been broken. To use wired glass was, of course, one way of removing the danger. Wired glass was more common in municipal dwellings than in speculative, as Table 7.5 shows. In fact the investigation indicated that the use of glass at a low level in municipal housing is much less common than in speculative dwellings. Perhaps this is due more to considerations of maintenance than safety.

When entering one house via the front door it was necessary to duck under the soffit of the stairs to get round the door and into the hall. This fault appeared to have been due to the door having been hung on the wrong side rather than the hall being badly designed. It is mentioned

TABLE 7.5

Glazing below lock rail level

Glass	Municipal N = 91	Speculative N = 84	Other N = 8	All N = 183
Front door				
Sheet or similar	28	75	2	105
Wired	10			10
Living rooms				
Sheet or similar	14	56	5	75
Wired	11	3		14

here under the heading of safety because many visitors to that house must have given their heads a nasty bang as they came in.

Floor finishes

Only one point in connection with floor finishes is worthy of note; in a block of flats where old persons were housed on the bottom floor, the corridor was paved with terrazzo tiles, these got very slippery when wet and an old lady had slipped and fallen on them.

Fires

The open fire may be on the way out but as will be shown in Chapter 12 it still has some way to go. A permanent fixing for a fireguard in front of an open fire was provided for 21 out of 32 open fires in municipal dwellings and for two out of 32 in speculative dwellings. In four dwellings, two municipal and two speculative, beds were found to be within 3 ft of fixed electric fires. In another dwelling, a showhouse, a fixed electric fire in the dining alcove was in such a position that one almost brushed past it to get by the table on the way to the kitchen, and that was when no-one was sitting at the table.

Electrical, miscellaneous

Whether or not it would be possible to change a fuse at the meter without having to stand on something - in the dark - to reach it was noted. The findings are given in Table 7.6.

TABLE 7.6

Fuses within reach

Item	Municipal	Speculative	Other	All
Yes	58	57	6	121
No	21	24	2	47
Not known	9	3		12
Total	88	84	8	180

Light switches were sometimes badly placed; in an old person's bungalow it was necessary to walk to the opposite end of the kitchen to put the light on after entering the back door. In a speculative house the switch in the dining room was almost in the middle of the wall opposite the door by which one would enter from the kitchen; there were folding doors between the dining room and adjacent living room but the switch was also some distance from these doors. It was uncommon in bedrooms to find switches suitably positioned near the bed, some but not all old persons' dwellings had them; in speculative dwellings the occupier may have paid extra for a ceiling switch - if it was installed when the house was built then it was counted and included in Table 7.7. Usually only one switch was provided and that meant that the door was between the bed, or the part of the room where the bed would have to be placed when the room was furnished, and the switch. If the switch was positioned so that it would be possible to reach it without walking away from the bed then it was judged to be within reach.

TABLE 7.7

Light switches in bedrooms

Switches near bed	Municipal	Speculative	Other	All
Yes	26	24	4	54
No	194	216	13	423
	220	240	17	477

Particulars of the location of power socket outlets in bedrooms and the number of them provided in various rooms will be given in Chapter 16.

Fire extinguishers

No fire extinguisher or definite place to put one was observed in any of the dwellings visited.

Kitchens

Safety points observed in kitchens are given in Table 7.8. Several of the cookers with unused space at the side were very dangerously positioned by doorways (as one example in Plate 16.1). One cooker in the corner of a kitchen, a position in itself undesirable, had a flap on the grilling compartment, when this flap was down it came in front of the doorway in the wall at the side of the cooker and if anyone attempted to open the door it hit the flap. What was considered to be an obstruction in the other cases numbered in Table 7.8 is not easy to define, examples are - where the swing of a cupboard door intersected the swing of another door - doors opening back against cookers or otherwise interfering with anyone working there - similarly with a sink or preparation table.

With the work sequence, because a drainer was considered to be a work surface, provided another surface was fixed between sink and cooker, the required sequence was partially achieved.

Ceiling airers over cookers do not appear to be a likely source of danger, not one of the kitchens had a ceiling airer. Only one, in a municipal dwelling had a lockable cupboard.

Lighting will be considered in Chapter 15 and the provision of power socket outlets in Chapter 16.

Bathrooms

Out of the 183 designs of dwelling examined 23 had grab rails by the bath, those with this provision included all municipal old persons dwellings but one, and one private flat for old people of limited means.

TABLE 7.8

Safety and danger points in kitchens

Item	Municipal N = 91	Speculative N = 84	Other N = 8	All N = 183
Cooker				
Unused space at sides	38	47	4	89
Under window	14	17	1	32
Work surfaces				
At different heights or not continuous	47	39	6	92
Work sequence				
Surface - cooker - surface - sink - surface				
Yes	23	14	2	39
Partially (one missing)	49	47	6	102
Door swings and position				
Causing obstruction	22	34	1	57

The four bathrooms in speculative dwellings which are included had baths which incorporated a grab rail in their design rather than separate rails.

Twenty bathrooms were fitted with door bolts which could be opened from both sides, although this provision was more common in old persons' dwellings than elsewhere about half of them were deficient in this way. Apart from old persons' dwellings the proportion was about the same in municipal and speculative dwellings: approximately 8%. A distressing incident reported recently in the Birmingham Post emphasises the need for all bathroom doors to be capable of opening from outside; a two-year old boy, born with enlarged lymphatic glands which made him more vulnerable than usual to injury, infection or to emotional tension such as fright, locked himself in a bathroom and died from a combination of fright, cold infection and aspiration of vomit before entry into the bathroom could be effected.

No bathroom had a lockable cupboard for medicines or other articles dangerous to children. All but two had pull switches, the exceptions having switches on the wall outside, most of the cords of the pull switches were long enough for children to reach. Often the ceiling switch was badly positioned in the middle of the doorway so that it was not possible to close the door without shutting the cord in it. One or two people had screwed an eyelet into the door jamb and passed the cord through that but this caused wear on the cord and before long it broke. It is remarkable that so little thought is given to this sort of thing.

Safe heating or wiring provision was provided in 43 bathrooms, 15 municipal, 24 speculative and four others. An example of the danger that might arise when provision for heating bathrooms is not made was found in one house where the occupier had fitted an electric socket outlet in the bathroom himself. The position he chose for the outlet was 6 in from the floor, 3 ft 6 in, measured horizontally, from the bath and 1 ft 3 in from the washbasin.

CONCLUSIONS

Designers and constructors of the dwellings examined did not appear to have been safety conscious, nearly all recommended safety points that were checked proved to have been observed more in their absence than their presence. Some recommendations are plainly more important than others but items such as inadequate handrails on stairs, failure to guard stairs properly, very low sills in upper storeys, cookers by doorways and some others, where dangers would appear to be obvious, occurred all too frequently. Later in this thesis, this lack of awareness of the probable causes of accidents will be shown to extend to the natural lighting of stairways, the positioning of power outlets in kitchens, and failure to advise tenants of flats on fire precautions.

SUGGESTIONS FOR FURTHER WORK

There seems to be a need for more details of the cause of accidents and hence the design which could prevent them - what should be the minimum sill height, for example.

Not only cases resulting in deaths should be investigated, for instance, it would be useful to know how many children are cut by low level glass in doors and the like.

CHAPTER 8

SECURITY

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S E C U R I T Y

SUMMARY

It is shown that there are few recommendations with regard to protection of dwellings against thieves, and the standard of protection in observed dwellings of 183 different designs is described.

INTRODUCTION

A home should be reasonably secure both to give peace of mind to occupants who fear intrusion and to safeguard their possessions. Generally security is given little consideration in respect of dwellings. The normal mortice lock fitted to a back door has two, three or four levers and is made in 36 differs. Keys are numbered and usually different keys are required for locks fitted in the same house. It follows, therefore, that when the same type of lock is used throughout an estate the key that fits one of the external door locks of a particular house may be in the possession of a number of unauthorised individuals.

The ineffectiveness of the ordinary mortice lock with up to four levers is further demonstrated by the fact that all makes can be opened by only eight master keys, reputed to be obtainable from fences at £50 a set*.

Cylinder rim night latches are made with many more differs than the

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* Related by Mr. A.S. McAinsh, Area Representative, Chubb and Sons Lock and Safe Co Ltd., 18-19 Lionel Street, Birmingham. March 1967.

mortice locks referred to above but they can often be opened after breaking an adjacent pane of glass, alternatively the cylinder can be drilled out. Sometimes the cylinder can be rotated and sometimes the latch can be slipped in with a strip of celluloid.

Windows with ordinary fasteners and stays are usually easily opened even without breaking the glass. It is, however, unusual for an intruder who cannot open a window to enter by passing through a broken pane.

Insurance companies have no specific requirements with regard to security of houses, partly because of the lack of sufficient inspectors and, perhaps, partly because a general ungrading of security might lead to leapfrogging with housebreakers.

RECOMMENDED STANDARDS

Recommendations on locks and fastenings made by the British Insurance Association[1] are as follows:

(i) External doors. Fit a lock made by a reputable firm of lock manufacturers. On doors lockable from inside, fit not less than two bolts, at least 10 in long, or for better security, fit key operated rack bolts.

(ii) Windows. Fit window locks on easily accessible windows.

It would seem advisable to extend the Association's recommendations with regard to door locks to the requirement that they should be at least equal to B.S. 3621(2). The mortice dead lock to this standard requires a door at least 1¾ in thick which might limit its use but, of course, the strength of a lock is governed by the door and frame it is fitted to. The length of a door bolt which the Association specify would not appear to be the most important factor; usually the weakness lies in the staple, the security of which is improved threefold by having the fixing plate at right-angles to the shoot of the bolt*.

RESULTS

Generally the type of lock used did not vary from one dwelling to another. Almost all speculative dwellings had a cylinder rim night latch on the front door and a mortice lock on the back door (Table 8.1). Mortice locks were used rather more for front doors of municipal dwellings than they were for speculative dwellings. If this was done with the idea of providing greater security it was not always successful: two tenants claimed that it was possible to open their front door through the letter box. The arrangement which made this possible in one case is shown in Plate 8.1. It was said that a man turned the key from the inside by putting his hand through the letter box. In the other case the arrangement of lock and letter box was similar and the housewife said she was able to turn the key with the aid of a pair of pincers.

As shown in Table 8.1 only one thief-resistant lock to B.S. 3621

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* Related by Mr. N.P. Wheatley, Secretary, Birmingham Security Surveyors Association - 5th April, 1967.

TABLE 8.1

Type of door lock

Lock	Municipal	Speculative	Other	All
Front Door (all dwellings)				
To B.S. 3621	1			1
Other mortice	28	3	1	32
Cylinder rim night latch	62	80	7	149
Lock set		1		1
	91	84	8	183
Back Door (houses and bungalows)				
Mortice	40	70	3	113
Cylinder rim night latch	2	8		10
Rim	7	3	1	11
	49	81	4	134

was observed. The survey also showed that the cheap and ugly rim lock has not gone out of use for back doors.

The back door referred to in Tables 8.1 and 8.2 normally opened into the kitchen, in one or two dwellings it opened into the hall, in other dwellings the only back door provided was a french window or glazed door giving ingress to the living room. Many dwellings had both a door to the kitchen and a door to the living room. In the survey, when there were

TABLE 8.2

Bolts fitted to doors

Number of Bolts	Municipal	Speculative	Other	All
Front Door (all dwellings)				
One	30	24	4	58
Two	20	21		41
None	41	39	4	84
	91	84	8	183
Back Door (houses and bungalows)				
One	17	15	1	33
Two	16	19		35
None	16	47	3	66
	49	81	4	134

two doors, the kitchen door was regarded as the back door. Somewhat illogically, when there was no kitchen door the living room door was regarded as the back door. Although locks and bolts on this door were not recorded on inspection the impression gained was that all were fitted with cheap mortice locks and that only a few were fitted with bolts. The overall picture of security with regard to back doors is, therefore, not radically changed whether or not french windows are included.

Bolts on both front and back doors were almost all of the tower or barrel bolt variety and, not surprisingly less than the recommended 10 in in length. Only one had the fixing plate of the staple at right-angles to the door. Just two rack bolts were used but neither were key operated as recommended.

No dwelling was fitted with window locks.

CONCLUSION

Cheap locks, easily opened or forced, are used and as half the entrance doors have no bolts fitted either, their standard of security is extremely low. Window locks are not used, consequently a thief could easily obtain entry via ground floor windows.

CHAPTER 9

SANITATION AND REFUSE DISPOSAL

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SANITATION AND REFUSE DISPOSAL

SUMMARY

The numerous requirements of the Building Regulations with respect to drainage, sanitary conveniences and refuse disposal in housing are summarised and recommended standards for the provision of these items are stated. The provision of appliances in 183 designs of dwellings is reported upon.

INTRODUCTION

In J.C. Stobart's famous volume "The Glory that was Greece" he says "There is no truer sign of civilisation and culture than good sanitation. It goes with refined senses and orderly habits. A good drain implies as much as a beautiful statue". The Minoan civilisation of which he speaks had a standard of cleanliness that the world did not reach again until the great sanitary movement of the late nineteenth century. In this country the Public Health Acts of that time were enacted largely to promote good sanitation. They set standards which have been raised by further legislation up to the 1965 Building Regulations.

STATUTORY REQUIREMENTS

Under the Public Health Act 1936 Section 43, "sufficient and satisfactory closet accommodation" must be provided for new buildings.

Section 37 of the same Act requires that satisfactory provision must be made for drainage of a building. Drainage is defined as including the conveyance by means of a sink and any other necessary appliance, of refuse water and the conveyance of rain water from roofs. The Act of 1961 stipulates that each separate dwelling must be provided with a bathroom containing either a fixed bath or a shower.

To comply with Section 55 of the Public Health Act 1936, satisfactory means of access from a house to the street for the purpose of the removal of refuse and faecal matter must be provided.

The Building Regulations 1965

The regulations applicable to housing are summarised below:

Soil pipes, waste pipes and ventilating pipes. (Regulations N4, N5, N7)

Soil pipes, waste pipes or ventilating pipes must:

(i) be of adequate size, strength and durability,

(ii) have joints that remain airtight, do not cause electrolytic corrosion due to the association of dissimilar materials, and do not form any obstruction in the interior of the pipe,

(iii) have bends (where necessary) with the largest practicable radius of curvature,

(iv) be adequately supported, without restraining thermal movement, by fittings which are securely attached to the building,

(v) be capable of withstanding a smoke or air test for a minimum period of 3 minutes at a pressure equivalent to a head of not less than $1\frac{1}{2}$ in of water,

(vi) be reasonably accessible for maintenance and repair throughout their length,

(vii) have means of access to permit internal cleansing.

Soil and waste appliances or the pipes serving them must have a trap with a water seal which will not be destroyed under working conditions. The pipes must be placed outside the building, except that wastes from ground floor appliances may discharge over a gulley, but below the grating, and in such a manner as will not cause dampness within the building.

The topmost end of the ventilation pipe must be fitted with a durable cage, be high enough and so positioned as not to transmit foul air in a manner as to become prejudicial to health or a nuisance.

Overflow pipes (Regulation N6)

An overflow pipe may discharge into a waste pipe if disconnected from the drainage system by the trap, otherwise, it must discharge so that it does not cause dampness or damage in the building.

Rainwater Gutters and Pipes (Regulations N8, N9)

Gutters and pipes must be of adequate size, strength and durability, be adequately supported and so arranged as not to cause dampness or damage. Gutters must be jointed as to remain water-tight and fitted with outlets to drain the whole length of the gutter. Requirements for rainwater pipes within a building are the same as those for soil and waste pipes. Unless provision is made in the sewage for rainwater as well as soil and waste water, rainwater pipes must not discharge into or connect with a soil or waste pipe.

Drains and private sewers (Regulations N10-17)

Sufficient strength and durability, and watertight joints are required. Also, drains and private sewers must be in straight lines between points where changes in direction or gradient occur, be self-cleansing and efficiently carry away the maximum volume of matter which may be discharged into them. The minimum internal diameter is 4" for the conveyance of soil water and 3" in other cases.

Where a drainage system passes through a building it must be adequately supported and reasonably accessible for maintenance and repair.

Drains and private sewers must be capable of withstanding a suitable test for watertightness, after backfilling.

Means of access, as necessary for inspection and cleansing are required, and the regulations give maximum distances for the siting of inspection chambers together with details of their construction.

Traps must be used at inlets to drains other than junctions between a drain and soil pipe, wastepipe or ventilating pipe. Inlets to a drain used for surface water only are exempt from this requirement.

Where drains are constructed close to a building precautions must be taken to ensure that the stability of the structure is not impaired. Special precautions must also be taken when drains pass through walls or under walls or other part of a building.

Junctions must be made obliquely in the direction of the flow. A connection between drain and sewer must be made so that the connection will remain watertight and otherwise satisfactory under all working conditions.

The Regulations also contain particulars of the requirements of cesspools, septic tanks and similar structures.

Sanitary conveniences (Regulations P1-4)

Waterclosets must have a smooth and readily cleansed non-absorbent surface and discharge through a trap. The flushing apparatus must be capable of securing the effective cleansing of the receptacle.

The room containing the watercloset must not open on to a habitable room other than a bedroom or onto a kitchen. If the accommodation for the watercloset does open on to a bedroom, there must also be other means of entrance, unless an additional watercloset is provided for use with the house.

The requirement of earthclosets are also covered.

Ventilation of sanitary accommodation is dealt with in Chapter 13.

Refuse disposal (Regulations J1-4)

The regulations are concerned with standards of fire prevention, ventilation, access for cleaning, and safety in use of refuse storage container chambers, refuse chute shafts and pipes, and refuse hoppers.

The chambers must be built as fire-resisting compartments, be impervious to moisture and have a floor which falls towards a trapped gulley. Only a flush door having ½ hour fire-resistance situated in an external wall may be used for removal and replacement of the containers. Where delivery is by hopper only, the chamber must be ventilated in a manner which will not be prejudicial to health or a nuisance.

Refuse chutes must be constructed so that if refuse in them should catch fire they will prevent ignition of any part of the building. Their inner surfaces must be impervious to moisture, they must be circular in cross-section with an internal diameter of not less than 15", have adequate means of access for inspection and cleaning, be ventilated to the external air and fitted at their lower end with a shutter capable of closing the outlet.

Ventilation pipes or shafts should prevent spread of fire, be not less than 28" in cross-sectional area, have outlets protected against the entry of rain and not transmit foul air in such a way as to become prejudicial to health or a nuisance.

Hoppers for chutes leading to refuse storage container chambers must be situated in a well ventilated place, but not within a dwelling, be of non-combustible material, efficiently discharge refuse, be incapable of remaining in any position other than open or closed and prevent, as far as possible, the emission of dirt or foul air. When the hopper is used in conjunction with a refuse chute it must not project into the chute.

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RECOMMENDED STANDARDS

The principal recommendations with regard to sanitation are to be found in Part H of CP3: Chapter VII: 1950[1]. Under the heading of "General Recommendations" appears the following:

"A sanitation system should be reliable; it should function at all times in all seasons, and it should be designed with due regard to the health, comfort and convenience of its users."

Further recommendations with regard to drainage systems that will safeguard the health of their users and ensure reliability are as follows:

(i) rapid and efficient removal of waste matter without leakage;

(ii) prevention of access of foul gases to the building and provision for their escape from the system;

(iii) adequate and easy access for clearing obstructions;

(iv) protection by siting and insulation against extremes of temperature;

(v) prevention of undue external or internal corrosion and erosion, by choice and protection of materials of construction;

(vi) avoidance of air-locks, siphonage, proneness to obstruction, deposit and damage.

With regard to sanitary fitments CP3 recommends that "Fitments should be impervious, quiet in operation, easy to clean and maintain, and of a convenient size, shape and height. They should provide for the removal of contents quickly and completely, overflows should be adequate to deal with maximum inflow. Wastes and overflows should be screened against the entry of anything likely to cause obstruction".

Provision of sanitary appliances

As a minimum provision CP3 recommends that in every house or flat there should be a bath, a lavatory basin, a W.C. and a sink. In addition it states that a second W.C. and a laundry sink are desirable. Further recommendations are that the bath and W.C. should be separately accommodated if only one W.C. is provided and that for houses and flats with more than three bedrooms, the provisions will need to be appropriately increased. Similar recommendations are made in CP305: 1952: Sanitary appliances(2).

The Parker-Morris report states that in two or three-storey houses, a second W.C., one on the entrance floor, is preferred whatever the size of family.

As the desirable is not always possible a minimum satisfactory scale of provision is given. It is as follows:

3 person families	1 W.C. which may be combined with the bathroom
4 person families and 5 person families in one-level dwellings	1 W.C. separate from bathroom
5 person and larger families in 2 or 3 storey houses or in two-level maisonettes 6 person and larger families in one-level dwellings	1 W.C. combined with bathroom and 1 W.C. separate

The report further recommends that except where a W.C. adjoins a bathroom, a wash basin should be provided in the compartment. The reason for this is given as the fact that the major cause of the spread of gastro-intestinal infection is lack of adequate hand-washing facilities and that without such facilities it is impossible to train children in the importance of hand-washing. In allowing that the washbasin may be in a separate room from the W.C. the report not only ignores the habits of children but overlooks the fact that with family use the bathroom will frequently be occupied when its hand-washing facilities are required.

The Council of British Ceramic Sanitaryware Manufacturers, say that a survey they carried out in 1965-6[3], in which opinions were obtained from branches of three Women's Organisations in Great Britain, showed that there appeared to be a demand for the following sanitary provision:

(i) more bathroom space,

(ii) a separate W.C. in addition to one which may be in the bathroom,

(iii) the separate W.C. to be located in a cloakroom with its own washbasin (downstairs in a house),

(iv) a washbasin in at least one bedroom of the house,

(v) a bidet,

(vi) metal and ceramic kitchen sinks.

Refuse disposal

In giving evidence to the Parker-Morris Committee, the Institution of Municipal Engineers stated "Whilst every effort is made by those responsible for refuse collection, the present unsavoury and unsanitary combination of dustbin and dustcart is not in line with 20th century progress in other fields". The Committee felt that water borne systems, or dwelling or site incineration facilities appeared to offer the major prospects for progress.

General recommendations given in CP3; Chapter VII: 1950: Part L are as follows:

"Storage should be provided for refuse which will require manual removal from buildings, and should be arranged so as to avoid undue carrying of refuse and its conveyance through buildings. Receptacles should be sited so that any nuisance during storage, emptying or removal is reduced to a minimum. The storage capacity required will be governed by the interval between clearances, and may be influenced by the possibility of burning part of the refuse on the premises."

"All receptacles should be constructed so that they can be easily cleaned and should be of impermeable and fire-resistant material. They should have closely fitting covers and be watertight, and be proof against flies, rodents and domestic animals."

The volume of refuse to be expected, per person housed, per week is suggested as 1 ft^3 in CP306[(4)]. B.R.S. Digest 40 (second series)[(5)] confirms this figure which was obtained from a user study. For dustbin and ~~commercial~~ communal container systems an average disposal capacity of 3 ft^3 per dwelling is considered adequate but it is pointed out that for dwellings with chutes a weekly disposal capacity of up to 5 ft^3 would be desirable. The increased capacity appears to be necessary largely because tenants cannot observe the placing and volume of refuse in the container.

The study of users showed that about 40% of tenants deposited refuse after dark, the proportion being higher in blocks of flats with communal containers or chutes and lower in those with dustbins. This shows the need for good artificial lighting of disposal points and for planning and construction to reduce noise from disposal systems.

PREVIOUS WORK

User studies by the Building Research Station have determined habits of local authority tenants in using sanitary appliances and obtained opinions on the desirability of additional appliances. This work appears to be unpublished outside the review of user studies by Hole and Attenburrow published in 1966[6] but it was probably available to the Parker-Morris Committee when they formulated their recommendations. Other studies of user experience, this time in connection with refuse disposal in flats, made by the Building Research Station were used when compiling CP 306 (1960) and have been referred to previously in this chapter.

The Council of British Ceramic Sanitaryware Manufacturers (1967)[7] sent questionnaires to local authorities and private house-builders in an attempt to determine the standard of provision of sanitary appliances in three-bedroom houses. Of those who replied, 64% of local authorities and 70% of private builders were specifying W.C.'s separate from bathrooms. Two W.C.'s were then being specified by 45% of local authorities and 23% of builders.

RESULTS

The requirements of the Building Regulations were assumed to be met in the buildings examined. Some cases where soil pipes were not up to standard have been described in Chapter 3, as also has trouble experienced with surface water. As elsewhere in this work the examination covered different designs. So far as sanitation was concerned the examination was limited to the provision of sanitary appliances.

As shown in Table 9.1 a higher proportion of municipal dwellings than speculative had W.C.'s separate from the bathroom: 30% compared with 12%. The difference was not maintained when it came to the provision of a second W.C. (Table 9.2) but it is to be expected that implementation of Parker-Morris recommendations will in future give municipal dwellings a distinct advantage in this respect also. Two speculative dwellings had vanitory units in the bathroom instead of a washbasin and another two had a W.C., shower unit and washbasin adjacent to the first bedroom. Five speculative dwellings had shower fittings to be used in connection with the bath. No dwelling of any kind was provided with a bidet.

Refuse disposal was by way of a dustbin in most cases, multi-storey flats and a few others had refuse chutes. Occupiers were not asked about refuse disposal but there were complaints about it in two blocks of flats. In one, the tenant concerned said that the chutes were always getting blocked and that they smelled, in the other block which did not have a resident caretaker the tenant complained about the mess around the door of the chute; when this was inspected it was found to be in a deplorable state.

TABLE 9.1

Provision of W.C.'s in all types of dwelling

Class of dwelling	W.C. in bathroom	First or only W.C. separate from bathroom		Total
		With washbasin	Without washbasin	
Municipal	64	2	25	91
Speculative	75	1	8	84
Other	5	.	3	8
	144	3	36	183

TABLE 9.2

Provision of second W.C. in two-storey houses and two-level maisonettes

Class of dwelling	Number of dwellings examined	W.C. with washbasin	W.C. without washbasin
Municipal	45	5	3
Speculative[(a)]	74	6	5
Other	4	1	1
	123	12	9

(a) In addition two houses had a third W.C.

In spite of the widespread use of washing machines no special plumbing was provided for them in any dwelling except that three speculative dwellings had utility rooms.

CONCLUSIONS

Trouble with soil pipes, although not extensive, suggests that now these are required to be installed within dwellings, closer inspection or tests are necessary. In other respects the Building Regulations appeared adequately to cover the disposal of waste and soil.

Although separate W.C.'s are being provided any advantage this may have is generally offset by the lack of washing facilities in the compartment. Few dwellings have more than the minimum of washing facilities. Standards could be raised by the provision of washbasins in all W.C. compartments, showers, bidets and special provisions for washing clothes.

There is no sign of any effort to improve methods of refuse disposal.

CHAPTER 10

FACILITIES FOR COMMUNICATIONS

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FACILITIES FOR COMMUNICATIONS

SUMMARY

The need is seen for facilities for the reception of radio and television broadcasts and for the installation of telephones in dwellings. The way this need has been met in 182 dwellings of different design is described.

INTRODUCTION

Now that television is regarded as part of every home and an ever increasing number of homes have a telephone, it would seem desirable that provision for radio and television reception is made when the building is constructed and that at least a lead-in tube is provided for a telephone.

RECOMMENDED STANDARDS

The Parker Morris Committee drew the attention of local authorities and other large property owners to the importance for appearance of estates that they should take every opportunity to mitigate the nuisance of roof top aerials. They suggested that local authorities might provide master aerial installations, or where this is not possible, and where a loft or indoor aerial is really inadequate, they might consider standardising upon a suitable aerial, or requiring that tenants' aerials should be sited where they cannot be seen from the street or against the skyline.

The following recommendations with regard to radio and television aerials are taken from CP 327.201 The Reception of Sound and Television Broadcasting[1]:

"Where it is intended that aerials shall be subsequently installed by the occupier of the premises, it is desirable to provide suitable supports to which outdoor aerials can be fixed and a lead-in tube for the aerial lead-in or feeder. Alternatively, if it is desired to provide for the use of indoor aerials the occupier should be encouraged to install these in the loft or attic space wherever practicable, by making it easy for him to run a lead-in or feeder from that space to the most likely receiver position. At sites where there is a choice of position for an aerial giving equally good results then that position should be chosen in which the aerial is least conspicuous."

It is further strongly recommended that where it is either undesirable or impossible to use separate aerials for each receiver, aerial and earth sockets connected to a communal system should be provided. CP3 Chapter VII: 1950 Part G[2], states that provision may be needed for leading in telephones from underground cables or overhead lines and that concealed internal wiring and accommodation for apparatus may also be necessary.

The G.P.O. in their booklet "Facilities for Telephones in New Buildings"[3] say that a modern house is not complete unless it has provision for concealed wiring for the telephone in two or more rooms.

RESULTS

Communal television aerial systems with sockets in each dwelling were provided in all eleven multi-storey blocks of flats visited and all six blocks of maisonettes. Other municipal flats fared less well, seven out of 25 blocks had no provision at all for aerials: the other 18 had at least a cable to the roof and a suitable socket installed, most appeared to be connected to a master aerial but this was not always confirmed. The three speculative flats which were visited had no facilities but in three privately rented flats facilities were provided.

In houses and bungalows, around 70% had aerial facilities for television. So far as it is known these consisted merely of a socket and concealed cable run into the roof. The percentage of dwellings with facilities did not vary much between municipal and speculative dwellings - the actual figures were 34 out of 49 municipal and 58 out of 81 speculative with three out of four others.

Only one socket for television reception was provided in each dwelling, a few people did not use it because it was not suitably positioned, one or two had had outdoor aerials installed and the feed had been brought down the outside of the building. Two dwellings, one municipal and one speculative had radio aerials as well as television.

Facilities for the installation of a telephone were scarce in municipal dwellings. They were observed in two multi-storey blocks, others may have had vertical risers but only the two mentioned had feeds into the flats. One block of maisonettes had similar facilities but no other municipal flat had any provision at all. In six flats of other classes only one, built by a housing association, had provision for a telephone.

More telephone facilities were provided in houses and bungalows: the class of dwelling with the highest percentage was "speculative N.H.B.R.C certificated" with 40% (17 out of 42) provided with a lead-in tube. Other speculative with facilities were three out of 27 non-certificated, and five out of six showhouses. When speculative houses where it was not known whether or not a certificate was issued were included, the total was 25 out of 81. In municipal dwellings only four out of 49 houses and bungalows had a lead-in tube provided. The total count is completed by three out of four other dwellings that were provided with facilities for the installation of telephones.

CONCLUSION

To erect dwellings now-a-days without facilities for television reception is surely to erect them incomplete, and when multi-storey flats and maisonettes were excluded, nearly 30% of designs came into this category.

Whether the provision of telephone facilities is economically justified is perhaps more difficult to determine particularly in municipal dwellings but when it is considered that dwellings are built to last for at least 60 years it would appear reasonable to make the minimum provision to each dwelling in anticipation of its need in the future, if not now.

Regretably nearly all municipal dwellings and 70% of speculative dwellings are lacking in this respect.

Surveyors ladder
Camera, tripod and exposure meter.
Surveyors lath
Level
Nife lamp
Sketch pad and check list
Sunlight indicator
Anemometer
Photoflood lamps and reflector
Daylight factor meter
Street guide and maps.

Plate 1.1 Equipment carried on survey

Plate 2.1 Cracking above ground floor window (Note the poor finish of the lintel)

Plate 7.1 Wide gap in balustrade is dangerous to children

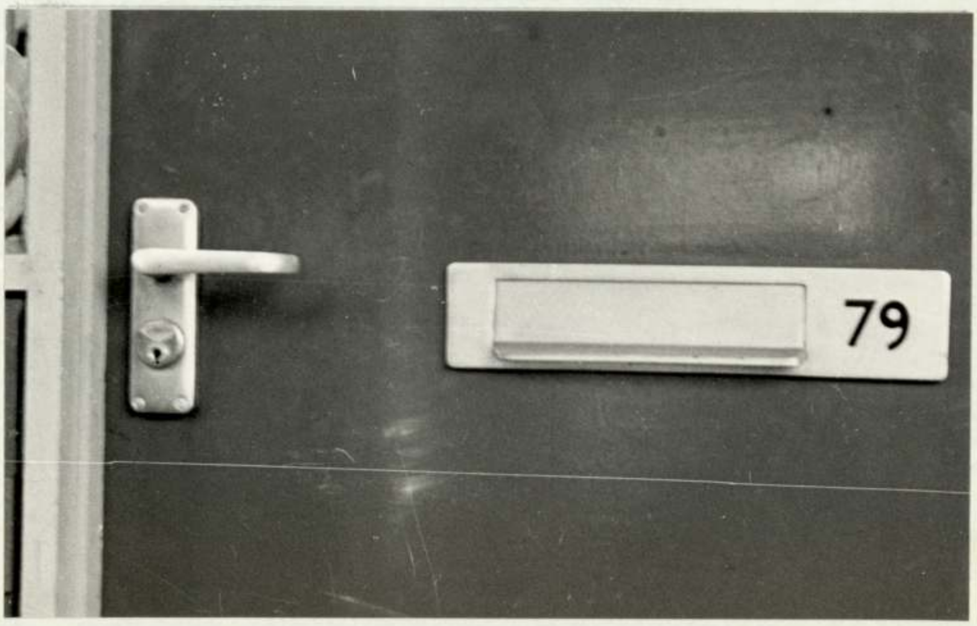


Plate 8.1 Position of letter box aids illegal entry

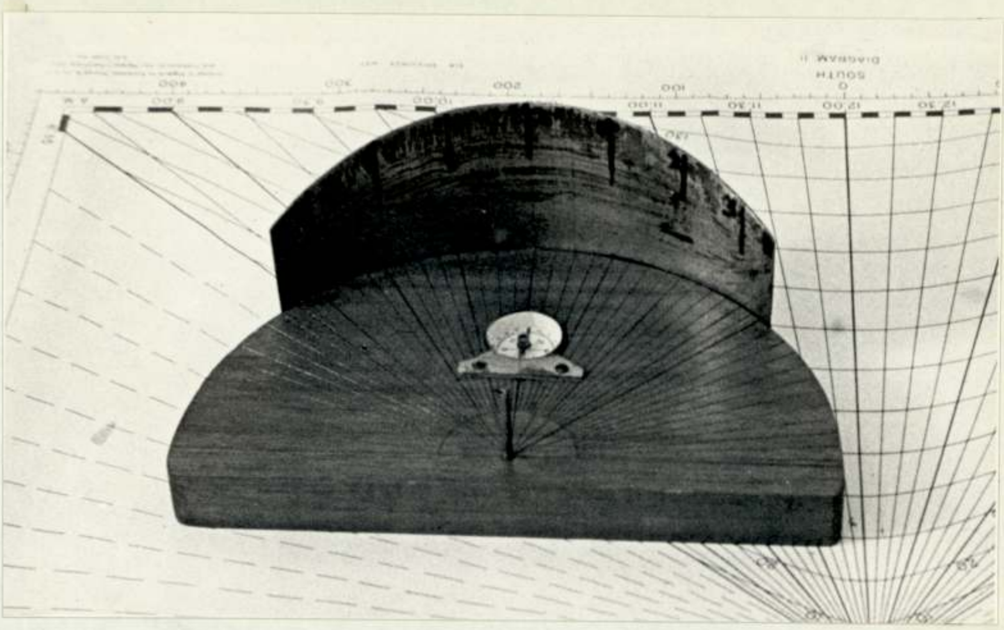


Plate 15.1 Specially made sunlight indicator

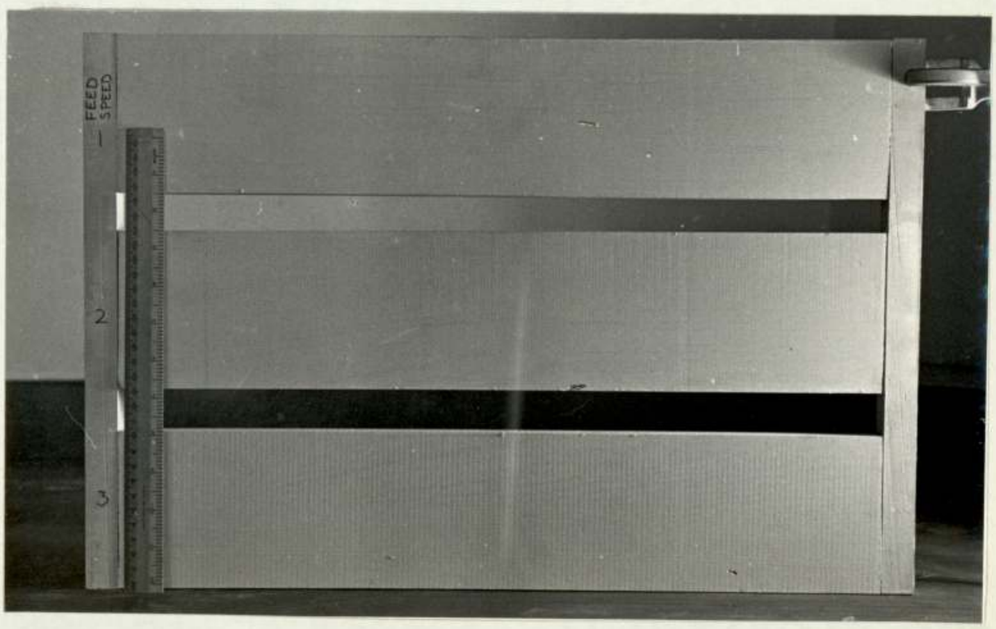


Plate 18.1 Cutter marks on softwood which has been primed and painted with flat paint. Feed speed (1) 16 marks to 1 in, (2) 10 to 1 in, (3) 7 to 1 in.

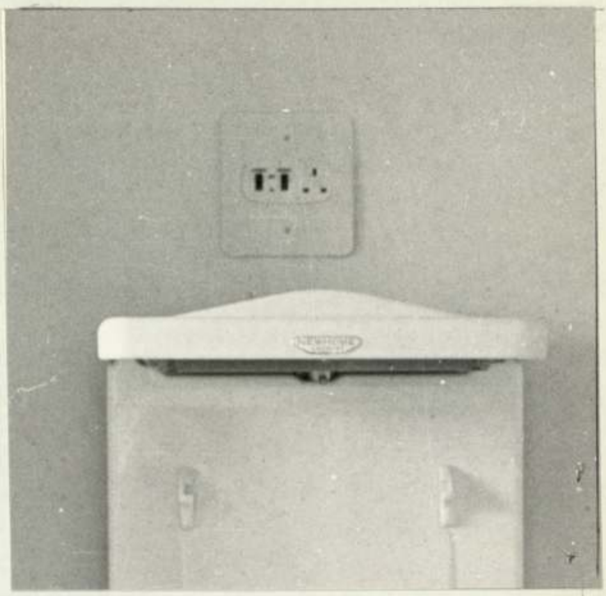


Plate 16.1 Badly positioned socket outlets. Cookers also badly positioned (top left) by doorway, (bottom) in corner of room.

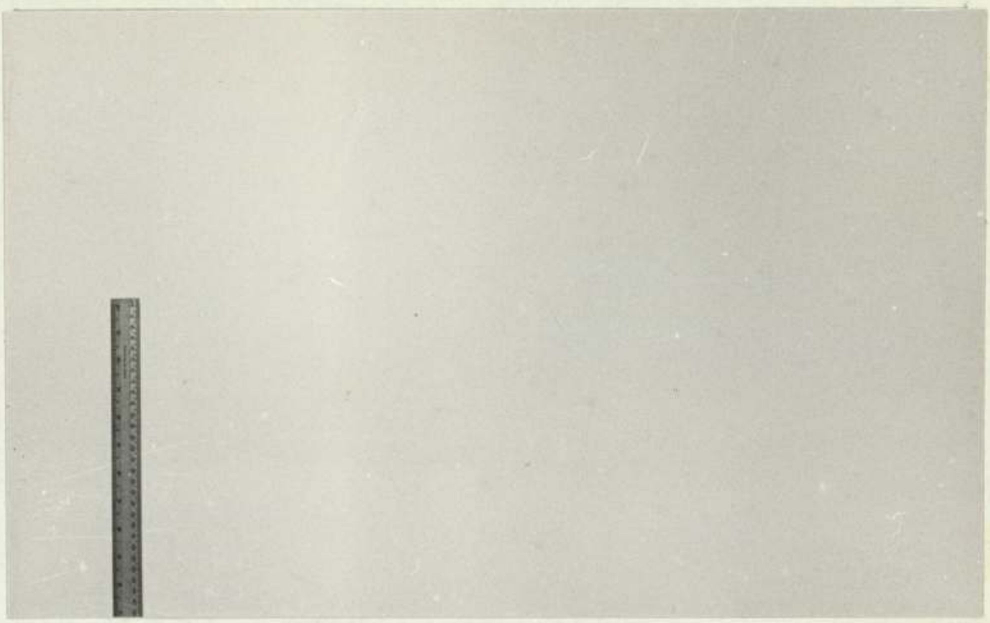
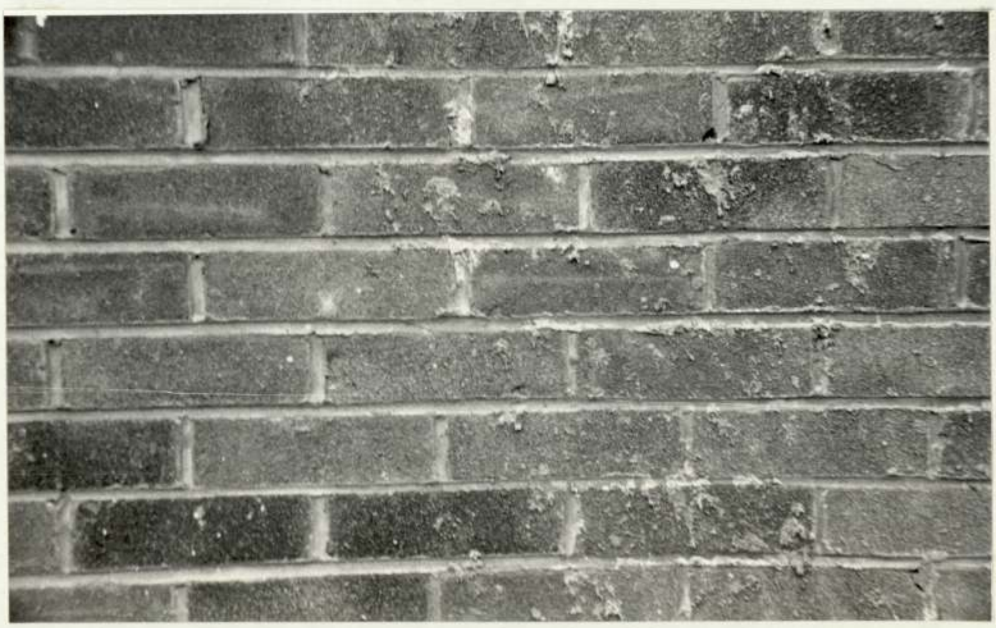


Plate 18.2 Plastered and flat painted surface with frontal lighting

Plate 18.3 Same surface as above with lighting from side.

Plate 18.4 Lead slate not dressed down over tiles



Pla te 18.5 Mortar splashes on faced brickwork

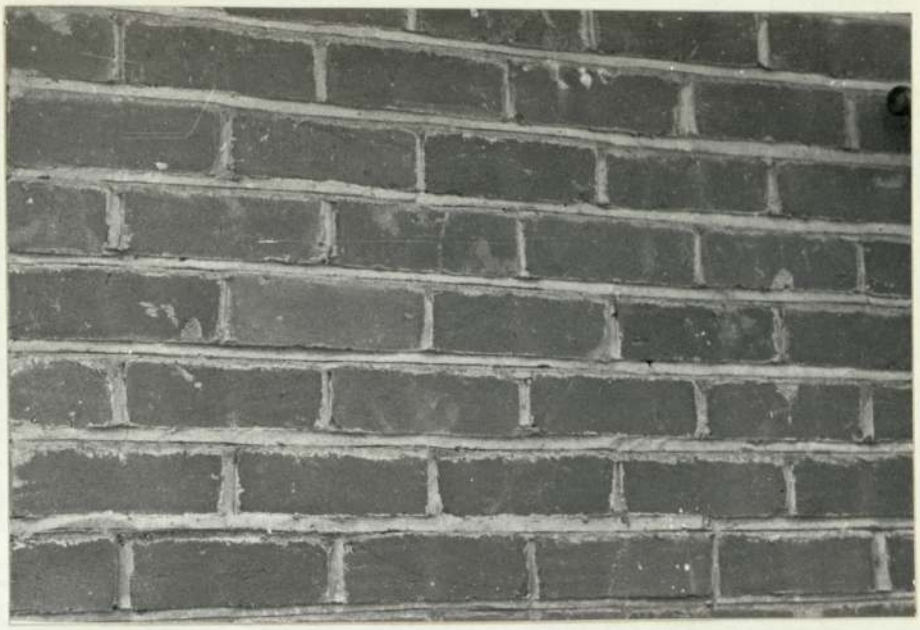


Plate 18.6 Example of poor workmanship in wall

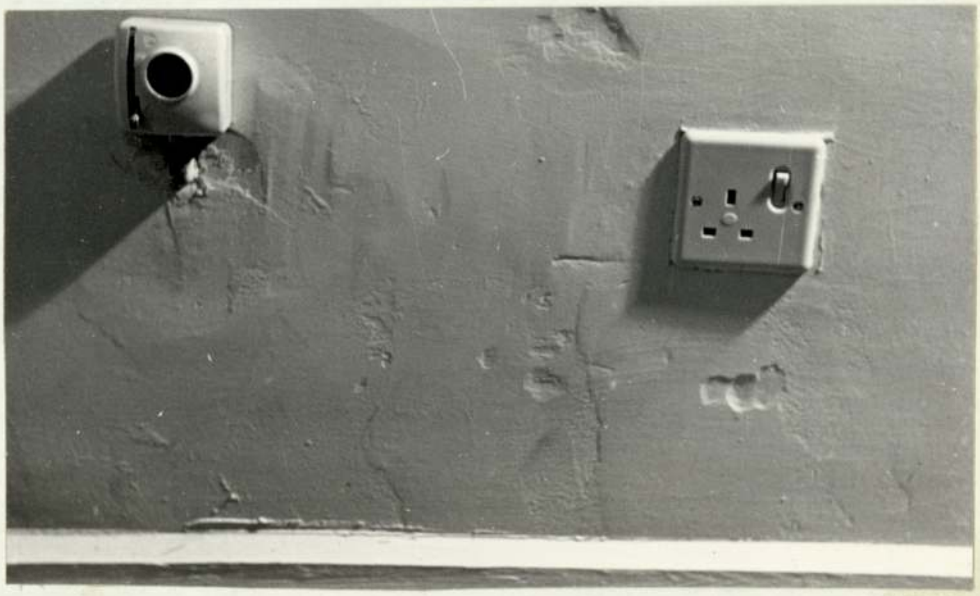


Plate 18.7 A collection of defects in plasterwork

Plate 18.8 Unsightly joints between partitions of brickwork and plasterboa rd.

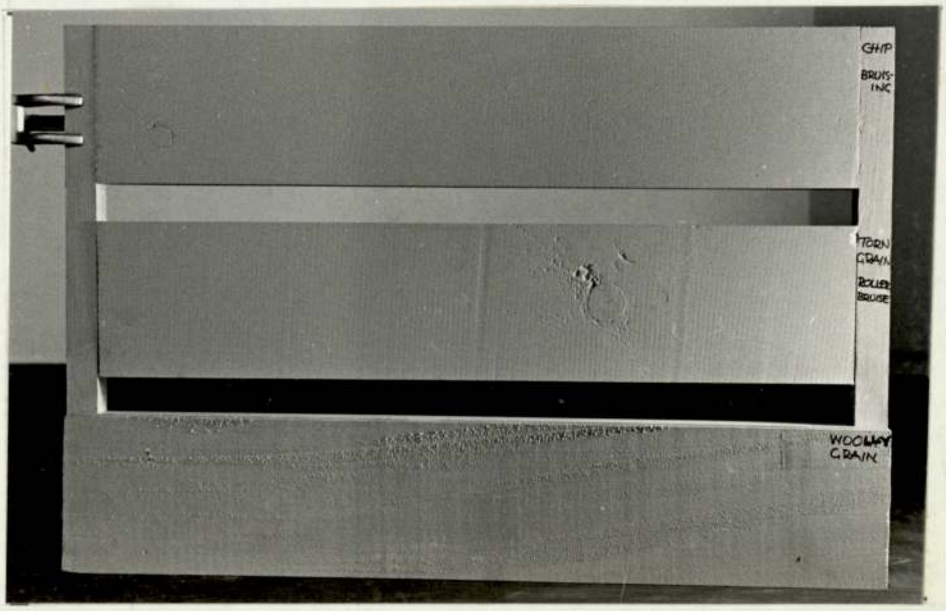


Plate 18.9 Common defects in wood finish. Chip bruising (top) Torn grain and roller bruises (centre). Woolly grain (bottom).

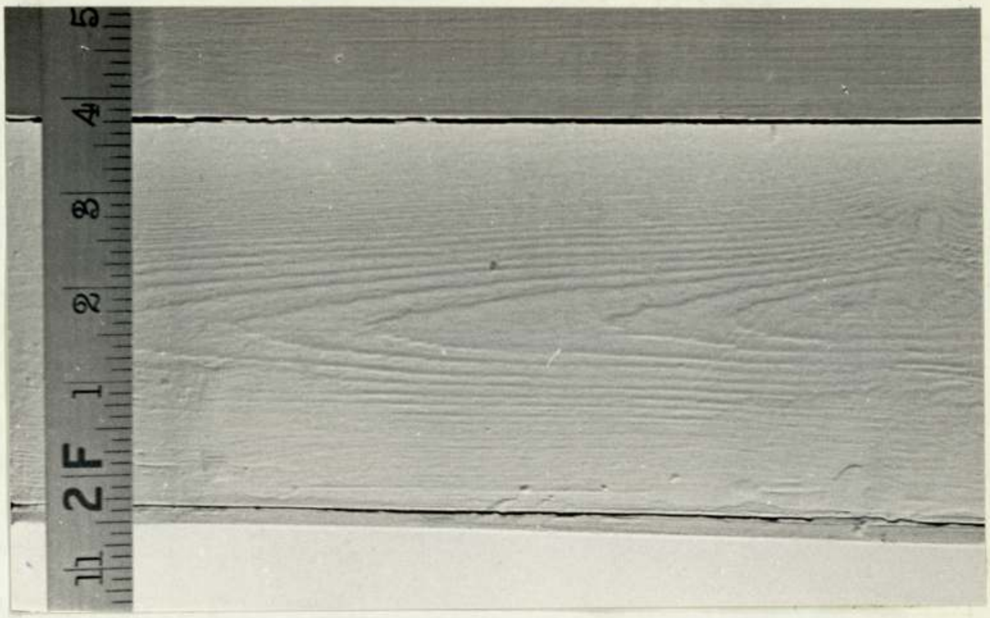


Plate 18.10 Raised grain in softwood

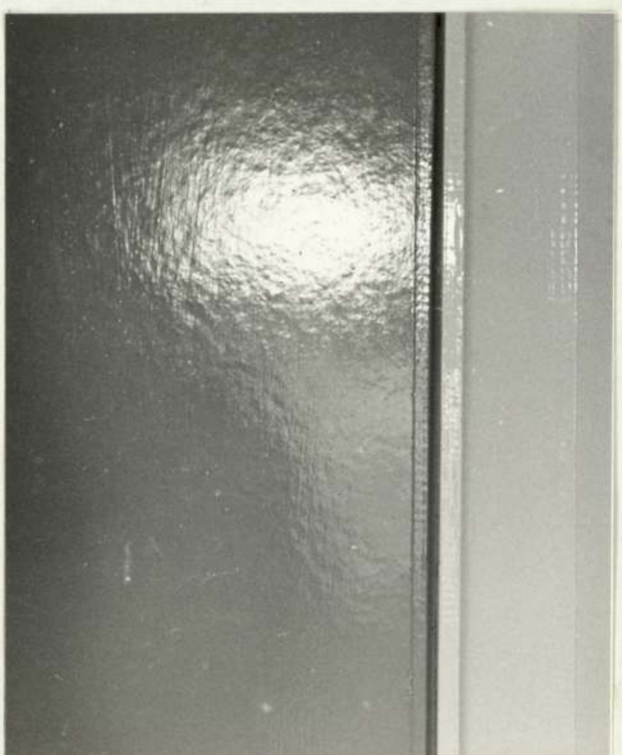


Plate 18.11 Mottled finish of hardboard as seen on flush door.

P A R T   2

P E R F O R M A N C E

CHAPTER 11

THERMAL INSULATION

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T H E R M A L   I N S U L A T I O N

SUMMARY

From the data obtained in a survey of 311 dwellings of different design, parameters characterising the thermal insulation of average dwellings of different types and with different forms of construction are evolved. The observed insulation of the elements of construction together with the insulation of the dwellings as a whole is recorded. Finally the observed insulation of each dwelling is compared with the insulation it would have if the construction was of a standardised form.

INTRODUCTION

In Tudor times house construction comprising a timber frame, wattle and daub cladding enclosing a cavity, and a thatched roof must have provided good thermal insulation. Thereafter construction in brick and tile became the norm and the thermal insulation of British homes became notoriously low. The poor insulating qualities of burnt-clay materials coupled with a temperate climate and cheap fuel established a disregard for heat conservation which has persisted until today despite the demand for increased comfort, and a real rise in fuel costs.

Of late there has been some improvement in wall and roof insulation in house construction. First the all-brick cavity wall came into general use, then clinker and lightweight concrete blocks became acceptable for the inner leaf. Close upon the increasing use of the cavity wall came an improvement in roof insulation aided by the development of materials such as glasswool, vermiculite, and cellular polystyrene. Unfortunately, some of the improvement is now countered by the additional heat loss through the larger window area of modern homes often linked with the loss caused by the use, once again, of suspended timber ground floors. Such floors all but disappeared under timber licencing in the 1940's and 1950's, and although it is now clear that if ventilation below joist and board construction is adequate, insulation is sub-standard, the re-introduction of these floors has not been accompanied by an improvement in insulating standard.

Boarded, tile-hung or otherwise finished 'feature' panels are currently commonplace in housing. These panels can easily be brought to a higher standard of insulation than brick or concrete walls by the incorporation of insulating material in the construction if it is hollow or by the use of insulating blocks for the backing wall if the construction is solid.

In non-traditional construction, insulating material is generally introduced to improve the natural insulating properties of materials used for the fabric.

STATUTORY REQUIREMENTS

The Building Regulations 1965

The requirements in respect of thermal insulation under Regulations

F3, F4, and F5 are given in Table 11.1. The U values were unchanged from those of the former Model Byelaws, 1959 amendment. Despite the requirements for floors, conventional, timber suspended ground floor construction is permitted.

TABLE 11.1

Maximum permitted U values for dwellings

Element	U values Btu/ft^2h degF	U values W/m^2degC
Roof and ceiling	0.25	1.42
External wall	0.30	1.70
Floor permanently exposed to the external air	0.25	1.42

The requirements are not very stringent and being exclusive of openings they may not be very effective in the case of walls. A definition of an opening is given in the Regulations, it 'includes any doorway, window, skylight, hinged panel, louvre or ventilator in the structure of an external wall or roof, and also any part of a wall which is constructed of glass blocks'. In Scotland openings are taken into account and the Building Standards (Scotland) Regulations 1963 while requiring a U value of 0.30 Btu/ft^2h degF (1.70 W/m^2 degC) for walls, specify that the overall U value inclusive of glazing (single glazing 1.00 (5.68)*, double glazing 0.50 (2.84) is not to be more than 0.42 (2.38).

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* When units are not specified, U values are given in Btu/ft^2h degF with equivalent W/m^2 degC in brackets.

To prevent a wall which consists largely of glazing being brought within the Scottish Regulations by a surround of small area highly insulated, it is required that "... where the average thermal transmittance coefficient over all the windows and other glazed openings in the external walls of the house ... is 0.75 or more, the average thermal transmittance coefficient over the remaining parts of the walls shall be taken to be not less than 0.20". Similarly, when the figure for the windows is less than 0.75 the walls shall be taken to be not less than 1.00.

RECOMMENDED STANDARDS

Recommendations in respect of maximum U values were made in two Post War Building Studies, No. 1(1) in 1944 and No. 19(2) in 1945 and also in C.P.3(3) in 1949; they are shown in Table 2.

TABLE 11.2

Recommended maximum U values for dwellings

Element	U values	
	P.W.B.S. No.1 & No.19	C.P.3
Roof and ceiling	0.20 (1.14)	0.20
External wall		
(a) for any part	0.20	0.20
(b) for living room	0.15 (0.85)	
Ground floor	0.20	0.20

The recommendations made in Post War Building Studies No. 1 were for dwellings with full control over heat output, for dwellings without full control a maximum value of 0.30 (1.70) was given. This is greater than the maximum now permitted by the Building Regulations[4] for floors and roofs, even so, the recommended values for walls quoted in Table 2 are lower than what is commonly reached today, likewise, the value for ground floors is considerably exceeded by suspended timber floors. The value for roof and ceiling given in C.P.3 is only intended to apply when the top floor is heated.

As in the Building Regulations the effect of openings is ignored in all these recommendations. Since a certain thermal insulation is necessary for reasons of health as well as comfort and the need to conserve fuel resources it would appear to be more satisfactory if overall U values for walls were recommended. This concept can be extended to a recommended 'Shell' U value, which is an overall U value for all the enclosing surfaces of a dwelling. A unit characterising even more strongly the thermal insulating value of a building as a whole is expressed in terms of the overall heat loss per ft^2 (m^2) of floor. A similar expression is heat loss per ft^3 (m^3) of space enclosed by the building. The first of these units is used in the U.S.A., the second in France.

In the U.S.A. minimum property standards established by the Federal Housing Administration[5] to encourage improvement in housing standards and conditions require that the total calculated heat loss of the 'living unit' shall not exceed 50 Btu/ft^2 [per hour] of the total floor area of the space to be heated. The inside design temperature is not to be less than 70°F. The outside design temperature is to be that established for the location involved. If this were applied to England and Wales using the usual design temperature of 30°F for outside air, the maximum heat loss per degF in terms of floor area would be $\frac{50 \text{ Btu}}{70 - 30^{\circ}\text{F}}$ = 1.25 Btu/h degF ft^2 of floor (7.10 W/degC m^2 of floor): a figure easily met by conventional British construction although requiring more insulation in most parts of the U.S.A. where the outside design temperature is lower.

In France the 'space index of thermal insulation'[(6)] is used. It is denoted by G and represents the heat loss per hour in kcal/m^3 of the internal volume of the building for 1 degC temperature difference between inside and outside air. It includes ventilation heat losses on the assumption that one full change of air takes place every hour except that in large rooms with windows facing in more than one direction the value is increased by 30%.

Maximum allowable values of G applicable to multi-storey blocks of flats in France are as shown in Table 11.3. Since 0.3 kcal are needed to increase the temperature of 1 m^3 of air by 1 degC, ventilation heat losses, at 1 m^3/h are responsible for 0.3 in the index figures given in kcal/h degC m^3 (0.02 when converted to Btu/h degF ft^3).

TABLE 11.3

Maximum space indices of thermal insulation
of multi-storey blocks of flats in France

Zone	Space Index	
	kcal/h degC m^3	Btu/h degF ft^3
Eastern area and mountainous regions	1.1	0.068
Mediterranean area	1.5	0.094
Elsewhere	1.3	0.081

PREVIOUS WORK

In general, work on thermal insulation has been concerned with heat transfer in different materials and different forms of construction and not with buildings as a whole. In particular, little work has been done on standards of insulation in housing.

The results of research into heat transfer in materials have enabled the thermal conductivities of many building materials to be given in publications such as the Institution of Heating and Ventilating Engineers' Guide(7) and the Building Research Station's Thermal Insulation of Buildings (1955)(8).

The effect of moisture content on the thermal properties of building materials has been studied by Pratt (1964, 1969)(9, 10) and others. Tests carried out by the London Brick Company (1968)(11) have taken account of the effects of moisture and the external environment.

Composite and cavity wall construction have been tested in the wall laboratories of the Building Research Station (1951)[12] and the London Brick Company (1968)[11]. Heat loss through roofs has been measured in a roof laboratory at the Building Research Station (1951). Billington investigated heat loss through solid floors in contact with the ground and the results of his work have been incorporated in the I.H.V.E. Guide.

Some work by the Building Research Station (1956)[13] on average heat transmittances showed that these differed from published U values particularly in the case of pitched roofs and windows.

Weston[14] studied the plans of over 200 pre-war and post-war houses in 1951 and deduced a design equation to give the seasonal heat loss of dwellings of that era in terms of their floor area and construction.

Various investigations have been made into the economics of thermal insulation. Those of a combined research team of the Swedish firm of Rockwool AB and members of the Building Research Department of the Stockholm Institute of Technology[15] are of particular interest in relation to housing.

EXAMINATION OF DWELLINGS

For each dwelling examined overall dimensions of length and breadth, floor-to-ceiling heights, and sizes of door and window openings were obtained. Panels differing in construction from the main walling were also measured. The construction and insulation of walls, floors and roof was determined by inspection, supplemented in the case of private building by questioning owner-occupiers (who usually had seen their house built) and by asking the builder; in the case of local authority building information was obtained from the architects.

When examining a house inspection of the roof space was sufficient to show the ceiling insulation and the material used for the inner leaf of the gable wall. In the absence of further information it was assumed that the construction of the gable was typical of the remainder of the external wall construction. Reliance was placed on the information given by local authority architects (only one authority found itself unable to give information relating to construction) but with private building a more thorough examination was made as it was not known whether the builders would provide information:on the occasions when they did it was often inadequate. For instance, under the heading of 'Construction (materials and thickness) of external walls' several builders replied with '11" cavity work' or 11" cavity brickwork' when inspection had shown that the gable was built with an inner leaf of clinker blocks. In these cases it was assumed that clinker blocks had been used on all external walls.

Information on the construction of feature panels was more difficult to obtain (the question relating to this was often ignored by builders), if work was still in progress on the site it was sometimes possible to see the form of construction then employed and it could be assumed that the same had been used for the building under examination. In some cases it was necessary to make an assumption based on thickness and whether or not the panel appeared to be hollow. Any errors introduced by the assumptions made would be small and can safely be ignored.

Panels in window frames, showing as panels from outside but backed up inside with brickwork or blockwork to make them flush with the interior wall face, may or may not have had insulation incorporated in the structure, in no case was any observed. The insulating value of this type of panel was taken as being identical with that of the main wall. The area was always relatively small and any error would be negligible.

From the information obtained concerning the buildings, calculations were made to establish parameters relating to heat loss for different types of buildings and to determine the standard of thermal insulation of materials, components, elements and whole dwellings in the buildings examined.

DEFINITIONS AND DETERMINATION OF U VALUES

Thermal conductivity (k) The thermal transmission through unit area of a slab of a uniform material of unit thickness when unit difference of temperature is established between its faces (typical units: Btu in/ft^{2}h degF, W/m degC).

Thermal transmittance or overall heat transfer coefficient (U) The quantity of heat flowing in unit time through unit area of a given structure divided by the difference between the effective ambient temperature on either side of the structure (typical units: Btu/ft^{2}h degF, W/m^2 degC). The term 'effective ambient temperature' is used to indicate that the actual measured temperature may need to be corrected for factors such as atmospheric humidity, solar radiation and wind velocity before comparable results can be obtained.

U value A conventionally defined value of thermal transmittance of a structure related to design conditions.

(The above definitions are from BS.3533:1962 Glossary of terms relating to thermal insulation).

Units characterising thermal insulating values of elements and whole dwellings

Before defining these units it is necessary to define the surfaces from which heat loss is calculated when determining values of the units. The surfaces are the bounding surfaces of the residential part of the dwelling. The residential part is that part which is lived in and includes halls, landings, kitchens, bathrooms and bedrooms. In this part heating is desirable even though some of it may not contain fixed heating fitments. The term residential is used rather than habitable because of the special definition of a habitable room in the Building Regulations. Generally the only part of a dwelling which is excluded, apart from the garage of a house, is an entrance lobby where this does not form part of the main structure and is divided from it - as when the lobby is virtually a glass box built onto the front of a house.

The dimensions of the bounding surfaces are the internal dimensions except that internal partitions are ignored. In houses, the area of walling between hall and landing in the position where there is no floor between storeys is also ignored: this compensates approximately for the area of external wall occupied by partitions.

The values of the units characterising the thermal insulation of elements and dwellings are determined from the U values of the materials and constructions of which the elements and dwellings are built,they are, therefore, for unit temperature difference between indoor and outdoor ambient temperatures. Where the bounding surface of the residential part of a dwelling is not exposed to the open air but adjoins an unheated part the temperature difference of the air on either side of the surface is assumed to be less than unity. The proportionate value (ν) may be obtained from the equation

$$\nu = \frac{\Theta_u - \Theta_o}{\Theta_i - \Theta_o}$$

where

Θ_u = temperature in unheated space

Θ_i = indoor design temperature of residential part of dwelling

Θ_o = outdoor design temperature

For the estimation of temperature in the unheated space the following equation from the A.S.H.R.A.E. Guide[16] may be used:

$$\Theta_u = \frac{\Theta_i\,(A_1U_1 + A_2U_2 + A_3U_3 + \text{etc.}) + \Theta_o(A_aU_a + A_bU_b + A_cU_c + \text{etc.})}{A_1U_1 + A_2U_2 + A_3U_3 + \text{etc.} + A_aU_a + A_bU_b + A_cU_c + \text{etc.}}$$

where

A_1, A_2, A_3 etc. = areas of surface of unheated space adjacent to residential part of dwelling.

A_a, A_b, A_c etc. = areas of surface of unheated space exposed to outdoors.

U_1, U_2, U_3 etc. = U values of surfaces of A_1, A_2, A_3 etc.

U_a, U_b, U_c etc. = U values of surfaces of A_a, A_b, A_c etc.

Estimated temperatures applicable to various common situations are given in the appendix.

Where the residential part of one dwelling adjoins the residential part of another it is assumed that no heat transfer takes place.

Overall-wall U value   Conduction heat loss from bounding surfaces of the residential part of a dwelling, where those surfaces are vertical or at more than 70 degrees to the horizontal, for unit temperature difference between indoor and outdoor air, divided by the area of the surfaces. Heat loss is calculated from average U values, exposure and orientation being ignored (typical units Btu/ft^{2}h degF, W/m^2 degC). It may be expressed as:

$$U_o = \frac{A_eU_e + A_uU_u\nu + A_wU_w + A_pU_p}{A_o}$$

where

A_o = area of bounding walls

A_e = area of main external walling

A_u = area of wall adjacent to unheated spaces

A_w = area of windows and other openings

A_p = area of feature panels or panels of walling

U_o = U value of overall wall

U_e = U value of main external walling

U_u = U value of wall adjacent to unheated space

U_w = U value of window or other openings (see p. 11.25)

U_p = U value of feature panels or panels of walling

ν = (see definition on p. 11.12)

<u>Shell U value</u> Conduction heat loss from all bounding surfaces for unit temperature difference between indoor and outdoor air divided by the area of the surfaces. Heat loss is calculated from average U values (typical units: Btu/ft^{2}h degF, W/m^2 degC).

<u>Floor index of thermal insulation</u> This index is so named in this work because of the analogy with the space index of thermal insulation. It takes into account the effect on U values of orientation and exposure and also includes ventilation heat loss. The index is defined as follows:

> Conduction heat loss from all bounding surfaces of the residential part of a dwelling having regard to exposure and orientation together with ventilation heat loss (exposure and ventilation heat loss are defined below) divided by the floor area of the dwelling as measured within the bounding walls and over all partitions and other construction (typical units: Btu/h degF ft^2 of floor, W/degC m^2 of floor).

Exposure is defined in the I.H.V.E. Guide as follows:

Sheltered: Includes the first two storeys above ground of buildings in the interior of towns.

Normal: Includes the third, fourth and fifth storeys of buildings in the interior of towns.

Severe: Includes sixth and higher storeys of buildings in the interior of towns, and buildings exposed on hill sites, the coast and riverside.

Ventilation is taken to be at the rate of one air change per hour. This is felt to be a reasonable assumption although it is recognised that the rate of air change might be much greater where solid fuel open fires are utilised. Using a nominal value for all dwellings enables comparisons of their insulating qualities to be made without introducing another variable. One air change is an approximate average of the recommendations in respect of air change in dwellings made in the I.H.V.E. Guide (see Ventilation p. 13.4).

The volume on which the ventilation heat loss is calculated is that within the bounding surfaces of the residential part, no deductions are made for partitions, cupboards, etc. The quantity of heat lost with 1 ft^3 of air for 1 degF temperature difference between inside and outside air is taken as 0.02 Btu, greater accuracy is felt to be unwarrented in view of the assumptions made with respect to the rate and volume of air change.

Space index of thermal insulation The heat loss as defined above for the floor index divided by the cubic content of the space enclosed by the bounding surfaces (typical units: Btu/ft^3h degF, W/m^3 degC).

U values of elements U values of different elements were calculated from information given in the 1965 edition of the I.H.V.E. Guide supplemented by 'Thermal Insulation of Buildings' and when these sources failed, manufacturers particulars.

Roofs and ceilings Normal roof construction for houses is tiles on battens and felt with plasterboard ceiling below. To this is now added some insulating material, usually glasswool mat to comply with the thermal insulation requirements of the Building Regulations. The U value of the basic construction is not given in the I.H.V.E. Guide. Deducing it from the forms of construction quoted gives a different result from calculating it from the separate parts of the construction. The value of 0.43 is given in Thermal Insulation of Buildings and as this is approximately the mean of the values obtained from the I.H.V.E. Guide it was adopted. The U value of the roof is reduced to 0.16 when 1 in. thick glasswool insulation ($\frac{1}{k}$ = 4.00 Btu in/ft^{2}h degF) is laid over the joists. Thermal Insulation of Buildings gives 0.14 when 1 in. glasswool (bitumen bonded, $\frac{1}{k}$ as above) is draped over ceiling joists and 0.16 when it is laid between joists. In this work the U value of 0.16 (0.91) was used for basic roof construction insulated with 1 in. thick glasswool. Calculated U values of pitched roofs with other forms of insulation are given in the appendix together with U values of flat roofs encountered in the survey.

Walls House walls are usually either 11 in. thick with two 4½ in. brick skins or 10½ in. thick with an outer skin of brick and an inner skin of clinker or lightweight concrete blocks. The all-brick construction with an unventilated cavity and plaster on the inside has a U value of 0.30 (normal N.W. exposure) according to the I.H.V.E. Guide. When clinker blocks are used the U value is reduced to 0.23 assuming the k value of the blocks is 2.50 Btu in/ft^2h degF. U values claimed by various manufacturers of proprietory clinker blocks vary from 0.20 to 0.25 for $10\frac{1}{2}$ in. cavity walls when their blocks are used for the inner skin. Thermal Insulation of Buildings gives 0.22 to 0.25. The value of 0.23 (1.31) was adopted when the blocks were of unknown origin and density, otherwise manufacturers figures for conductivity were used in the calculation of U values for walling. Values obtained for these and other walls and feature panels in walls are given in the appendix.

Floors Values of thermal transmittance of solid floors were taken from Billington's tables in the I.H.V.E. Guide. An approximate value for intermediate dimensions was obtained by interpolation; for example, for a pair of semi-detached houses of about 40 ft by 25ft area measured outside the walls, the U value of a solid floor was taken as 0.12 (0.68). A terraced house would have a lower value and a detached house with area 25 ft by 25 ft a value of 0.134 (0.76).

The U value for a timber suspended ground floor ventilated by means of air-bricks on more than one side and with a covering of parquet, linoleum or rubber is given as 0.35 in the I.H.V.E. Guide. For a similar floor without a covering the value is 0.40. The lower value (0.35 Btu/ft^2h degF, 1.99 W/m^2 degC) was used in this work on the assumption that the floors were properly ventilated and that some covering would be used as the normal construction did not give a finished floor surface. It was observed that a few occupiers had not provided any covering beyond small rugs but it was clear that this was regarded as a temporary and rather unsatisfactory arrangement and that a full floor covering would be provided when it could be afforded.

Windows It is felt that confusion exists on the figure to adopt for the U value of windows. Although the I.H.V.E. Guide states that the figure 1.00 (normal N.W. exposure) is generally accepted, this is the U value of glass and it ignores the frame. The Guide does draw attention to some figures obtained from thermal conductance tests on wood and metal windows but unfortunately the information concerning the construction of the frames is quite inadequate to ascertain whether or not the figures quoted would be applicable to the types of window found in housing.

An investigation into the estimation of seasonal heat requirements in houses carried out by the Building Research Station [13] showed that allowing for frames of wooden windows and curtains the average thermal transmittance coefficient for windows with single glazing was 0.6 over the heating season. This figure cannot be used for the calculation of maximum heat loss when curtains may or may not be drawn.

To obtain a reliable figure, a U value for wooden windows with single glazing was computed from data obtained in the survey. The areas of 1450 windows in 179 dwellings of all types were found and classified in intervals of 10 ft^2 up to 70 ft with an additional area classification of 70 - 100 ft^2, Glazed doors were included and the proportion of them in any area classification noted. The frequency of each area classification is shown in Table 11.4 together with the total area of all glazed openings (windows and doors) in each classification expressed in ft^2 and as a percentage of the total area

TABLE 11.4

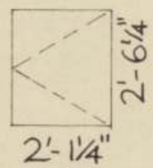
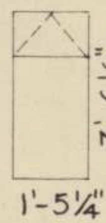
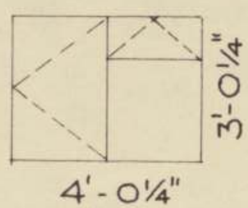
Areas of windows and glazed doors in 179 dwellings

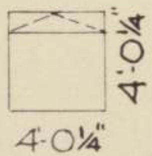
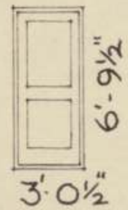
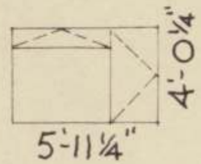
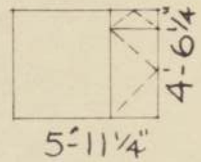
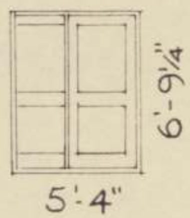
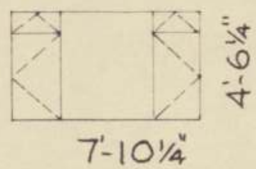
Area classification ft^2	No. of glazed openings	Area of glazed openings in each class ft^2	Percent
0 - 10	170	850	$2\frac{1}{2}$
10 - 20	489	7335	21
20 - 30	430	10750	31
30 - 40	195	6825	21
40 - 50	91	4095	12
50 - 60	42	2310	7
60 - 70	20	1300	$3\frac{1}{2}$
70 -100	13	1105	3
Total	1450	34570	

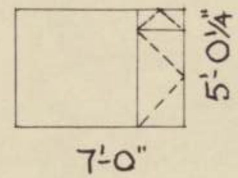
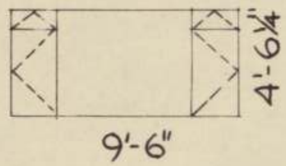
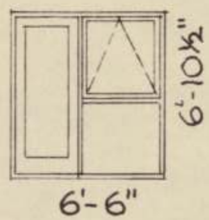
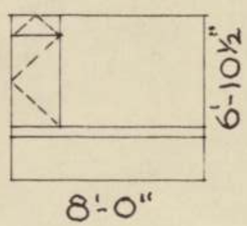
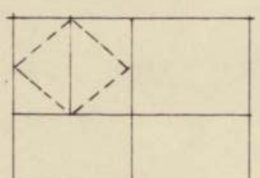
The mean area of a glazed opening was found to be 23.8 ft^2 (2.21 m^2) with the average number of glazed openings per dwelling 8.1.

Typical designs of windows and glazed doors in each class were selected from BS.644[17], architects drawings and manufacturers catalogues (17 designs in all as shown in Table 11.5). British Standard sections were assumed to be used where applicable, other sections were typical of those shown in manufacturers catalogues and observed in buildings. All

Table 11·5
Designs and U-values of windows and glazed doors

Area class'f'n	Design	Overall area	Glass area (daylight)	Frame area	Sash or door area	Overall U-value
ft^2		ft^2	ft^2	ft^2	ft^2	$Btu/ft^2 h \deg F$
0 – 10	a 	5·3	2·9	1·5	0·7	0·67
0 – 10	b 	5·0	2·8	1·8	0·3	0·66
0 – 10 10 – 20	c half-glass door	as upper half of fully-glazed door				0·64
10 – 20	d 	12·1	7·4	3·2	1·2	0·71

10 - 20	e  4'-0¼" 4'-0¼"	16·2	11·8	3·5	0·72	0·79
10 - 20 20 - 30	f  6'-9½" 3'-0½"	20·6	10·4	3·6	6·3	0·64
20 - 30	g  4'-0¼" 5'-11¼"	23·9	17·0	4·6	1·5	0·78
20 - 30	h  4'-6¼" 5'-11¼"	26·9	20·5	4·3	1·2	0·82
30 - 40	i  6'-9¼" 5'-4"	36·2	20·6	5·8	9·8	0·69
30 - 40	j  4'-6¼" 7'-10¼"	3·7	26·0	6·5	2·7	0·80

30-40	k		35·1	28·3	5·1	1·3	0·85
40-50	ℓ		42·9	32·8	6·8	2·7	0·83
40-50	m		45·0	31·2	6·7	7·0	0·77
50-60	n		55·0	43·8	9·9	1·3	0·84
60-70 70-100	o		70·0	57·9	8·7	2·2	0·86

windows were of the casement type; pivot hung wooden windows are used in housing but to a much lesser extent than casement windows. The appearances and members of the two types are not markedly different.

Assumed widths of members are shown in Fig. 11.1, thicknesses and U values are given in Table 11.6.

TABLE 11.6

Thickness and U values* of members in windows and glazed doorways

Member		Thickness in.	U value Btu/ft^2h degF
Frame:	window	$2\frac{3}{4}$	0.24
	door	$3\frac{1}{4}$	0.21
Sash		$1\frac{5}{8}$	0.35
Door		$1\frac{3}{4}$	0.33
Glass		-	1.00

* k for redwood 0.87 Btu in/ft^2h degF

The overall U value of each window was calculated using the proportionate area method:

$$U_w = \frac{A_gU_g + A_fU_f + A_sU_s}{A_w}$$

where:

A_w = area of window or doorway

A_g = area of glass

U-VALUES OF WINDOWS AND GLAZED DOORS

Dimensions used in calculations

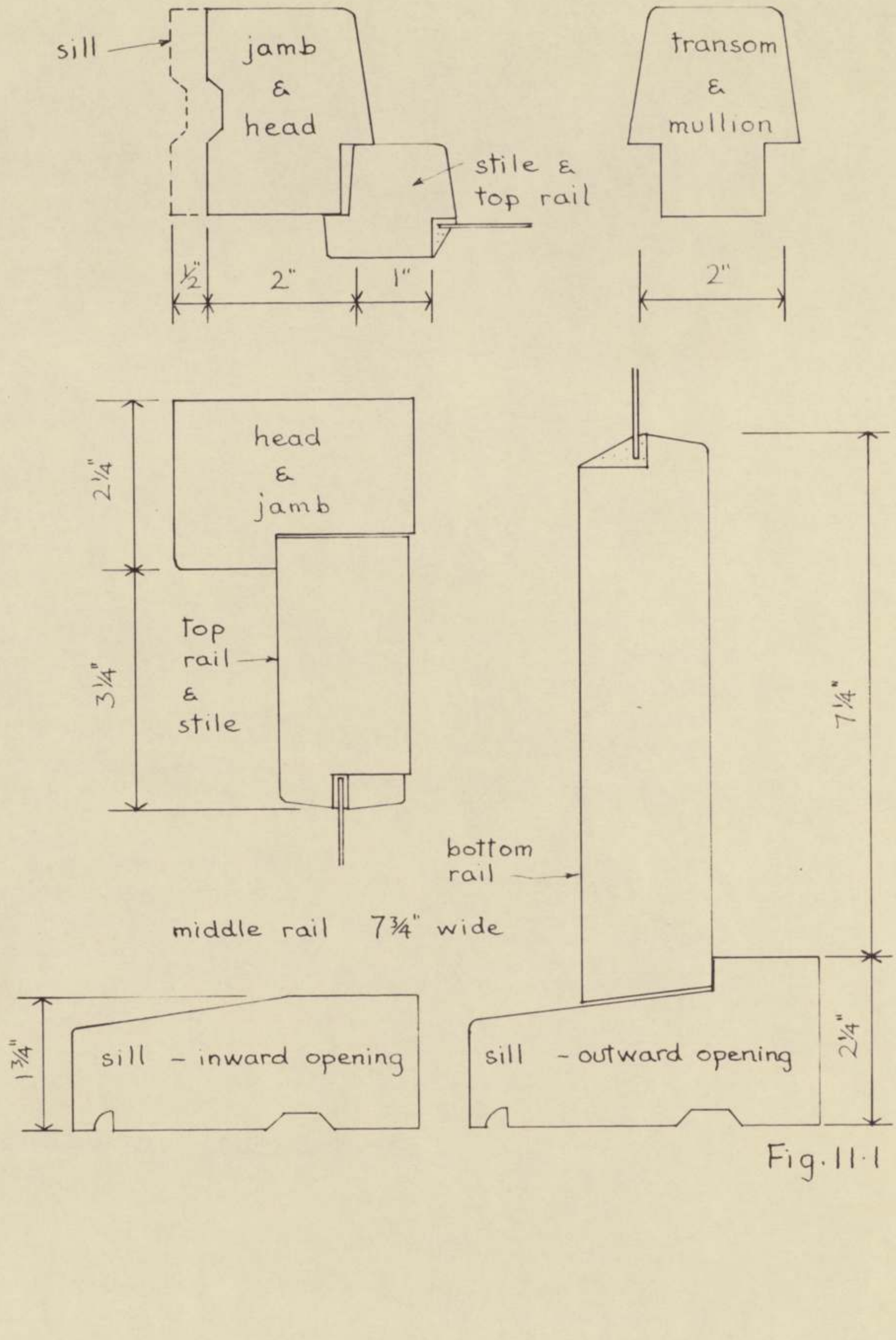


Fig. 11·1

A_f = area of frame

A_s = area of sash or door

U_w = U value of window or doorway

U_g = U value of glass

U_f = U value of frame

U_s = U value of sash or door.

The results are shown in Table 11.7 which also shows that using an estimated proportion of designs in each area classification an average U value for all glazed openings of 0.792 is obtained. This was rounded off to 0.80 (4.54) for use in heat loss calculations

Current literature seems to indicate that a U value of 1.00 (5.68) for metal windows is acceptable and this is the value adopted for both steel and aluminium windows with single glazing.

To obtain a value for metal windows in wood surrounds a window of average size (24 ft^2) was used as a basis for the calculations. The U value obtained was 0.90 (5.11).

Double glazing is rare in housing but a few examples were encountered. For wood windows a U value of 0.42 (2.38) was calculated. Just two examples of double glazing in metal windows were observed. They were glazed with a double glazing panel and a U value of 0.58 (3.29) was estimated.

Throughout this work U values and indices of thermal insulation are

TABLE 11.7

Overall U values of windows and glazed doors

Area classification ft^2	Design (as Table 11.5)	Percentage of class	O/a U value Btu/ft^2h degF	Percentage of total area	Mean U value x percent area
0 - 10	a b c	40 40 20	0.67 0.66 0.64	$2\frac{1}{2}$	0.017
10 - 20	c d e f	5 45 46 4	0.64 0.71 0.79 0.64	21	0.155
20 - 30	f g h	4 48 48	0.64 0.78 0.82	31	0.245
30 - 40	i j k	$33\frac{1}{3}$ $33\frac{1}{3}$ $33\frac{1}{3}$	o.69 0.80 0.85	21	0.164
40 - 50	l m	50 50	0.83 0.77	12	0.096
50 - 60	n	100	0.84	7	0.059
60 - 70	o	100	0.86	$3\frac{1}{2}$	0.030
70 - 100	o	100	0.86	3	0.026
Average U value for all glazed openings					0.792

given to two places of decimals except that when a space index is expressed in Imperial Units three decimal places are used.

RESULTS AND ANALYSIS OF DATA

All dwellings observed were of different design in respect of layout and proportions of elements. Many were of similar construction but although the variety of materials and assemblies for a particular element was limited, different combinations of elemental forms increased the multiformity of construction. This coupled to the varied design and type of the dwellings necessitated detailed analysis of the mass of data.

Merely to have given observed values of insulation would not have shown how much the standard of insulation achieved was due to the design, e.g. area of windows, and how much was due to the materials and forms of construction. For this reason an attempt was made to separate design from construction.

The parameters of design affecting thermal insulation are the proportions of the different surfaces through which heat is lost, so average dwellings of different types, houses, bungalows, etc. were defined by mean surface/floor ratios. This removed the design variable and enabled standards of insulation which could be achieved by the use of different materials and construction to be compared.

To show the affect of design alone, the heat loss for each dwelling was calculated on the assumption that all dwellings were of the same construction and materials.

Lastly, the insulation actually achieved was compared with that given by the standardised construction to show whether or not, when allowing for freedom of design, the standard of construction was satisfactory as regards thermal insulation.

Before proceeding to thermal considerations it was necessary to classify and describe the types and sizes of dwellings observed.

General classification of dwellings

Examination of the different types of dwelling led to their classification under the following headings.

Houses

Detached All detached houses observed were in the speculative class and of two-storey construction. They differed considerably in design: garages were attached, built-in or separate, two of the sample of 18 were of 'split level' design, some had one-storey additions and there were other variations. Their diversity precluded sub-division into more than one class.

Semi-detached In the speculative class these houses were divided into (a) wholly two-storey, and (b) partly single storey, the latter occuring when a garage is built into the house and there is a single storey above or when part of the house (excepting a small porch or similar) is of one-storey construction. All municipal semi-detached houses observed were of wholly two-storey construction.

Terraced Both speculative and municipal houses of this class showed more variation in design than semi-detached houses but the frequency of any particular variation was insufficient to warrant the formation of a sub-class. All but one of the terraced houses observed were of two-storey construction, the exception having three storeys.

Bungalows

As with houses, bungalows can be classified as detached, semi-detached, and terraced. The municipal bungalows observed were built for occupation by old persons. Of the ten designs analysed eight had only one bedroom, one had two bedrooms and one no separate bedroom at all: a bed-sitting room being provided. All were either semi-detached or terraced.

The speculative bungalows observed were limited to four detached and two semi-detached. In addition one dwelling of the type sometimes known as a chalet bungalow was observed. This is essentially a bungalow with some extra rooms in the roof.

Flats

Not only may flats be in different positions vertically in a block, that is, on bottom, intermediate or top floors, but they can be in different positions horizontally and so vary in the number of walls exposed to the open air. Some, like semi-detached houses, have three external walls, others at the corner of a block may have only two external walls. With balcony access, flats with two external walls can occur when the arrangement is similar to that of an intermediate terraced house, although no flats with balconies were observed some two-storey blocks of flats built like terraced houses were included in the survey. In 39 blocks of flats of different design only one contained a flat with a single external wall. Flats are, therefore, classified as being on ground, intermediate or top floors, having two or three external walls and because they fall into two groups as regards size, one or two bedrooms.

Maisonettes

These are similar to flats but having two storeys. Probably they are most commonly built in the form of a terrace and over a single storey of flats. They are also built four storeys high, one maisonette on top of another in terraces and blocks. Other arrangements are possible but were not observed.

One of the six blocks observed was four storeys high in the form of a terrace (or slab block). It had a central corridor on ground and second floors with the lower floors of separate maisonettes on either side, the upper floors were at right-angles to the lower floors running from front to rear and across the centrl corridor. Another four-storey block contained some maisonettes so positioned that they had only one external wall. The other blocks observed were in terraces with access from balconies or individual external staircases.

The small number of maisonettes available for analysis precluded a classification beyond that of position, vertically and horizontally. No speculative maisonettes were observed.

Old persons' grouped dwellings

These dwellings consist of small flats (sometimes known as flatlets) or bungalows linked together by corridors or covered walkways. Communal lounges and other rooms are provided. Three groups of dwellings were observed, in one the flatlets contained only a bedsitting room and kitchen, another had similar accommodation with the addition of a water-closet and wash-basin, the other had flatlets large enough for occupation by married couples and contained separate living room and bedroom together with kitchen and bathroom. One group included a single-storey block, otherwise they were all two-storey buildings. All were municipally owned.

Floor Area

As the Floor Index of Thermal Insulation is expressed in terms of unit floor area and because the design of dwellings, in so far as it affects heat loss, can be described in terms of the ratio of area of elements to floor area, it was necessary to examine floor areas of the different types of dwellings. The areas considered were those within the external walls as defined for Floor Index.

Houses

The first information elicited was whether garages were incorporated into the structure of houses at the expense of the floor area of the residential part. In only semi-detached houses were designs suffiently simple and observations in sufficient numbers to enable this to be investigated. The floor areas of wholly two-storey and partly single storey semi-detached houses were tabulated and statistics determined as shown in Table 11.8.

TABLE 11.8

Floor area of residential part of semi-detached houses

Area ft^2	Area m^2	Wholly two-storey	Partly single-storey
700 - 725	65 - 67		1
725 - 750	67 - 70	1	1
750 - 775	70 - 72	2	1
775 - 800	72 - 74	2	
800 - 825	74 - 77	3	
825 - 850	77 - 79	5	2
850 - 875	79 - 81	1	2
875 - 900	81 - 84	2	
900 - 925	84 - 86	6	4
925 - 950	86 - 88	2	1
950 - 975	88 - 91	1	1
975 - 1000	91 - 93		1
Total		25	14
Statistics*			
Mean	ft^2	856	868
	m^2	80	81
Standard Dev.	ft^2	58	74
	m^2	5.4	6.9

* Calculated from ungrouped data.

It was assumed that both samples were from normally distributed populations and Snedecor's F-ratio was used to determine that the samples could have come from populations with the same variance. The method used was as follows:

<u>Hypothesis</u> Both samples of floor areas of semi-detached houses are from populations with the same variance.

Estimated population variance,

$$\tilde{\sigma}^2 = s^2\left(\frac{N}{N - 1}\right)$$

$\tilde{\sigma}_a^{\,2}$ and $\tilde{\sigma}_b^{\,2}$ denote population variances of wholly two-storey and partly single-storey houses respectively.

H: $\tilde{\sigma}_a^{\,2} = \tilde{\sigma}_b^{\,2}$ and there is essentially no difference in the population variances.

H_1: $\tilde{\sigma}_a^{\,2} \neq \tilde{\sigma}_b^{\,2}$ and there is a significant difference in the population variance.

$$\text{F-ratio: } F = \frac{\tilde{\sigma}_b^{\,2}}{\tilde{\sigma}_a^{\,2}} = 1.68$$

The 5% point is 2.11. Therefore, there is no reason to suppose the null hypothesis false.

Once it was established that both samples could have come from populations with the same variance, Student's t-test could be used to test the hypothesis given below.

<u>Hypothesis</u> There is no significant difference in the mean floor area of the two classes of semi-detached houses.

μ_a and μ_b denote the means of wholly two-storey and partly single-storey houses respectively.

H_o: $\mu_a = \mu_b$ and there is essentially no difference in the classes.

H_1: $\mu_a \neq \mu_b$ and there is a significant difference between the classes.

Under the hypothesis H_o,

$$t = \frac{\overline{X}_a - \overline{X}_b}{\sigma\sqrt{1/N_a + 1/N_b}}$$

$$\sigma = \sqrt{\frac{N_a s_a^2 + N_b s_b^2}{N_a + N_b - 2}}$$

then $\sigma = 66$

and $t = -0.55$

$0.5 < \alpha < 0.6$

(α denotes probability of rejecting H_o if it is false).

There is no reason to suppose the null hypothesis false. It was accepted that the total floor area of a semi-detached house is not affected when the design incorporates a garage into the structure. The two classes were, therefore, treated as one so far as floor area was concerned.

TABLE 11.9

Floor area of residential part of houses

Area ft^2	Area m^2	Detached Speculative	Semi-detached Speculative	Semi-detached Municipal	Terraced Speculative	Terraced Municipal	All houses
650 - 700	60 - 65				2		2
700 - 750	65 - 70	1	3	3		1	8
750 - 800	70 - 74	2	5	2	2	1	12
800 - 850	74 - 79		10	5	4	2	21
850 - 900	79 - 84	2	5	10	1	1	19
900 - 950	84 - 88	1	13	5	1	4	24
950 - 1000	88 - 93	2	3	2	1	4	12
1000 - 1050	93 - 98	1			2		3
1050 - 1100	98 - 102	4			2		6
1100 - 1150	102 - 107	2					2
1150 - 1200	107 - 111			2			2
1200 - 1250	111 - 116	2			1		3
....	....						
1550 - 1600	144 - 149	1					
Total		18	39	29	16	13	115
Statistics*							
Mean	ft^2	1029	860	873	898	898	900
	m^2	95.6	79.9	81.1	83.4	83.4	83.6
Standard Dev.	ft^2	209	69	105	156	89	133
	m^2	19.4	6.4	9.7	14.5	8.3	12.4

* Calculated from ungrouped data.

For the terraced houses observed, both speculative and municipal classes have the same mean but the variance of speculative houses is greater than that of municipal houses.

The frequencies of different floor areas in houses of various classes and for the total of houses abserved are given in Table 11.9 together with means and standard deviations.

Bungalows

The floor area of nine old-persons bungalows, excluding one which consisted of bed-sitting room, kitchen and bedroom only with a floor area of 333 ft^2, gave the statistics shown in Table 11.10.

TABLE 11.10

Floor area of old-persons bungalows

Number observed	9
Range	437 - 540 ft^2
Mean	489 ft^2
Standard Dev.	33 ft^2

Four detached speculative bungalows had floor areas over the range 653 - 994 ft^2 with mean 789 ft^2; two semi-detached speculative bungalows had floor areas of 574 ft^2 and 649 ft^2 respectively; one chalet bungalow had a floor area of 1322 ft^2.

TABLE 11.11

Floor area of flats

Area ft^2	Area m^2	Municipal One-bed	Municipal Two-bed	Others	All flats
375 - 400	35 - 37			1	1
400 - 425	37 - 39				
425 - 450	39 - 42			1	1
450 - 475	42 - 44	4			4
475 - 500	44 - 46	3			3
500 - 525	46 - 49	2			2
525 - 550	49 - 51	1			1
550 - 575	51 - 53				
575 - 600	53 - 56		2		2
600 - 625	56 - 58		3	1	4
625 - 650	58 - 60		5		5
650 - 675	60 - 63		6		6
675 - 700	63 - 65		6	1	7
700 - 725	65 - 67		1		1
725 - 750	67 - 70		1		1
750 - 775	70 - 72		5	1	6
775 - 800	72 - 74		2		2
800 - 825	74 - 77		1		1
825 - 850	77 - 79				
850 - 875	79 - 81			1	1
Total		10	32	6	48
Statistics					
Mean	ft^2	480	685		637
	m^2	44.6	63.5		59.1
Standard Dev.	ft^2	22	60		111
	m^2	2.0	5.6		10.3

Flats

The floor areas of 48 municipal flats with different plans are shown in Table 11.11 together with those under the heading 'Others' which covers speculative, privately rented and housing association flats.

Maisonettes

The maisonettes observed were of six different plans with a range of floor areas from 674 ft^2 to 867 ft^2 with a mean area of 722 ft^2.

Floor-to-ceiling heights

The vertical dimension governing heat loss from walls is the floor-to-ceiling height. Heights were found to vary between 7 ft 6 in (2.286 m), the minimum allowed by the Building Regulations, and just over 8 ft (2.438 m) except in one bungalow where the height was 8 ft 5 in. In the few other cases where 8 ft was exceeded by an inch or so, this was probably not the designer's intention.

Mean floor-to-ceiling heights are given in Table 11.12.

Ratio of external surfaces to floor area

In order to remove the design variable and so facilitate the comparison of the thermal insulation of dwellings of different forms of construction by the use of average design characteristics, the mean of the ratio of the area of each surface from which heat is lost (walls, openings, floors, ceilings) to the floor area of the residential part was required for the different classes of dwelling. From this, and the

TABLE 11.12

Floor-to-ceiling heights

Class of dwelling	No. of observations	Mean height ft	Mean height m
Houses			
Detached (Spec)	18	7.73	2.35
Semi-detached (Spec)	39	7.74	2.36
Semi-detached (Mun.)	29	7.72	2.35
Terraced (Spec)	16	7.81	2.38
Terraced (Mun)	10	7.70	2.35
All houses	112	7.74	2.36
Other dwellings			
Bungalows O.P. (Mun)	10	7.91	2.41
Bungalows (Spec)	6	8.00	2.44
Blocks of Flats (Mun)	33	7.75	2.36
Blocks of Flats (Others)	6	7.90	2.41
Blocks of Maisonettes (Mun)	6	7.82	2.38
Blocks of grouped dwellings	3	7.75	2.36
All dwellings	176	7.76	2.37

In subsequent calculations the mean floor-to-ceiling height is rounded off to 7.75 ft (2.36 m).

variance of the samples, population confidence limits were established. The dimensions which were used with respect to the surfaces were those defined for units characterising thermal insulation values of elements and whole dwellings described on p.11.11.

Houses

Over the lowest floors of houses there will be a topmost ceiling either immediately above or in an upper storey. Therefore, lowest floors and topmost ceilings have the same area, unless part of the topmost ceiling is sloping. Neither lowest floor nor topmost ceiling in two-storey houses can be in the ratio of less than 0.5 to the total floor. The topmost ceiling will be more if it includes a sloping part, both will be more if part of the house is single-storied.

The surface/floor ratios of houses are shown in Table 11.13. To group dwellings of similar design characteristics together it was necessary to modify the classification previously used for floor areas. Speculative semi-detached houses were separated into wholly two-storey and partly single-storey, and terraced houses into end houses and intermediate houses. Next the ratios in different classes of house were examined to see if any combinations of classes could be effected. Except in two cases, namely speculative and municipal semi-detached and all types of terraced house it was obvious on inspection that this was not permissible.

The data relating to terraced houses are shown in Table 11.14

TABLE 11.13

Ratio of surfaces, from which heat is lost, to floor area of residential part of houses

Sample or Population Confidence Limits $\alpha = 0.05$	Detached	Semi-detached			Terraced	
	Speculative	Speculative		Municipal	Speculative and Municipal	
					Some partly single storey	
	Some partly single-storey	Partly single-storey	Wholly two-storey	Wholly two-storey	End houses	Inter. houses
	N = 18	N = 14	N = 25	N = 29	N = 26	N = 26
Overall walls						
Sample						
Range	1.25 - 1.69	1.00 - 1.37	1.00 - 1.14	0.89 - 1.27	0.98 - 1.34	0.50 - 0.99
Mean	1.44	1.15	1.07	1.08	1.13	0.75
Std. dev.	0.12	0.13	0.04	0.09	0.10	0.14
Population						
Mean	1.38 - 1.50	1.07 - 1.23	1.05 - 1.09	1.04 - 1.12	1.09 - 1.17	0.69 - 0.81
Std. dev.	0.90 - 0.18	0.10 - 0.22	0.03 - 0.05	0.07 - 0.13	0.08 - 0.14	0.12 - 0.20
Openings						
Sample						
Range	0.24 - 0.41	0.18 - 0.32	0.26 - 0.39	0.20 - 0.39	0.17 - 0.39	
Mean	0.30	0.28	0.30	0.26	0.27	
Std. dev.	0.04	0.05	0.03	0.04	0.06	
Population						
Mean	0.28 - 0.32	0.26 - 0.31	0.29 - 0.31	0.24 - 0.28	0.24 - 0.29	
Std. dev.	0.03 - 0.06	0.03 - 0.08	0.02 - 0.04	0.03 - 0.05	0.04 - 0.08	
Lowest floors						
Sample						
Range	0.50 - 0.59	0.52 - 0.60	0.50 - 0.50	0.50 - 0.51	0.37 - 0.61	
Mean	0.52	0.55	0.50	0.50	0.51	
Std. dev.	0.03	0.02	..	..	0.04	
Topmost ceiling						
Sample						
Range	0.50 - 0.60	0.52 - 0.60	0.50 - 0.50	0.50 - 0.53	0.37 - 0.61	
Mean	0.52	0.55	0.50	0.51	0.51	
Std. dev.	0.03	0.02	..	0.01	0.04	

TABLE 11.14

Ratio of surfaces to floor area in terraced houses

Statistic	Class of house	
	Speculative N = 16	Municipal N = 10
	Overall Walls	
<u>End houses</u>		
Range	0.98 - 1.34	1.01 - 1.27
Mean	1.14	1.12
Variance	0.012	0.007
<u>Inter houses</u>		
Range	0.50 - 0.99	0.54 - 0.98
Mean	0.72	0.80
Variance	0.017	0.021
	Openings	
<u>End & Inter houses</u>		
Range	0.17 - 0.35	0.20 - 0.39
Mean	0.27	0.26
Variance	0.003	0.021

The null hypothesis that both samples of end houses were from populations with the same variance was tested by means of the F-ratio as described for floor areas on p.11.33. This was followed by testing the null hypothesis that there is no significant difference in (1) the mean wall ratios and (2) the mean openings ratios of the two classes, speculative and municipal, in the manner described on p.11.34. The results were as follows:

Overall walls. Variances: F-ratio = 0.608 (5% point is 2.59).

Means: $0.6 < \alpha < 0.8$.

Openings. Variances: no test necessary

Means: $0.6 < \alpha < 0.8$.

The null hypotheses were accepted.

As the intermediate terraced houses observed were in the same blocks as the end houses it was assumed that there was no significant difference between the relative means of these also and the data were combined to give the results shown in Table 11.14.

Although there is little difference in the means of wall/floor ratios of semi-detached speculative and municipal houses of wholly two-storey construction the difference in their variances will not allow the assumption that they are from populations with the same mean.

The null hypothesis that wall/floor ratios of municipal semi-detached and all terraced end houses are from populations with the same mean was tested with the following results:

Variances: F-ratio = 1.25 (5% point is 1.91)

Means: $0.05 < \alpha < 0.10$.

The null hypothesis might be accepted with a fair degree of confidence but in this work the two classes have been kept separate.

Before determining confidence limits for surface/floor ratios it was felt necessary to evaluate the assumption that the data were drawn from normally distributed populations. The frequencies in the samples were too low for the chi-square test so use was made of the Kolmogorov-Smirnov test. An example of its application is given in Fig. 11.2. The test showed that there was no reason to doubt the assumption that the data relating to walls and openings of houses were drawn from normally distributed populations.

As the ratios for lowest floors and for topmost ceilings in two-storey houses cannot be less than 0.5 the data concerning these cannot be normally distributed. However, in view of the small variance of the ratios it was felt that little was lost in not establishing confidence limits.

Where confidence limits for population means were established the t-distribution was used.

When $\alpha = 0.05$ and $\phi = N-1$

$$\bar{x} + \frac{t_{.975}\, s}{\sqrt{N-1}} > \mu > \bar{x} - \frac{t_{.975}\, s}{\sqrt{N-1}}$$

where:

ϕ = degrees of freedom

$\bar{x}$ = mean of sample

μ = mean of population from which sample is drawn.

N = number of observations in sample.

Confidence limits (at 95% confidence level) for population variances were established, using the chi-square distribution, as follows:

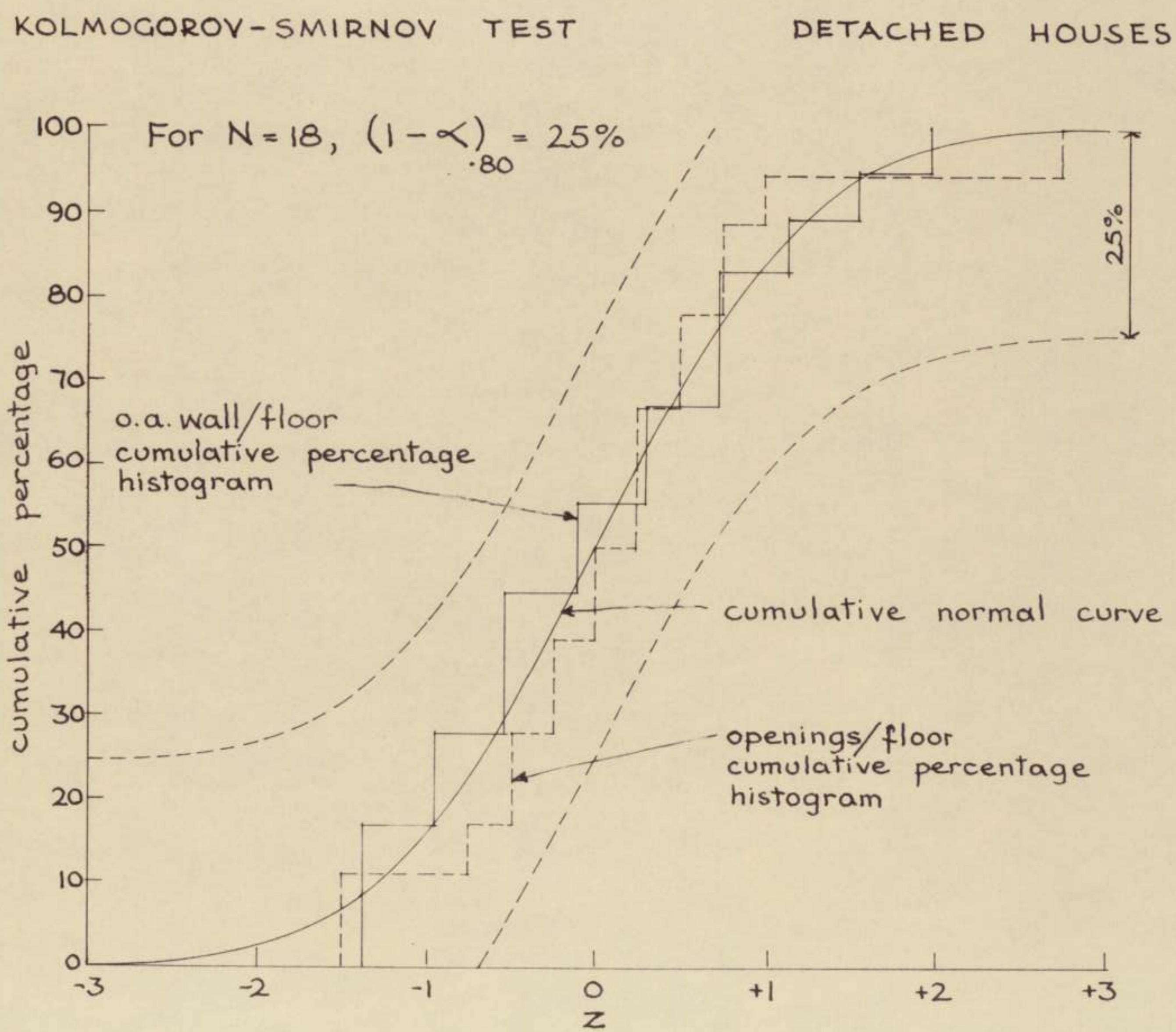

KOLMOGOROV-SMIRNOV TEST
DETACHED HOUSES
For N = 18, (1 − ∝).80 = 25%
o.a. wall/floor cumulative percentage histogram
cumulative normal curve
openings/floor cumulative percentage histogram
25%
cumulative percentage
100
90
80
70
60
50
40
30
20
10
0
-3
-2
-1
0
+1
+2
+3
z

Fig. 11·2

$$\frac{Ns^2}{\chi^2_{.025}} > \sigma^2 > \frac{Ns^2}{\chi^2_{.975}}$$

where:

σ^2 = population variance

Standard deviation of sample is denoted by σ

Bungalows

It was felt that the number of bungalows of different classes observed was too small to allow reliable conclusions to be drawn from them about mean surface/floor ratios. The largest sample was of nine municipal old-persons' bungalows (excluding the single example of the bed-sitting room type). This sample gave the statistics shown in Table 11.15.

TABLE 11.15

Ratio of surfaces from which heat is lost to floor area of residential part of old persons bungalows

Statistic	Overall Walls	Openings
Number of bungalows observed	9	
Range	1.01 - 1.43	0.22 - 0.35
Mean	1.11	0.29
Standard dev.	0.09	0.04

The mean overall wall/floor ratio of 1.11 is approximately the value obtained from a semi-detached bungalow 22 ft by 22 ft on plan with an 8 ft floor-to-ceiling height:

$$\frac{(22 + 22 + 22) \times 8}{22 \times 22} = 1.09$$

The round figure of 1.10 was accepted.

For terraced bungalows with a wall area two-thirds of that of semi-detached bungalows of the same size the overall wall/floor ratio will be:

$$\frac{2}{3} \times 1.10 = 0.73$$

Speculative semi-detached are larger than municipal, with an additional bedroom. If the frontage remains the same and the enlarged area is obtained by increasing the depth to say 28 ft, the overall wall/floor ratio will be:

$$\frac{(22 + 28 + 22) \times 8}{22 \times 28} = 0.94$$

For speculative detached bungalows, assuming a length of 35 ft the ratio becomes:

$$\frac{(35 + 22 + 35 + 22) \times 8}{35 \times 22} = 1.18$$

The rounded figures shown in Table 11.25, p.11.65 were adopted for use in calculating average U values of bungalows. 0.30 was the best estimate of openings based on bungalows and houses observed. Floors and ceiling ratios are, of course, each 1.00.

Flats

Unless access above the ground floor is by balconies or outside staircases, flats will have an internal wall adjacent to a corridor or stairwell. Some will also have walls adjacent to lift shafts or refuse chutes. For this reason flats were treated differently from houses and bungalows when finding surface/floor ratios. Walls adjacent to corridors and the like (termed internal walls) had their ratios calculated separately from external walls. (Some examples of walls of flats are illustrated in the appendix, Fig.A1.1).

Except in one block with an outside staircase, entrance doors were in internal walls, normally, therefore, the only openings in external walls were windows.

As with houses it was considered whether the presentation of statistics could be simplified by combinations of classes. This was possible for internal walls and windows. Table 11.16 gives particulars relating to internal walls and windows in three classes of flat. One-bed flats with two external walls have been omitted because insufficient were observed for a valid analysis.

For internal wall/floor ratios the greatest difference between variances of samples was in those of the two classes of flat with three external walls.

TABLE 11.16

Ratio of internal wall and window areas to floor area in flats

Statistic	Municipal		
	Flats with three external walls		Flats with two external walls
	Two-bed	One-bed	Two-bed
	N = 21	N = 11	N = 17
	Overall Internal Walls		
Range	0 - 0.39	0.13 - 0.52	0.05 - 0.44
Mean	0.24	0.26	0.22
Variance	0.0110	0.0143	0.0135
	Windows		
Range	0.14 - 0.28	0.15 - 0.30	0.11 - 0.26
Mean	0.19	0.20	0.16
Variance	0.0013	0.0026	0.0023

The null hypothesis that there is no significant difference in the variances of the internal wall/floor ratios of the two classes was tested by finding the F-ratio in the manner previously described with the following result:

F-ratio = 1.36. As the 5% point is 2.30 the null hypothesis was accepted. It was further assumed that the other sample, two-bedroom two external walls, could have come from a population with the same variance.

The greatest difference in means of internal wall/floor ratios was between one-bedroom three external wall flats and two-bedroom two external wall flats; the t-test was used, as before described, to test the null hypothesis that there was no significant difference between the means of these two samples with the result: $0.2 < \alpha < 0.4$. The null hypothesis was accepted and it was assumed that the mean internal wall/floor ratio was the same for all classes of flat.

Results of tests on window/floor ratios of both classes of flats with three external walls were:

Variance: F-ratio = 2.09

(5% point is 2.28)

Means: $0.5 < \alpha < 0.6$.

It was accepted that there was no significant difference between the two classes and they were combined in one.

In view of the limitation on windows when flats have only two external walls these windows must be in a separate class. Population estimates of windows were not made because the samples did not pass the Kolmogorov-Smirnov test for the assumption of normality.

Details of surface/floor ratios of flats are given in Table 11.17. The estimated overall external wall/floor ratio for one-bedroom two external wall flats was based on the assumption that with two walls rather than three it would be two thirds of the one-bedroom three external wall ratio, that is $\frac{2}{3} \times 1.04 = 0.69$, in the same way that for two-bedroom flats the observed mean $0.61 \approx \frac{2}{3} \times 0.91$.

TABLE 11.17

Ratio of surfaces, from which heat is lost, to floor area in flats

Sample or Population Confidence $\alpha = 0.05$	Municipal			
	Flats with three external walls		Flats with two external walls	
	Two-bed	One-bed	Two-bed	One-bed
	N = 21	N = 11	N = 17	Estimated
Overall external walls				
Sample				
Range	0.68 - 1.05	0.94 - 1.16	0.50 - 0.73	
Mean	0.91	1.04	0.61	0.69
Std. dev.	0.10	0.05	0.05	
Population				
Mean	0.87 - 0.95	1.01 - 1.08	0.58 - 0.64	
Std. dev.	0.07 - 0.14	0.04 - 0.10	0.04 - 0.08	
Overall internal walls				
Sample				
Range		0.00 - 0.52		
Mean		0.24		0.24
Std. dev.		0.11		
Population				
Mean		0.21 - 0.27		
Std. dev.		0.10 - 0.14		
Windows				
Sample				
Range	0.14 - 0.30		0.11 - 0.26	
Mean	0.19		0.16	0.16
Std. dev.	0.04		0.05	

Windows in one-bedroom two external wall flats were assumed to be the same as in two bedroom two external wall flats.

Maisonettes

The sample of maisonettes was too small to give reliable mean surface/floor ratios for this class of dwelling. Their similarity to terraced houses when built in slab blocks or flats when built in point blocks is obvious.

Construction and U values of elements

The various forms of construction observed in elements and their calculated U values are given in the appendix. The frequencies in which the different U values occurred are shown in Table 11.18. Class limits in this Table were chosen to emphasise the percentage occurring above or within maximum statutory and recommended U values, e.g. 0.30, 0.20 respectively for walling.

The main wall construction of houses and bungalows fell largely into two categories either it was 10½in. (260 mm) cavity work with clinker block inner leaf or 11 in. (275 mm) cavity work entirely of brick. A higher proportion of all-brick cavity walls was found in flats and maisonettes than in houses. In buildings of three-storeys or more this was obviously for strength. Some of these buildings also included walls of 13½in. solid brick and 15½in. cavity brickwork. Multi-storey flats of framed construction were faced with brickwork in cavity construction with insulating blocks for the inner leaf, other multi-storey flats had walls of concrete, either dense or no-fines.

TABLE 11.18

Percentage frequencies of element U-values observed in dwellings

U-values		Houses and bungalows (a)		Blocks of flats and maisonettes (b)	All dwellings (c)
		Spec.	Mun.	Mun.	Spec & Mun
Bru/ft^{2}h degF	W/m^2 degC	N = 80	N = 48	N = 41	N = 175
		Walling (d)			
0.11 - 0.15	0.62 - 0.085		4	2	2
0.16 - 0.20	0.91 - 1.14	8	15	20	13
0.21 - 0.25	1.19 - 1.42	73	27	17	47
0.26 - 0.30	1.48 - 1.70	19	50	61	37
0.31 - 0.35	1.76 - 1.99		4		1
0.36 - 0.40	2.04 - 2.27				
0.41 - 0.45	2.33 - 2.56	1			1
0.30	1.70	19	48	56	35
		Feature Panels			
No panel		42	52	68	53
0.11 - 0.15	0.62 - 0.85	5	10	2	6
0.16 - 0.20	0.91 - 1.14	22	10	12	16
0.21 - 0.25	1.19 - 1.42	22	8	2	13
0.26 - 0.30	1.48 - 1.70	8	8	12	9
0.31 - 0.35	1.76 - 1.99		6		2
0.36 - 0.40	2.04 - 2.27		2		1
0.41 - 0.45	2.33 - 2.56				
0.46 - 0.50	2.61 - 2.84		2	2	1

Continued

TABLE 11.18 (Continued)

U-values		Houses and bungalows (a)		Blocks of flats and maisonettes (b)	All dwellings (c)
Btu/ft^{2}h degF	W/m^2 degC	Spec.	Mun.	Mun.	Spec & Mun
		N = 80	N = 48	N = 41	N = 175
Ground Floor					
				N = 37	N = 171
0.06 - 0.10	0.34 - 0.57	11	14	65	25
0.11 - 0.15	0.62 - 0.85	46	80	24	50
0.16 - 0.20	0.91 - 1.14	1			1
0.21 - 0.25	1.19 - 1.42				
0.26 - 0.30	1.48 - 1.70	8			4
0.31 - 0.35	1.76 - 1.99	34	6	11	21
Topmost Ceiling and Roof					
				N = 41	N = 175
0.11 - 0.15	0.62 - 0.85	3	4	20	7
0.16 - 0.20	0.91 - 1.14	74	88	73	78
0.21 - 0.25	1.19 - 1.42	5	4	7	5
0.26 - 0.30	1.48 - 1.70	1			1
0.31 - 0.35	1.76 - 1.99	14	4		8
0.36 - 0.40	2.04 - 2.27				
0.41 - 0.45	2.33 - 2.56	3			2
0.16	0.91	73	86	54	71

Continued

TABLE 11.18 (Continued)

(a) Speculative: 2 non-traditional construction
Municipal: 11 non-traditional.

(b) Flats: 16 two-storey, 9 three storey (1 non-traditional),
10 multi-storey (6 non-traditional).
Maisonettes: 4 three-storey (1 non-traditional), 2 four-storey.

(c) Includes six flats of other than municipal class.

(d) Principal wall U-value given if building had different walls.

Feature panels were more varied in construction than walls but their insulating properties did not differ greatly.

Ground floors also fell into two categories, solid and hollow; usually windows likewise into two categories, wood and metal. With ground floors, U-values for solid floors varied from 0.06 (0.34) to 0.14 (0.79) according to the plan size of the slab. Timber hollow floors have a U-value of 0.35 (1.99) when floor covering is provided but the overall U-value for the floor (which is recorded in Table 11.18) will be reduced when part of it is solid as, for example, when the kitchen has a solid floor and the remainder of the house a hollow floor. Ceilings of pitched roofs were nearly all insulated with 1 in. glasswool giving a U value of

0.16 (0.91); flat roofs were usually less well insulated.

Two common U values in walls and roofs respectively each occur at class boundaries; the frequencies of these are additionally shown separately in Table 11.18 to indicate that they somewhat distort the true distribution.

U values of walls separating dwellings from corridors, stairwells and the like in blocks of flats are given in Table 11.19. 9 inch brickwork (U value 0.36) was the most common form of construction.

TABLE 11.19

U values of internal walls observed in blocks of flats

U values		Municipal		Others	Totals	
Btu/ft^{2}h degF	W/m^2 degC	No.	%	No.	No.	%
Nil		1	3		1	2
0.11 - 0.15	0.62 - 0.85	3	8		3	7
0.16 - 0.20	0.91 - 1.14	2	5		2	5
0.21 - 0.25	1.19 - 1.42					
0.26 - 0.30	1.48 - 1.70	9	24		2	20
0.31 - 0.35	1.76 - 1.99	4	11		4	9
0.36 - 0.40	2.04 - 2.27	10	26	3	13	30
0.41 - 0.45	2.33 - 2.56	3	8	2	5	11
0.46 - 0.50	2.61 - 2.84	6	16	1	7	16
Totals		38		6	44	

Overall wall U values

The overall U value of walls is naturally affected largely by the area of openings in the walls, average overall wall U values for different constructions (as shown later) involve mean proportions of openings in walls. The extent of openings has previously been indicated as a mean opening/floor ratio. Expressing openings as a percentage of overall wall area in houses gives the values shown in Table 11.20.

TABLE 11.20

Percentage area of openings in wall area of houses

		Percentage area of openings
Detached (Spec.)		21
Semi-detached	(partly single-storey (Spec.)	24
	(wholly two-storey (Spec.)	28
	(wholly two-storey (Mun.)	24
Terraced (Spec. & Mun.)	(end houses	24
	(inter houses	36

For comparison the percentage of windows in external walls of flats is given in Table 11.21.

TABLE 11.21

Percentage area of windows in external wall area of flats

Type of flat		Percentage area of windows
Three external walls	(Two-bed	21
	(One-bed	18
Two external walls	(Two-bed	26
	(One-bed	23*

*Estimated

Average overall wall U values in dwellings of different types for different forms and combinations of construction were calculated from surface/floor ratios of walling and openings. The results for houses are shown in Table 11.22. In flats the overall wall U value corresponds to the shell U value of intermediate flats where walls form the only bounding surfaces from which heat is lost, hence average overall wall U values for flats can be seen under the heading "Shell U values" in Table 11.27 p.11.67 . It is emphasised that overall wall area includes both external and internal wall area unlike Table 11.20 where only external wall area is considered.

No average values were calculated for dwellings other than houses and flats because of lack of sufficient data.

For the calculation of population confidence levels the higher value for wall/floor ratio was used with the lower value for openings to give the lower limit: conversely the lower wall/floor ratio and higher openings/floor ratio gave the higher limit, e.g. in detached houses with $10\frac{1}{2}$ in. cavity walls and wood windows:

$$\frac{(1.50 - 0.28) \times 0.23 + 0.28 \times 0.80}{1.50} = 0.34$$

$$\frac{(1.38 - 0.32) \times 0.23 + 0.32 \times 0.80}{1.38} = 0.36$$

Average values which would be obtained if the walling was to the C.P.3 recommendation were also obtained. These with values for other forms of construction are shown in Table 11.22.

When calculating the values shown in Table 11.22 two doors were assumed to be included in the area of openings. These with their frames were assumed to have an area of 40 ft^2 (3.72 m^2): 0.04 - 0.05 of the mean floor area. Generally front entrance doors are fully glazed and back entrance doors at least half-glazed, so for simplicity of calculation a U value of 0.80, as for wood windows was used.

In flats, entrance doors occurred in internal walls, almost all the doors were flush panelled with a U value taken as 0.40 (2.27). The assumed U value of the internal wall for the purpose of calculating overall wall U values was that of the most common form of construction, 9 in. brick plastered one side, 0.36 (2.04); the door U value was close enough to make adjustment for the door unnecessary especially as this was halved

TABLE 11.22

Average overall-wall U-values in houses with elements of various constructions (calculated from mean surface/floor ratios)

CONSTRUCTION OF ELEMENTS				TYPE OF HOUSE					
WALLS		WINDOWS		DETACHED	SEMI-DETACHED			TERRACED	
4½" bk 2" cav. and inner leaf of:				Speculative	Speculative		Municipal	Speculative and Municipal	
4" clink	4½" bk	Wood	Metal	Some partly single-storey	Partly single-storey	Wholly two-storey	Wholly two-storey	Some partly single-storey	
U-values Imp (SI)								End houses	Inter houses
0.23 (1.31)	0.30 (1.70)	0.80 (4.54)	1.00 (5.68)	N = 18	N = 14	N = 25	N = 29	N = 26	N = 26
Sample									
X		X		0.35 (1.99)	0.37 (2.10)	0.39 (2.23)	0.37 (2.09)	0.37 (2.08)	0.44 (2.47)
X			X	0.38 (2.18)	0.41 (2.32)	0.44 (2.48)	0.41 (2.31)	0.41 (2.31)	0.50 (2.82)
	X	X		0.41 (2.30)	0.41 (2.35)	0.44 (2.50)	0.42 (2.38)	0.42 (2.38)	0.48 (2.73)
	X		X	0.44 (2.50)	0.45 (2.57)	0.49 (2.77)	0.46 (2.61)	0.46 (2.61)	0.54 (3.07)
Population Confidence Limits*									
X		X		0.34 - 0.36 (1.92 - 2.05)	0.35 - 0.40 (1.99 - 2.24)	0.38 - 0.40 (2.17 - 2.26)	0.35 - 0.38 (2.00 - 2.18)	0.35 - 0.38 (1.97 - 2.17)	0.40 - 0.47 (2.27 - 2.67)
X			X	0.37 - 0.40 (2.10 - 2.28)	0.39 - 0.45 (2.19 - 2.52)	0.43 - 0.45 (2.42 - 2.54)	0.39 - 0.43 (2.19 - 2.43)	0.38 - 0.43 (2.16 - 2.43)	0.45 - 0.54 (2.54 - 3.08)
	X	X		0.40 - 0.42 (2.24 - 2.36)	0.39 - 0.44 (2.21 - 2.48)	0.42 - 0.45 (2.40 - 2.54)	0.41 - 0.44 (2.31 - 2.47)	0.40 - 0.43 (2.29 - 2.46)	0.45 - 0.51 (2.54 - 2.90)
	X		X	0.43 - 0.46 (2.42 - 2.58)	0.42 - 0.48 (2.40 - 2.75)	0.48 - 0.50 (2.65 - 2.83)	0.44 - 0.48 (2.50 - 2.72)	0.44 - 0.48 (2.48 - 2.72)	0.50 - 0.58 (2.83 - 3.31)
C.P. 3 Recommendations									
0.20 (1.14)									
Sample									
X		X		0.33 (1.85)	0.35 (1.96)	0.37 (2.09)	0.34 (1.95)	0.34 (1.95)	0.42 (2.36)
X			X	0.36 (2.06)	0.39 (2.19)	0.42 (2.36)	0.38 (2.17)	0.38 (2.16)	0.48 (2.71)
Population Confidence Limits*									
X		X		0.31 - 0.34 (1.78 - 1.92)	0.33 - 0.37 (1.86 - 2.12)	0.36 - 0.38 (2.04 - 2.14)	0.33 - 0.36 (1.87 - 2.06)	0.32 - 0.36 (1.83 - 2.04)	0.38 - 0.45 (2.15 - 2.57)
X			X	0.35 - 0.38 (1.96 - 2.15)	0.36 - 0.42 (2.05 - 2.41)	0.40 - 0.43 (2.29 - 2.42)	0.36 - 0.41 (2.06 - 2.31)	0.36 - 0.41 (2.03 - 2.31)	0.43 - 0.53 (2.42 - 2.98)

* $\alpha = 0.05$

when the temperature difference between flat and corridor was assumed to be half of that between indoor and outdoor air. (The mean of estimated temperatures in 37 corridors, with range 40°F to 57°F, was 47°F).

If part of the bounding surface of a house is adjacent to a garage and is constructed as a 4½ in. (113 mm) brick wall, the heat loss for unit area of that wall will be approximately equal to that of an external 10½ in. wall if the temperature of the garage is halfway between that of the indoor and outdoor air, given that the U value of the 10½ in. wall is 0.23 and that of the 4½ in. wall is as calculated below:

	R
4½ in. brick	0.56
½ in. plaster	0.13
Two internal surfaces	1.40
	2.09

$$U = \frac{1}{2.09} = 0.48$$

Allowance has been made in Table 11.22 for the reduced heat loss from surfaces adjacent to garages in respect of 11 in. (275 mm) walls of partly single-storey semi-detached houses where a portion of the wall equal to 0.18 of the floor area was assumed to be adjacent to the garage. This figure was obtained as follows:
Assume garage 16 ft by 8 ft on plan built in for three-quarters* of its

* Later analysis showed that the average probably lies between one-half and three-quarters.

length, and floor-to-ceiling height of 7 ft 9 in, then bounding wall area adjacent to garage

$$\left[(16 \times \tfrac{3}{4}) + 8\right] \times 7.75 = 155 \text{ ft}^2$$

Average floor area of semi-detached house is 860 ft. Ratio of area of wall adjacent to garage to floor area $= \frac{155}{860} = 0.18$.

Observed overall wall U values for houses and bungalows are given in Table 11.23. The values for flats and maisonettes given in Table 11.24 are averages for the dwellings in the different blocks and do not relate to individual dwellings. As previously pointed out the shell U value of a flat on an intermediate floor will be the same as the overall wall U value hence information concerning overall wall U values in flats of different classes can be obtained from Table 11.27.

Shell U values

Using the mean ratios of surfaces of samples, average shell U values were determined from the U values of overall walls, floors, and ceilings. For houses and bungalows, two types of floor, solid and hollow were considered, in flats only solid floors were included. In all cases the ceiling insulation was assumed to be equal to that of a pitched roof with a covering of tiles on battens insulated with 1 in. glasswool. Shell U values for average dwellings of various types with elements of different construction are shown in Tables 11.25, 11.26 and 11.27.

Where some of the heat loss is through a garage or other unheated part, the shell U value obtained for houses with solid ground floors is not appreciably affected by the assumption that the lowest floor is

TABLE 11.23

Observed overall-wall U-values in houses and bungalows

U-value		HOUSES						BUNGALOWS			ALL HOUSES AND BUNGALOWS
		Speculative			Mun.	Spec. and Mun.		Mun. (O.P.)		Spec.	
Btu/ft^{2}h degF	W/m^2 degC	Detached	Semi-detached Partly single-storey	Semi-detached Wholly two-storey	Semi-detached Wholly two-storey	Terraced End houses	Terraced Inter. houses	Semi-detached and end terraced	Inter. terraced	Detached (N = 5) Semi-detached (N = 2)	
0.28 - 0.29	1.59 - 1.65							1			1
0.30 - 0.31	1.70 - 1.76	1	1		1	1					4
0.32 - 0.33	1.82 - 1.87	6	1		1	5		2	1		16
0.34 - 0.35	1.93 - 1.99	2	3	1	2	4		1		4	17
0.36 - 0.37	2.04 - 2.10	2	3	3	3	3	5			1	20
0.38 - 0.39	2.16 - 2.21	4	4	9	6	3	2	1			29
0.40 - 0.41	2.27 - 2.33	3	1	3	2	2	1	2	1		15
0.42 - 0.43	2.38 - 2.44		1	5	4	3	5	1			19
0.44 - 0.45	2.50 - 2.56			4	9	2	2	2	1	1	21
0.46 - 0.47	2.61 - 2.67				1	2	1		2	1	7
0.48 - 0.49	2.73 - 2.78						1				1
0.50 - 0.51	2.84 - 2.90						2				2
0.52 - 0.53	2.95 - 3.01						4				4
0.54 - 0.55	3.07 - 3.12						1				1
0.56 - 0.57	3.18 - 3.24						1				1
Total		18	14	25	29	25	25	10	5	7	158

TABLE 11.24

Observed overall wall U values in blocks of flats and maisonettes

U Value		Flats		Maisonettes	All flats and Maisonettes
Btu/ft^{2}h degF	W/m^2 degC	Municipal	Other	Municipal	
0.20 - 0.21	1.14 - 1.19	1			1
0.22 - 0.23	1.25 - 1.31				
0.24 - 0.25	1.36 - 1.42	2			2
0.26 - 0.27	1.48 - 1.53	3			3
0.28 - 0.29	1.59 - 1.65				
0.30 - 0.31	1.70 - 1.76	5		1	6
0.32 - 0.33	1.82 - 1.87	4	2	1	7
0.34 - 0.35	1.93 - 1.99	2	1		3
0.36 - 0.37	2.04 - 2.10	7	2		9
0.38 - 0.39	2.16 - 2.21	3			3
0.40 - 0.41	2.27 - 2.33	4		2	6
0.42 - 0.43	2.38 - 2.44	1	1		2
0.44 - 0.45	2.50 - 2.56	3			3
0.46 - 0.47	2.61 - 2.67				
0.48 - 0.49	2.73 - 2.78			2	2
Total		35	6	6	47

TABLE 11.25

Average shell U-values in houses with elements of various constructions (calculated from mean surface/floor ratios)

CONSTRUCTION OF ELEMENTS (a)						TYPE OF HOUSE					
WALLS		WINDOWS		GROUND FLOORS		DETACHED	SEMI-DETACHED			TERRACED	
4½" bk 2" cav. and inner leaf of:		Wood	Metal	Solid	Hollow	Speculative	Speculative		Municipal	Speculative and Municipal	
4" clink	4½" bk					Some partly single-storey	Partly single-storey	Wholly two-storey	Wholly two-storey	Some partly single-storey	
U-values: Btu/ft²h degF (W/m² degC)										End houses	Inter houses
0.23 (1.31)	0.30 (1.70)	0.80 (4.54)	1.00 (5.68)	0.10-0.13(b) (0.57-0.74)	0.35 (1.99)	N = 18	N = 14	N = 25	N = 29	N = 26	N = 26
X		X		X		0.26 (1.48)	0.26 (1.46)	0.27 (1.53)	0.26 (1.46)	0.26 (1.46)	0.26 (1.47)
X			X	X		0.28 (1.59)	0.28 (1.57)	0.30 (1.68)	0.28 (1.58)	0.28 (1.59)	0.29 (1.62)
	X	X		X		0.30 (1.70)	0.28 (1.61)	0.30 (1.68)	0.29 (1.62)	0.29 (1.63)	0.28 (1.58)
X		X			X	0.31 (1.76)	0.30 (1.71)	0.32 (1.85)	0.31 (1.78)	0.31 (1.78)	0.33 (1.89)
	X		X	X		0.32 (1.82)	0.30 (1.73)	0.32 (1.82)	0.31 (1.73)	0.31 (1.75)	0.30 (1.73)
X			X		X	0.33 (1.87)	0.32 (1.83)	0.35 (1.99)	0.33 (1.89)	0.34 (1.90)	0.36 (2.03)
	X	X			X	0.34 (1.93)	0.33 (1.86)	0.35 (1.99)	0.34 (1.93)	0.34 (1.94)	0.35 (1.99)
	X		X		X	0.36 (2.04)	0.35 (1.98)	0.38 (2.14)	0.36 (2.04)	0.36 (2.06)	0.38 (2.14)
C.P. 3 Recomm ndations (c)											
0.20 (1.14)		X		0.20 (1.14)		0.27 (1.53)	0.28 (1.56)	0.29 (1.64)	0.26 (1.48)	0.28 (1.56)	0.29 (1.66)
			X			0.29 (1.63)	0.30 (1.69)	0.31 (1.78)	0.28 (1.59)	0.30 (1.69)	0.32 (1.81)

(a) Topm ist ceiling: U-value 0.16 (0.91)

(b) For : ntermediate terraced houses 0.10 (0.57), semi-detached and end terraced houses 0.12 (0.68), detached houses 0.13 (0.74)

(c) Topmost ceiling: 0.20 (1.14)

TABLE 11.26

Average shell U-values in bungalows with elements of various constructions (calculated from estimated mean surface/floor ratios)

CONSTRUCTION OF ELEMENTS (a)						TYPE OF BUNGALOW			
WALLS		WINDOWS		GROUND FLOORS		SPECULATIVE		MUNICIPAL (Old Persons')	
4½" bk 2" cav. and inner leaf of:		Wood	Metal	Solid	Hollow	Detached	Semi-detached	Semi-detached	Terraced
4" clink	4½" bk					Ratio of overall wall area to floor area			
						1.20	0.95	1.10	0.75
U-values: Btu/ft²h degF (W/m² degC)						Ratio of area of openings to floor area			
0.23 (1.31)	0.30 (1.70)	0.80 (4.54)	1.00 (5.68)	0.10-0.13 (b) (0.57-0.74)	0.35 (1.99)	0.30	0.30	0.30	0.30
x		x		x		0.23 (1.31)	0.24 (1.35)	0.23 (1.29)	0.22 (1.25)
x			x	x		0.25 (1.40)	0.24 (1.39)	0.24 (1.36)	0.24 (1.33)
	x	x		x		0.25 (1.42)	0.24 (1.37)	0.25 (1.39)	0.23 (1.31)
	x		x	x		0.27 (1.51)	0.26 (1.47)	0.26 (1.47)	0.25 (1.40)
x		x			x	0.30 (1.70)	0.31 (1.73)	0.30 (1.71)	0.31 (1.77)
x			x		x	0.32 (1.79)	0.32 (1.83)	0.32 (1.79)	0.33 (1.85)
	x	x			x	0.32 (1.81)	0.32 (1.82)	0.32 (1.81)	0.32 (1.83)
	x		x		x	0.33 (1.90)	0.34 (1.91)	0.33 (1.89)	0.34 (1.91)
C.P. 3 Recommendations (c)									
{0.20 (1.14)}		x		{0.20 (1.14)}		0.26 (1.45)	0.26 (1.48)	0.26 (1.46)	0.27 (1.50)
{0.20 (1.14)}			x	{0.20 (1.14)}		0.27 (1.54)	0.28 (1.58)	0.27 (1.52)	0.28 (1.57)

(a) Topmost ceiling: U-value 0.16 (0.91)

(b) For intermediate terraced bungalows 0.10 (0.57), semi-detached and end terraced bungalows 0.12 (0.68), detached bungalows 0.13 (0.74).

(c) Topmost ceiling: 0.20

TABLE 11.27

Average shell U-values in flats with elements of various constructions (a) (calculated from mean surface/floor ratios)

External walls		Windows		Flats with three external walls		Flats with two external walls	
		Wood	Metal				
U-values: Btu/ft^{2}h degF (W/m^2 degC)				Two bedroom	One bedroom	Two bedroom	One bedroom
0.23 (1.31)	0.30 (1.70)	0.80 (4.54)	1.00 (5.68)	N = 21	N = 11	N = 17	Estimated
__Intermediate Floor__							
X		X		0.31 (1.78)	0.31 (1.73)	0.32 (1.84)	0.32 (1.79)
X			X	0.35 (1.96)	0.34 (1.90)	0.37 (2.08)	0.35 (1.98)
	X	X		0.36 (2.04)	0.35 (2.00)	0.36 (2.04)	0.36 (2.02)
	X		X	0.39 (2.21)	0.38 (2.16)	0.40 (2.26)	0.39 (2.21)
__Ground Floor__							
X		X		0.22 (1.22)	0.22 (1.22)	0.20 (1.15)	0.20 (1.16)
X			X	0.23 (1.32)	0.23 (1.32)	0.22 (1.27)	0.22 (1.25)
	X	X		0.24 (1.36)	0.24 (1.37)	0.22 (1.24)	0.22 (1.27)
	X		X	0.26 (1.45)	0.26 (1.46)	0.24 (1.35)	0.24 (1.36)
__Top Floor__							
X		X		0.24 (1.38)	0.24 (1.37)	0.24 (1.33)	0.24 (1.33)
X			X	0.26 (1.48)	0.26 (1.46)	0.26 (1.45)	0.25 (1.43)
	X	X		0.27 (1.52)	0.27 (1.52)	0.25 (1.43)	0.25 (1.44)
	X		X	0.28 (1.61)	0.28 (1.61)	0.27 (1.53)	0.27 (1.53)

C.P. 3 Recommendations (b)

0.20 (1.14)	Wood	Metal	Three ext. walls, Two bedroom	Three ext. walls, One bedroom	Two ext. walls, Two bedroom	Two ext. walls, One bedroom
__Intermediate Floor__						
X	X		0.30 (1.68)	0.29 (1.62)	0.31 (1.74)	0.30 (1.69)
X		X	0.33 (1.86)	0.31 (1.78)	0.35 (1.96)	0.33 (1.89)
__Ground and Top Floor__						
X	X		0.25 (1.43)	0.25 (1.41)	0.25 (1.41)	0.25 (1.40)
X		X	0.27 (1.52)	0.26 (1.50)	0.27 (1.51)	0.26 (1.50)

(a) Topmost ceiling: U-value 0.16 (0.91) Ground floor: 0.10 (0.57) Internal (corridor) wall: 0.36 (2.04) $\{x \frac{1}{2}\}$

(b) Topmost ceiling: 0.20 Ground floor: 0.20 (1.14) entirely of solid construction because the heat loss per unit area of a floor of wooden construction over a garage where the temperature is half-way between that of indoor and outdoor air is not materially different from that of the solid floor. For example: for a wooden floor of boards on joists with a plaster ceiling when the heat flow is downwards the U value is 0.22 (1.25) and the heat loss is equivalent to that of a solid floor with U value 0.11 (0.62).

When the ground floor is hollow it is necessary to make allowance for the different thermal transmittance of the floor over a garage built into the house. This was done for the partly single-storey speculative houses in Table 11.25 , where $\frac{96}{860}$ = 0.11 of the floor is assumed to be over the garage (for assumed floor areas see p.11.61).

Estimated surface/floor ratios were used when determining average shell U values for bungalows.

Population confidence limits of parameters are not given in Tables 11.25 and 11.27 because with the population means of ground floor/floor and ceiling/floor assumed to equal the sample mean the population confidence limits of shell U values only vary as the limits of the overall wall U value, and can be estimated from them if required.

Observed shell U values are given in Tables 11.28, 11.29, 11.30 and 11.31

TABLE 11.28

Observed shell U-values in houses and bungalows

U-value		HOUSES						BUNGALOWS			ALL HOUSES AND BUNGALOWS
		Speculative			Mun.	Spec. and Mun.		Municipal (O.P.)		Spec.	
Btu/ft²h degF	W/m² degC	Detached	Semi-detached Partly single-storey	Semi-detached Wholly two-storey	Semi-detached Wholly two-storey	Terraced End houses	Terraced Inter. Houses	Semi-detached and end terraced	Inter. terraced	Detached (N = 5) Semi-detached (N = 2)	
0.20 - 0.21	1.14 - 1.19							1	3		4
0.22 - 0.23	1.25 - 1.31		1		1	3	1	2	1	3	12
0.24 - 0.25	1.36 - 1.42	2	1	1	4	4	5	5	1	1	24
0.26 - 0.27	1.48 - 1.53	5	4	5	8	4	4				30
0.28 - 0.29	1.59 - 1.65	5	3	4	11	4	5	2			34
0.30 - 0.31	1.70 - 1.76	2	2	5	4	3	2			1	19
0.32 - 0.33	1.82 - 1.87	3	1	4		3	2				13
0.34 - 0.35	1.93 - 1.99	1	2	4	1	2	2			1	13
0.36 - 0.37	2.04 - 2.10					1	3			1	5
0.38 - 0.39	2.16 - 2.21					1					1
0.40 - 0.41	2.27 - 2.33						1				1
0.42 - 0.43	2.38 - 2.44			2							2
Total		18	14	25	29	25	25	10	5	7	158

TABLE 11.29

Observed shell U-values in flats

U-value		GROUND FLOOR						INTERMEDIATE FLOOR						TOP FLOOR						TOTAL FLATS OF ALL TYPES
		Municipal						Municipal						Municipal						
		No. of external walls				Other flats	All flats	No. of external walls				Other flats	All flats	No. of external walls				Other flats	All flats	
		Three		Two				Three		Two				Three		Two				
Btu/ft^{2}h degF	W/m^2 degC	2 bed	1 bed	2 bed	1 bed			2 bed	1 bed	2 bed	1 bed			2 bed	1 bed	2 bed	1 bed			
0.14 - 0.15	0.79 - 0.85			1			1													1
0.16 - 0.17	0.91 - 0.97			2			2													2
0.18 - 0.19	1.02 - 1.08	1		4			5									2			2	7
0.20 - 0.21	1.14 - 1.19	1	1	2		1	5							1		2			3	8
0.22 - 0.23	1.25 - 1.31	4	1	1		1	7							1		2			3	10
0.24 - 0.25	1.36 - 1.42	5	3	2	2	1	13			1			1	3	1	2	1	3	10	24
0.26 - 0.27	1.48 - 1.53	2	1				3			1			1	5	5	4	1	1	16	20
0.28 - 0.29	1.59 - 1.65		1			1	2			1	1		2	4	1	2	1	1	9	13
0.30 - 0.31	1.70 - 1.76							1	1	3			5	4	1	1			6	11
0.32 - 0.33	1.82 - 1.87					1	1		1	1		1	3							4
0.34 - 0.35	1.93 - 1.99	1	1		1	1	4			4	1		5							9
0.36 - 0.37	2.04 - 2.10	2					2	4		1		1	6							8
0.38 - 0.39	2.16 - 2.21	1					1	2					2							3
0.40 - 0.41	2.27 - 2.33							2		1			3							3
0.42 - 0.43	2.38 - 2.44									1			1							1
0.44 - 0.45	2.50 - 2.56																	1	1	1
Total		17	8	12	3	6	46	9	2	14	2	2	29	18	8	15	3	6	50	125

TABLE 11.30

Observed shell U values in maisonettes

U values		Three external walls		Two external walls		All
Btu/ft^{2}h degF	W/m^2 degC	Ground floor	Top floor	Ground floor	Top floor	
0.24 - 0.25	1.36 - 1.42		1	1	2	4
0.26 - 0.27	1.48 - 1.53	1				1
0.28 - 0.29	1.59 - 1.65	1	2			3
0.30 - 0.31	1.70 - 1.76		2	1	2	5
0.32 - 0.33	1.82 - 1.87		1		1	2
0.34 - 0.35	1.93 - 1.99				1	1
Totals		2	6	2	6	16

TABLE 11.31

Observed shell U values in old persons grouped dwellings

U values		Two-storey				One-storey		All
		Number of external walls						
		Two		One		Two	One	
Btu/ft^{2}h degC	w/m^2 degC	Ground floor	Top floor	Ground floor	Top floor	Ground floor		
0.14 - 0.15	0.79 - 0.85	1		1				2
0.16 - 0.17	0.91 - 0.97	1			2			3
0.18 - 0.19	1.02 - 1.08		2			1	1	4
0.20 - 0.21	1.14 - 1.19	1	1	1				3
Totals		3	3	2	2	1	1	12

Indices of thermal insulation

The relationship between the indices of thermal insulation and shell U value is as follows:

Floor index of thermal insulation

$$= \frac{\text{shell U value} \times \text{area of surfaces}}{\text{floor area}}$$

+ ventilation heat loss per unit area of floor

and,

Space index of thermal insulation

$$= \frac{\text{floor index of thermal insulation}}{\text{floor-to-ceiling height.}}$$

When obtaining the average indices shown in Tables 11.32, 11.33, 11.34 and 11.35 the factors used to calculate ventilation heat loss were 0.02 Btu to raise the temperature of 1 ft^3 of air by 1 degF, and 7.75 ft average floor-to-ceiling height, giving 0.155 Btu per 1 ft^2 of floor area.

Because of the simple relationship between floor and space indices only two examples of average space indices for dwellings are given (Table 11.35).

Standardised indices of thermal insulation

Observed floor indices of thermal insulation are recorded in Tables 11.36, 11.37, 11.38 and 11.39 and space indices for the two types of dwelling are given as an example in Table 11.40. In all these Tables the

TABLE 11.32

Average floor indices of thermal insulation in houses with elements of various constructions (calculated from mean surface/floor ratios)

CONSTRUCTION OF ELEMENTS (a)						TYPE OF HOUSE					
WALLS		WINDOWS		GROUND FLOORS		DETACHED	SEMI-DETACHED			TERRACED	
4½" bk 2" cav. and inner leaf of:		Wood	Metal	Solid	Hollow	Speculative	Speculative		Municipal	Speculative and Municipal	
4" clink	4½" bk					Some partly single-storey	Partly single-storey	Wholly single-storey	Wholly two-storey	Some partly single-storey	
U-values: Btu/ft^{2}h degF (W/m^2 degC)										End houses	Inter houses
0.23 (1.31)	0.30 (1.70)	0.80 (4.54)	1.00 (5.68)	0.10-0.13 (b) (0.57 - 0.74)	0.35 (1.99)	N = 18	N = 14	N = 25	N = 29	N = 26	N = 26
x		x		x		0.81 (4.59)	0.73 (4.16)	0.71 (4.04)	0.69 (3.94)	0.71 (4.04)	0.61 (3.49)
x			x	x		0.86 (4.88)	0.78 (4.42)	0.77 (4.35)	0.74 (4.18)	0.76 (4.30)	0.66 (3.75)
	x	x		x		0.89 (5.04)	0.79 (4.51)	0.77 (4.35)	0.75 (4.26)	0.77 (4.38)	0.65 (3.68)
x		x			x	0.92 (5.24)	0.83 (4.73)	0.83 (4.70)	0.81 (4.59)	0.83 (4.71)	0.74 (4.21)
	x		x	x		0.94 (5.34)	0.84 (4.77)	0.82 (4.65)	0.79 (4.50)	0.82 (4.64)	0.69 (3.94)
x			x		x	0.97 (5.53)	0.88 (4.99)	0.88 (5.00)	0.85 (4.83)	0.88 (4.97)	0.79 (4.47)
	x	x			x	1.00 (5.68)	0.89 (5.08)	0.88 (5.00)	0.87 (4.92)	0.89 (5.05)	0.78 (4.41)
	x		x		x	1.05 (5.96)	0.94 (5.34)	0.93 (5.30)	0.91 (5.16)	0.94 (5.31)	0.82 (4.67)
C.P. 3 Recommendations											
0.20 (1.14)		x		0.20 (1.14)		0.83 (4.72)	0.77 (4.39)	0.75 (4.26)	0.70 (3.98)	0.75 (4.24)	0.67 (3.81)
0.20 (1.14)			x	0.20 (1.14)		0.88 (5.01)	0.82 (4.65)	0.80 (4.57)	0.74 (4.20)	0.79 (4.50)	0.72 (4.07)

(a) (b) As Table 11.25

TABLE 11.33

Average floor indices of thermal insulation in bungalows with elements of various constructions
(calculated from estimated mean surface/floor ratios)

CONSTRUCTION OF ELEMENTS (a)						TYPE OF BUNGALOW			
WALLS		WINDOWS		GROUND FLOORS		SPECULATIVE		MUNICIPAL (Old Persons')	
$4\frac{1}{2}$" bk 2" cav. and inner leaf of:						Detached	Semi-detached	Semi-detached	Terraced
4" clink	$4\frac{1}{2}$" bk	Wood	Metal	Solid	Hollow	Ratio of overall wall area to floor area			
						1.20	0.95	1.10	0.75
U-values: Btu/ft^2 degF (W/m^2 degC)						Ratio of area of openings to floor area			
0.23 (1.31)	0.30 (1.70)	0.80 (4.54)	1.00 (5.68)	0.10-0.13 (b) (0.57 - 0.74)	0.35 (1.99)	0.30	0.30	0.30	0.30
X		X		X		0.89 (5.07)	0.83 (4.68)	0.86 (4.88)	0.76 (4.31)
X			X	X		0.94 (5.35)	0.88 (4.97)	0.90 (5.12)	0.80 (4.55)
	X	X		X		0.96 (5.42)	0.87 (4.94)	0.92 (5.20)	0.79 (4.49)
	X		X	X		1.01 (5.71)	0.92 (5.22)	0.96 (5.43)	0.83 (4.72)
X		X			X	1.11 (6.31)	1.06 (5.99)	1.09 (6.18)	1.01 (5.73)
X			X		X	1.16 (6.60)	1.11 (6.27)	1.13 (6.42)	1.05 (5.97)
	X	X			X	1.18 (6.67)	1.10 (6.25)	1.15 (6.50)	1.04 (5.91)
	X		X		X	1.23 (6.96)	1.15 (6.53)	1.19 (6.74)	1.08 (6.14)
C.P. 3 Recommendations (c)									
{0.20 (1.14)}		X		{0.20 (1.14)}		0.98 (5.54)	0.93 (5.25)	0.96 (5.42)	0.89 (5.03)
{0.20 (1.14)}			X	{0.20 (1.14)}		1.03 (5.82)	0.98 (5.54)	0.99 (5.60)	0.92 (5.21)

(a) (b) (c) As Table 11.26

TABLE 11.34

Average floor indices of thermal insulation in flats with elements of various constructions (a)
(calculated from mean surface/floor ratios)

External Walls		Windows		Flats with three external walls		Flats with two external walls	
		Wood	Metal	Two bedroom	One bedroom	Two bedroom	One bedroom
U-values Imp (S.I.)							
0.23 (1.31)	0.30 (1.70)	0.80 (4.54)	1.00 (5.68)	N = 21	N = 11	N = 17	Estimated
Intermediate Floor							
X		X		0.52 (2.94)	0.55 (3.10)	0.43 (2.44)	0.45 (2.54)
X			X	0.55 (3.14)	0.58 (3.32)	0.47 (2.65)	0.48 (2.73)
	X	X		0.57 (3.23)	0.61 (3.44)	0.46 (2.62)	0.49 (2.75)
	X		X	0.60 (3.43)	0.64 (3.65)	0.49 (2.80)	0.52 (2.94)
Ground Floor							
X		X		0.62 (3.50)	0.65 (3.67)	0.53 (3.01)	0.55 (3.11)
X			X	0.65 (3.71)	0.68 (3.88)	0.57 (3.22)	0.58 (3.29)
	X	X		0.67 (3.79)	0.71 (4.00)	0.56 (3.19)	0.59 (3.32)
	X		X	0.70 (4.00)	0.74 (4.22)	0.59 (3.37)	0.62 (3.50)
Top Floor							
X		X		0.68 (3.84)	0.71 (4.01)	0.59 (3.35)	0.61 (3.45)
X			X	0.71 (4.05)	0.74 (4.22)	0.62 (3.53)	0.64 (3.63)
	X	X		0.73 (4.13)	0.77 (4.34)	0.62 (3.52)	0.65 (3.66)
	X		X	0.76 (4.34)	0.80 (4.56)	0.65 (3.71)	0.68 (3.84)

C.P. Recommendations (b)

0.20 (1.14)	Wood	Metal	Flats with three external walls: Two bedroom	Flats with three external walls: One bedroom	Flats with two external walls: Two bedroom	Flats with two external walls: One bedroom
Intermediate Floor						
X	X		0.49 (2.81)	0.52 (2.95)	0.42 (2.36)	0.43 (2.45)
X		X	0.53 (3.02)	0.56 (3.16)	0.45 (2.54)	0.46 (2.63)
Ground and Top Floor						
X	X		0.69 (3.94)	0.72 (4.09)	0.62 (3.50)	0.63 (3.59)
X		X	0.73 (4.16)	0.76 (4.29)	0.65 (3.68)	0.66 (3.77)

(a) (b) As Table 11.27

TABLE 11.35

Average space indices of thermal insulation in houses with elements of various constructions
(Calculated from mean surface/floor ratios)

CONSTRUCTION OF ELEMENTS(a)						TYPE OF HOUSE	
Walls		Windows		Ground Floors		Speculative	
4½" bk 2" cav. and inner leaf of:		Wood	Metal	Solid	Hollow	Detached	Semi-Detached
4" clink	4½" bk					Some partly single-storey	Wholly two-storey
U-values: Btu/ft^{2}h degF (W/m^2 degC)							
0.23 (1.31)	0.30 (1.70)	0.80 (4.54)	1.00 (5.68)	0.10-0.13 (b) (0.57-0.74)	0.35 (1.99)	N = 18	N = 25
X		X		X		0.104 (0.59)	0.092 (0.52)
X			X	X		0.110 (0.63)	0.099 (0.56)
	X	X		X		0.115 (0.65)	0.099 (0.56)
X		X			X	0.119 (0.68)	0.107 (0.61)
	X		X	X		0.121 (0.69)	0.106 (0.60)
X			X		X	0.126 (0.71)	0.114 (0.65)
	X	X			X	0.129 (0.73)	0.114 (0.65)
	X		X		X	0.135 (0.77)	0.120 (0.68)
CP3 Recommendations (c)							
{0.20 (1.14)}		X		{0.20 (1.14)}		0.107 (0.61)	0.097 (0.55)
			X			0.114 (0.65)	0.104 (0.46)

(a) (b) (c) as Table 11.25

TABLE 11.36

Observed and standardized floor indices of thermal insulation of houses

Index		DETACHED		SEMI-DETACHED						TERRACED				ALL	
		Speculative		Speculative				Municipal		Speculative and Municipal					
		Some partly single-storey		Partly single-storey		Wholly two-storey		Wholly two-storey		Some partly single-storey					
										End houses		Inter houses			
Btu/h degF ft² of floor	W/degC m² of floor	Observed	Standardized	Observed	Standardized	Observed	Standardized	Observed	Standardized	Observed	Standardized	Observed	Standardized	Observed	Standardized
0.45-0.50	2.56-2.84											1		1	
0.50-0.55	2.84-3.12											2	1	2	1
0.55-0.60	3.12-3.41											3	3	3	3
0.60-0.65	3.41-3.69			1	1			2	1	4	5	5	6	12	13
0.65-0.70	3.69-3.97				1	6	5	7	18	4	6	6	9	23	39
0.70-0.75	3.97-4.26	3	1	4	4	5	18	15	7	5	9	5	6	37	45
0.75-0.80	4.26-4.54	5	6	3	8	5	2	3	2	3	5	2		21	23
0.80-0.85	4.54-4.83	2	9	2		4		2	1	4				14	10
0.85-0.90	4.83-5.11	3	1	4		3				4		1		15	1
0.90-0.95	5.11-5.39	3	1			2								5	1
0.95-1.00	5.39-5.68	1								1				2	
1.00-1.05	5.68-5.96	1												1	
Total		18	18	14	14	25	25	29	29	25	25	25	25	136	136

TABLE 11.37

Observed and standardized floor indices of thermal insulation in bungalows

Index		MUNICIPAL (Old Persons)				SPECULATIVE		ALL	
		Semi-detached and end terraced		Intermediate terraced		Detached (N = 4) Semi-detached (N = 2)			
Btu/h degF ft2 of floor	W/degC m2 of floor	Observed	Standardized	Observed	Standardized	Observed	Standardized	Observed	Standardized
0.65-0.70	3.69-3.97			2	1			2	1
0.70-0.75	3.97-4.26	1			1			1	1
0.75-0.80	4.26-4.54	1		1	1			2	1
0.80-0.85	4.54-4.83		5		2	3	3	3	10
0.85-0.90	4.83-5.11	5	3	1			2	1	5
0.90-0.95	5.11-5.39		1			1	1	1	2
0.95-1.00	5.39-5.68			1				1	
1.00-1.05	5.68-5.96	1						1	
1.05-1.10	5.96-6.25	1						1	
1.10-1.15	6.25-6.53	1	1			1		2	1
1.15-1.20	6.53-6.81								
1.20-1.25	6.81-7.10								
1.25-1.30	7.10-7.38								
1.30-1.35	7.38-7.67					1		1	
Total		10	10	5	5	6	6	21	21

TABLE 11.38

Observed and standardized floor indices of thermal insulation in flats

Index		MUNICIPAL								OTHERS		ALL	
		Flats with three external walls				Flats with two external walls							
		Two bedroom		One bedroom		Two bedroom		One bedroom					
Btu/h degF ft[2] of floor	W/degC m[2] of floor	Obser-ved	Stan-dardized	Obser-ved	Stan-dardized	Obser-ved	Stan-dardized	Obser-ved	Stan-dardized	Obser-ved	Stan-dardized	Obser-ved	Stan-dardized
Intermediate Floor													
0.30-0.35	1.70-1.99					1						1	
0.35-0.40	1.99-2.27					4	4				1	4	5
0.40-0.45	2.27-2.56		1			4	6	1		1		6	7
0.45-0.50	2.56-2.84		2			4	3	1	2	1		6	7
0.50-0.55	2.84-3.12	4	4	1	2		1				1	5	8
0.55-0.60	3.12-3.41	2	2	1		1						4	2
0.60-0.65	3.41-3.69	2										2	
0.65-0.70	3.69-3.97	1										1	
Total		9	9	2	2	14	14	2	2	2	2	29	29
Ground Floor													
0.40-0.45	2.27-2.56					2						2	
0.45-0.50	2.56-2.84					5	4				1	5	5
0.50-0.55	2.84-3.12	1	2			2	4	1	1	1	1	5	8
0.55-0.60	3.12-3.41	1	5			1	3		2	1	1	3	11
0.60-0.65	3.41-3.69	5	7	2	4	2	1				1	9	13
0.65-0.70	3.69-3.97	4	2	1	2			1		1	2	7	6
0.70-0.75	3.97-4.26	2	1	1	1					2		5	2
0.75-0.80	4.26-4.54	1		2	1					1		4	1
0.80-0.85	4.54-4.83			1				1				2	
0.85-0.90	4.83-5.11	2										2	
0.90-0.95	5.11-5.39			1								1	
0.95-1.00	5.39-5.68	1										1	
Total		17	17	8	8	12	12	3	3	6	6	46	46
Top Floor													
0.45-0.50	2.56-2.84					2						2	
0.50-0.55	2.84-3.12					2	5				1	2	6
0.55-0.60	3.12-3.41	1	1			5	4	1		1		8	5
0.60-0.65	3.41-3.69	2	5			3	4		3	1	2	6	14
0.65-0.70	3.69-3.97	3	8	2	3	2	2	1		1		9	13
0.70-0.75	3.97-4.26	7	2		3			1		1	3	9	8
0.75-0.80	4.26-4.54	3	2	4	1	1				1		9	3
0.80-0.85	4.54-4.83	2		2	1							4	1
0.85-0.90	4.83-5.11												
0.90-0.95	5.11-5.39												
0.95-1.00	5.39-5.68									1		1	
Total		18	18	8	8	15	15	3	3	6	6	50	50

TABLE 11.39

Observed and standardised floor indices of thermal insulation in maisonettes and old persons grouped dwellings

Index		Maisonettes		Old Persons Grouped Dwelling	
Btu/h degF ft^2 of floor	W/h degC m^2 of floor	Observed	Standardised	Observed	Standardised
No index			2		
0.45 - 0.50	2.56 - 2.84		1	1	
0.50 - 0.55	2.84 - 3.12	5	5	3	
0.55 - 0.60	3.12 - 3.41	3	2	3	1
0.60 - 0.65	3.41 - 3.69	3	4	3	3
0.65 - 0.70	3.69 - 3.97	3		1	3
0.70 - 0.75	3.97 - 4.26				3
0.75 - 0.80	4.26 - 4.54			1	1
0.80 - 0.85	4.54 - 4.83				1
	Total	14	14	12	12

TABLE 11.40

Observed and standardised space indices of thermal insulation in houses

Index		Speculative			
		Detached		Semi-detached	
		Some partly single-storey		Wholly two-storey	
Btu/h degF ft^3 of dwelling	W/degC m^3 of dwelling	Observed	Standardised	Observed	Standardised
0.080 - 0.085	0.45 - 0.48			1	
0.085 - 0.090	0.48 - 0.51			3	2
0.090 - 0.095	0.51 - 0.54	2	1	5	18
0.095 - 0.100	0.59 - 0.57	1	2	5	4
0.100 - 0.105	0.57 - 0.60	5	9	3	1
0.105 - 0.110	0.60 - 0.62	2	3	1	
0.110 - 0.115	0.62 - 0.65	3	1	4	
0.115 - 0.120	0.65 - 0.68	2	1	2	
0.120 - 0.125	0.68 - 0.71	1	1	1	
0.125 - 0.130	0.71 - 0.74	1			
0.130 - 0.135	0.74 - 0.77	1			
		18	18	25	25

TABLE 11.41

Difference between observed and standardized floor indices of thermal insulation in houses and bungalows

Difference (plus signifies observed better then standardized, minus signifies observed worse than standardized.)		HOUSES						BUNGALOWS			ALL HOUSES AND BUNGALOWS	HOUSES AND BUNGALOWS	
		Speculative			Mun.	Spec. and Mun.		Municipal (O.P.)		Spec.		(a)	(b)
Btu/h degF ft² of floor	W/degC m² of floor	Detached	Semi-detached Partly single-storey	Semi-detached Wholly two-storey	Semi-detached Wholly two-storey	Terraced End houses	Terraced Inter houses	Semi-detached and end terraced	Inter. terraced	Detached (N = 5) Semi-detached (N = 2)		Speculative	Municipal
+0.15-+0.10	+0.85-+0.57								1		1		1
+0.10-+0.05	+0.57-+0.28	2	1	1		1		1			6	5	1
+0.05- 0.00	+0.38- 0.00	7	5	6	9	9	8	2	1	4	51	28	23
0.00--0.05	0.00--0.28	2	1	7	10	3	6	3	2		34	15	19
-0.05--0.10	-0.28--0.57	3	3	2	9	6	4	2			29	17	12
-0.10--0.15	-0.57--0.85	2	3	4	1	2	5	1	1		19	15	4
-0.15--0.20	-0.85--1.14	2	1	4		3	1	1		1	13	11	2
-0.20--0.25	-1.14--1.42			1							1	1	
-0.25--0.30	-1.42--1.70					1					1	1	
-0.30--0.35	-1.70--1.99						1			1	2	2	
-0.35--0.40	-1.99--2.27												
-0.40--0.45	-2.27--2.56												
-0.45--0.50	-2.56--2.84									1	1	1	
Total		18	14	25	29	25	25	10	5	7	158	96	62

TABLE 11.42

Difference between observed and standardized floor indices of thermal insulation in flats

Difference (plus signifies observed better than standardized, minus signifies observed worse than standardized.)		GROUND FLOOR						INTERMEDIATE FLOOR						TOP FLOOR						TOTAL FLATS OF ALL TYPES
		Municipal				Other flats	All flats	Municipal				Other flats	All flats	Municipal				Other flats	All flats	
		No. of external walls						No. of external walls						No. of external walls						
		Three		Two				Three		Two				Three		Two				
Btu/h degF ft^2 of floor	W/degC m^2 of floor	2 bed	1 bed	2 bed	1 bed			2 bed	1 bed	2 bed	1 bed			2 bed	1 bed	2 bed	1 bed			
+0.15-+0.10	+0.85-+0.57			1			1									1			1	2
+0.10-+0.05	+0.57-+0.28			3		1	4									2	1		3	7
+0.05- 0.00	+0.28- 0.00	2		4	1		7	1	1	6	1	1	10	6	1	6		3	16	33
0.00--0.05	0.00--0.28	7	5	2		3	17	4		7	1		12	3	3	2	1		9	38
-0.05--0.10	-0.28--0.57	5	1	2	1		9	4	1	1		1	7	7	3	2		2	14	30
-0.10--0.15	-0.57--0.85		1				1								1	2	1		4	5
-0.15--0.20	-0.85--1.14					1	1							2					2	3
-0.20--0.25	-1.14--1.42					1	1													1
-0.25--0.30	-1.42--1.70						1													1
-0.30--0.35	-1.70--1.99	3	1		1		4													4
-0.35--0.40	-1.99--2.27																	1	1	1
Total		17	8	12	3	6	46	9	2	14	2	2	29	18	8	15	3	6	50	125

TABLE 11.43

Difference between observed and standardised floor indices of thermal insulation in maisonettes and old persons grouped dwellings

Difference		Maisonettes	O.P.G.D
+0.15 - +0.10	+0.85 - +0.57		6
+0.10 - +0.05	+0.57 - +0.28		4
+0.05 - 0.00	+0.28 - 0.00		2
0.00 - 0.05	0.00 - -0.28	9	
-0.05 - -0.10	-0.28 - -0.57	3	
		12	12

TABLE 11.44

Quality of insulation in houses and bungalows

Observed floor index compared with standardised floor index	Class of house or bungalow			
	Speculative		Municipal	
	No.	%	No.	%
Better	5	5	2	3
Equal	43	45	42	68
Worse	48	50	16	29
Total	96		62	

and (b), Table 11.41) failed to pass the Kolmogorov-Smirnov test for the assumption of normality in the population distributions.

If a dwelling with a difference between observed and standardised floor indices falling into the categories 0.05 to 0 or 0 to -0.05 is considered to have insulation equal to that of the standardised construction then a simplified comparation of results shows the distribution given in Table 11.44.

The categories of Table 11.44 were modified to (i) equal or better, and (ii) worse. The null hypothesis that there was no significant difference between the two classes (speculative and municipal) was then tested using the χ^2 test with Yate's correction for continuity.

$$\chi^2 \text{ (corrected)} = \sum_{i=1}^{r} \sum_{j=1}^{k} \frac{(|O_{ij} - E_{ij}| - 0.5)^2}{E_{ij}}$$

where:

O_{ij} = observed number of cases categorised in i-th row of j-th column.

E_{ij} = number of cases expected under H_o to be categorised in i-th row of j-th column.

The values of χ^2 yielded by the formula are distributed approximately as chi-square with one degree of freedom.

The result $\chi^2 = 6.04$, $\alpha = 0.05$ showed that the difference was probably significant.

DISCUSSION OF RESULTS

Surface/floor ratios

The mean overall wall/floor ratios observed were greater than those found by Weston in municipal houses in 1951. His were sample means which for walls fell outside the population confidence means of Table 11.13. It is not possible to say whether this indicates a deterioration in thermal insulation considerations of design because the surface areas observed by Weston are not clearly defined.

To typify current design and highlight the observed data a detached house without integral garage or single-storey addition is first considered. Such a house would have a perimeter wall of around 90 ft in length. For example: houses with ground floor areas of 20 ft. by 25 ft., 21 ft. by 24 ft. and 22 ft. by 23 ft. all have perimeters of 90 ft. Two storeys with a floor-to-ceiling height of 7 ft 9 in give a wall area of 1395 ft^2, the floor area is 1000 ft^2, or nearly so, therefore the wall/floor ratio is 1.40. Table 11.13 shows an observed value of 1.44; the additional area is due to garages built in and single-storey kitchens, lobbies and the like.

A semi-detached house of plain design has a perimeter wall of around 60 ft length, say a frontage of 18 ft and a depth of 24 ft. This gives a wall/floor ratio of 1.08 which agrees with the observed mean.

The additional wall/floor ratio of partly single-storey semi-detached houses might arise as follows:

Assume a garage, 16 ft by 8 ft internal dimensions on plan, built in for half of its length: a common arrangement.

Ground floor area of residential part	398 ft^2
First floor area of residential part	462 ft^2
Total floor area of residential part	860 ft^2
Garage area built in	64 ft^2

The wall area will be the same as for a house without garage with a ground floor and first floor area of 462 ft^2 each, but building in the garage reduces the floor area by 64 ft^2, that is by $\frac{64}{462 + 462} = 7\%$.
Therefore, ratio of wall area to residential floor area $= \frac{1.08}{0.93} = 1.16$ (observed mean 1.15).

The ratio of the lowest floor area to the residential floor area, and hence the ceiling/floor ratio also, in the above example is:

$$\frac{\text{Ground floor area + floor area over garage}}{\text{Total floor area}}$$

$$= \frac{398 + 64}{860} = 0.54 \text{ (observed mean 0.55).}$$

As would be expected semi-detached houses of partly single-storey construction showed more variety in design than wholly two-storey houses largely due to the length of garage built in. Perhaps not so obvious is the greater uniformity of speculative wholly two-storey semi-detached compared with municipal houses of the same type.

The end houses of terraces of the speculative class were nearly always of exactly the same design as other houses in the terrace except that they had a blank gable wall on one side instead of a party wall. There was a similar tendency in municipal houses but these often had "entries" to give access to the rear of intermediate houses, which were not found in speculative houses. This affected the plan of intermediate houses and increased the exposed wall area. Speculative terraced houses had more single storey projections of kitchens, cloakrooms and lobbies than semi-detached houses. These factors are reflected in the figures given in Table 11.13 and cast doubt on the common assumption that the end houses of terraces have the same design characteristics as semi-detached houses.

Three external walls of a two bedroom flat will have a length of about 80 ft floor area say 26 ft by 27 ft. The external wall area will then be 620 ft^2 and the wall/floor ratio 0.89 (observed mean 0.91). With two external walls the wall area reduces to 410 ft and the wall/floor ratio to 0.59 (observed mean 0.61).

One bedroom flats with three external walls will have an external perimeter of around 60 ft, floor area say 22 ft by 22 ft, wall/floor ratio 1.06 (observed mean 1.04). With two external walls the ratio becomes 0.70 (estimate from observed mean - 0.69).

The internal wall/floor ratio of 0.24 (Table 11.17) shows that for two bedroom flats the average internal wall will have a length a little greater than three-quarters of one of the flat's dimensions. In one bedroom flats the average length is about two-thirds of one of the dimensions.

Window/floor ratios have increased since Weston measured them. Municipal semi-detached show an increase of about 0.02, terraced houses a larger increase, that of 0.05, possibly due to the current use of a wall of windows and infill panels at front and rear, between party crosswalls in such dwellings. Weston's work did not include speculative housing, they may then have had larger window/floor ratios than municipal, certainly all speculative housing in this work showed a larger ratio of windows than municipal, this is not surprising - at first sight a house seems much more attractive and spacious when well lit.

For "flatted houses" Weston's figures were 0.14 and 0.15 respectively for the mean window/floor ratios of ground and first floor flats in a sample of twelve designs. The description seems to indicate that these flats had three external walls and two bedrooms which means that the ratio of windows to floor has increased by 0.04 - 0.05.

Element U values

The Building Regulations 1965 and hence their provisions concerning the thermal insulation of dwellings came into operation on 1st February 1966. The various local byelaws which the Regulations replaced were based on the Model Byelaws:Series IV:Buildings (1953 Edition) issued by the Ministry of Housing and Local Government. An amendment to the Model Byelaws published in 1959 required that thermal transmittance of walls, floors and roofs of domestic buildings to be limited to the same maximum values as are now required by the Building Regulations.

Some doubt exists as to whether all authorities in the area covered by the survey adopted the 1959 amendment. If they did not, the operation of the Building Regulations is not likely to have affected the construction of walls as the 1953 Model Byelaws included a requirement that the U value of external walls should not exceed 0.3, neither is it likely to have affected floors because hollow floors were permitted, but it may have affected ceiling insulation for the 1953 requirement was a maximum of 0.42 (Btu/ft^{2}h degF).

Apart from the difficulty of ascertaining whether the requirements concerning thermal insulation had changed, the effect of the Building Regulations was further obscured by the difficulty of determining whether a dwelling had been erected under the Byelaws or the Regulations. An attempt was made at this and it is believed that about 65% of the dwellings observed came under the Regulations.

Not all the walling with a U value of 0.30 in Table 11.18 was 11 in all-brick cavity work, 10 in no-fines concrete (see appendix) has the same U value. Two municipal houses and one flat were constructed of no-fines concrete of this thickness. When allowance is made for this there is still a high proportion of municipal walling of 0.30 U value and it is apparent that there has been a preference shown for 11 in all-brick cavity walls in municipal houses and bungalows, although speculative builders showed a marked preference for clinker blocks for the inner leaf. Presumably all-brick walls predominated in flats and maisonettes because they were felt necessary for strength. Solid brick walling 9 in thick was observed in a speculative house, completed March 1967, in spite of the Building Regulation's requirements (the owner said he liked it that way because it was good solid construction - no doubt the builder had made a selling point of it).

The walling of non-traditional construction generally showed little, if any, improvement on traditional except where advantage was taken of hollow construction to provide glasswool or cellular polystyrene insulation, even then in no case was the insulating material more than 1 in thick. One system on which a great deal of design work had been done and which was being extensively used by a local authority had a wall construction with a U value exceeding the maximum allowable under the Building Regulations. Other systems - no-fines concrete construction for example - were only just within the requirements.

Feature panels were on the whole of slightly better insulating value than the main walling, even so insulating materials were sparcely used, sometimes it was no more than insulating plasterboard.

The predominate use of solid ground floors in municipal housing did much to compensate for poorer wall insulation when compared with speculative.

There was less insulating plasterboard used as ceiling insulation in municipal housing than in speculative, otherwise roof and ceiling insulation in the two types did not differ greatly.

Little attention had been paid to the insulation of internal walls in flats and maisonettes,as with walls separating houses and garages it was often ridiculously low.

Overall wall U values

In the average design of most types of house, openings in walls reduced the overall wall U value below the Scottish minimum requirement of 0.42 when all-brick cavity walls were used. Indeed, in intermediate terraced houses the Scottish requirement was exceeded even with walling to CP3 recommendations, although of course, the area is limited in such houses. Of the observed values in houses and bungalows almost 30% exceeded 0.42 Btu/ft^{2}h degF (2.38 W/m^2 degC).

In flats and maisonettes the overall wall U value was calculated (as with houses) from the wall surfaces from which heat could be lost and therefore included the internal walls. Even so, some of the observed values still exceeded 0.42.

Double glazing was observed in only flats and only in three cases. In one block of flats where double wooden sashes were provided at all windows, a panel, approximately 20 ft^2 in area, below the living room window was composed of silica-asbestos ½ in thick with a U value of about 1.00 Btu/ft^{2}h degF*.

Although feature panels generally had only a slight effect on the observed overall U values, in some cases their effect on the walls on individual rooms must have been appreciable.

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* In the bedrooms it was not possible to separate the sashes to clear the glass on the inside without scraping the sashes on the ceiling.

Shell U values

The insulating value of the structure as a whole is, of course, of more value than the U value of its individual elements in assessing the standard of insulation in dwellings. As there are no statutory regulations or recommendations in terms of shell U values, Tables 11.25, 11.26 and 11.27 must be used to judge the standard of the observed values.

The principal limitation of the use of the shell U value is that values constituting a satisfactory standard are numerically different for the different types of dwellings. This is most apparent in flats. However, if recommended standards were expressed in terms of shell U values this might lead to a raising of standards without infringing too much on peoples freedom to build their homes the way they want to.

Indices of thermal insulation

The most satisfactory way of expressing the standard of thermal insulation in a dwelling is by means of an index of thermal insulation that takes into account all features of design and construction. The floor index is perhaps more meaningful than the space index because the floor area of a dwelling is descriptive of its accommodation. It is also more useful when considering the effect of floor and ceiling insulation, for instance, in a bungalow an improvement in the U value of the floor will make the same improvement, numerically, in the floor index.

There are no British recommendations in terms of an index of thermal insulation. If it were thought desirable that there should be, then the values given in Tables 11.32, 11.33 and 11.34 would give guidance in the adoption of reasonable figures. There would be no difficulty in improving on the U.S.A. maximum of 1.25 (Btu/h degF ft^2 of floor) for the floor index but the French maximum space index of 0.081 (Btu/ft^3h degF) for multi-storey flats outside the Eastern and Mediterranean areas might be more demanding if applied to ground floor and top floor flats (0.081 space index corresponds to 0.63 floor index).

The standardised floor index shows the standard of insulation which could easily have been achieved in a dwelling without, it is believed, adding to its cost. It is much higher than what is felt to be desirable and improvement would not be uneconomic. If a dwelling has actually been constructed in the standardised form its index is likely to be lower than the theoretical value because of the reduction in its heat loss due to orientation, adjacent garages, and perhaps feature panels.

In general terms, the method of construction in 50% of speculative house and bungalow designs, 29% of municipal house and bungalow designs and 36% of individual flat designs gave them a floor index of thermal insulation worse than that of standardised construction.

SUGGESTIONS FOR FURTHER WORK

Further research is needed to establish the standard of insulation in the total number of all recently constructed dwellings. The economic benefits which would ensue from an improvement in insulation could then be evaluated.

Living rooms are warmed to higher temperatures than other rooms but often contain proportionally larger glazed areas. Investigation into standards of insulation in living rooms might lead to study of the feasibility of providing such rooms with insulation superior to that of the rest of the dwelling as was recommended by the Egerton Committee.

Because of the low thermal insulation of the conventional suspended timber ground floor it is desirable to investigate whether there are now good reasons, economic, constructional, and pleasurable, for continuing their use.

Experimental studies to determine the thermal transmittance of different types of windows and doors are desirable.

Temperatures in unheated spaces in buildings and associated heat loss to them from adjacent surfaces need experimental study.

CHAPTER 12

H E A T I N G

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HEATING

SUMMARY

Recommended room temperatures are given and the concept of a house mean temperature described. The type of fuel used together with the system and extent of heating in 183 dwellings of different design and location is given and where possible the rating of the appliance and of radiators is compared with the calculated heat loss. The opinion of 192 occupiers of the efficiency of the systems in their homes and its cost is given. For warm-air systems the relation between excess capacity of the appliance and occupiers' opinion of heating costs is analysed.

INTRODUCTION

In heating a building we are concerned with maintaining a comfortable temperature. Feelings of warmth are governed by four thermal factors (i) the temperature of the air, (ii) the humidity of the air, (iii) the speed of movement of the air, (iv) radiation to and from our surroundings. Of these factors, humidity will have little effect at temperatures commonly found within buildings, movement of the air is necessary to avoid a feeling of stuffiness and to eliminate body odours but its speed must be limited to avoid draughts, radiation complements air temperature and the two should be considered together.

A scale of equivalent temperature which took account of air temperature, radiation and air-movement was developed by A.F. Dufton. It was used in Post-War Building Studies No.19 (The Egerton Report) to express recommended temperatures in dwellings but is not now in common use and more recent recommendations have been in terms of air temperature.

A new concept of environmental temperature is to be recommended for the 1970 IHVE Guide, this is a weighted mean temperature roughly equivalent to two-thirds mean radiant temperature and one-third air temperature.

RECOMMENDED STANDARDS

The recommendations of the Egerton Report of 1945 were based on a system of warming where the whole dwelling was to be maintained at a temperature of at least 45 - 50°F and rooms "topped up" as required. This concept was shown to be unworkable in practice largely because of the thermal capacity of the building and hence the failure of room temperature to drop to the "background temperature" when rooms were not in use(1).

Later the Parker Morris report recommended that the minimum standard should be an installation capable of heating kitchens and circulating areas to 55°F (13°C) and living areas to 65°F (18°C) when the outside temperature is 30°F - these are, presumably, air temperatures.

It is now generally felt that a higher temperature is desirable in living rooms and CP3006:1969 "Central heating for domestic premises, Part 1, Low pressure forced circulation hot water (Small bore) systems" gives the following room air temperatures on which it recommends heat loss calculations should be based:

	^{o}F	^{o}C
Living, dining or bedsitting room	70	21
Bedroom	55	13
Hall, kitchen and toilet	60	16
Bathroom	65	18

"The Guide to Good Practice" drawn up by the Heating and Ventilating Contractors Association and the Institution of Heating and Ventilating Engineers recommends that a central heating system should be able to provide the following air temperatures when it is 30^{o}F outside:

	^{o}F	^{o}C
Living rooms	70	21
Bathroom (where practicable)	65	18
Hall and landing	60	16
Bedrooms	55	13

These are essentially the same room temperatures as recommended by CP3006.

To meet the requirements of the National House Builders Registration Council a dwelling must be equipped with a fixed appliance or appliances capable of providing heat, at least to the principal living room, at a rate of not less than 4 Btu per hour per ft^3 of room capacity.

PREVIOUS WORK

Following publication of the Egerton Report (1945) extensive experimental work on the heating of housing was carried out at Abbots Langley by the Building Research Station (1949). This work showed that temperatures of individual rooms cannot be considered in isolation and led to the concept of a "house mean temperature" obtained by taking an average of the air temperature of all rooms in a house including the hall and landing with the living room included twice. It was found that this gave a close estimate of the heat loss of the whole house and two broad categories of outdoor-indoor temperature difference were established for a seasonal mean outdoor temperature of 43.5°F: 18°F when the whole house is heated and 12°F when the heating is confined to the lower part of the house.

When temperatures in flats were studied by Dick, Madge and Craig (1961)[2] they took the straight mean of room air temperatures to find a "flat mean temperature". This gave 64 degF for centrally heated flats, 60 degF for flats with individual solid fuel appliances and 57.5 degF for those with electric floor-warming systems. Their evidence suggested that the typical winter average temperature rise of a flat is about 20 degF with central heating and about 14 degF with electric floor-warming. They stated that the lower value for floor-warming appeared to be satisfactory and "there were no widespread complaints that the dwellings were cold."

Eight local authority developments in London and the Midlands were surveyed by Messrs Wates Ltd (1967)[3] who stated that the level of acceptability of the heating installations ranged from 90% satisfaction in one area with gas-fired ducted warm air to dining room, hall and bedroom to 40% satisfaction in the two and three-bedroom flats in another area where there was no specific provision for space heating.

A survey commissioned by the National House Builders Registration Council (1968) included an investigation into forms of heating and type of fuel provided in new houses and recorded the degree of satisfaction that purchasers felt with their heating arrangements. Two-thirds of new houses were provided with central heating, half of these being gas-fired. Of central heating fuels, oil gave the greatest satisfaction followed by gas then solid fuel.

EXAMINATION OF DWELLINGS

The system of heating and type of fuel used was noted together with the rating of the appliance where this was possible. No ratings were available for underfloor heating, neither could ratings be recorded when appliances bore no indication of their input or output and the occupiers had no instruction booklet or card on which the rating was indicated. Where a hot water system was installed the area of the radiators was taken in some cases.

At first, thermostat settings were noted but it soon became apparent that most people were constantly altering the setting and that there was little value to be obtained from recording the setting at the time of observation.

In blocks of flats where more than one flat of the same plan was visited on different floors, the rating of the appliance was noted during the examination of the first flat visited. It was assumed that the same appliance would be used in all flats of the same size in the block. This was not verified and later it was decided that only appliances actually seen should be included in the results. The same consideration was observed with terraced houses even though it was likely that the same appliance was used in end houses as in intermediate houses.

All occupiers were asked whether they found the temperature in living rooms, kitchen, and bedrooms during winter time either cold, all right or too hot. They were also asked whether they thought the cost of heating was cheap, reasonable or expensive.

DEFINITIONS

Whole house heating - The provision of heating arrangements in all rooms of a dwelling.

Part house heating - The provision of heating arrangements from a central source in more than one room of a dwelling.

Single fires - Fixed fires each heating one room only.

Appliance rating - The heat output, as stated by the manufacturer, of a boiler, warm air furnace or heater.

RESULTS

A total of 183 different buildings was visited and the method of heating examined. The number of people interviewed exceeded the number of buildings because where the buildings comprized multiple dwellings generally more than one dwelling was visited and the occupier interviewed. There were, of course, no occupiers in showhouses and in some other dwellings the occupiers were unable to express any opinions as to the adequacy of the heating, usually because they had not been in occupation during the winter.

Two-thirds of all buildings visited had central heating as shown in Table 12.1, but the proportion was greater in municipal dwellings than in speculative dwellings. Gas was used for 60% of all central heating systems but was more favoured in speculative dwellings, as shown in Table 12.2. Only solid fuel single fires were fitted in municipal dwellings but gas and electric fires were fitted in speculative dwellings.

TABLE 12.1

Method of heating dwellings

Heating System	Municipal		Speculative		Others	All	
	No	%	No	%		No	%
Central heating:							
whole house	25	27	27	32	5	57	31
part house	46	51	18	21	1	65	36
Single fire:	20	22	39	46	2	61	33
Totals	91		84		8	183	

TABLE 12.2

Fuels used for heating

	Municipal No.	Municipal %	Speculative No.	Speculative %	Other	All No	All %
Central Heating							
Solid	16	23	6	13		22	18
Oil			3	7		3	3
Gas	37	52	31	69	5	73	60
Electricity	18	25	5	11	1	24	20
Totals	71		45		6	122	
Single Fires							
Solid	17	85	19	49	1	37	61
Gas			13	33		13	21
Electricity			5	13	1	6	10
More than one	3	15	2	5		5	8
Totals	20		39		2	61	

More than half the central heating systems observed used ducted warm air (Table 12.3). Municipal houses did not have radiator systems other than those where the heat was generated by a high-output back boiler except in one multi-storey block of flats where a central boiler supplied heat to all flats.

A wide divergence in the size of appliance fitted in dwellings of similar heat requirements was observed. This is illustrated in Fig. 12.1

TABLE 12.3

Type of central heating

Heating System	Municipal No.	Municipal %	Speculative No.	Speculative %	Other	All No	All %
Radiators heated by							
boiler			12	27	2	14	11
master radiator			1	2		1	1
Ducted warm air	40	57	23	51	3	66	54
Underfloor	15	21	3	7	1	19	16
High-output back boiler	15	21	6	13		21	17
Central boiler	1	1				1	1
Totals	71		45		6	122	

12.2, 12.3 and 12.4. The heat loss shown in Figs. 12.1, 12.2 and 12.3 is the heat loss calculated as described in the section on thermal insulation for a 32^{o}F temperature difference between indoor and outdoor air. The heat requirement in Fig. 12.4 is the same heat loss plus an allowance of 6000 Btu/h* for heating domestic hot water where the system was required to do this.

What allowance should be made for "boiler margin", if any, is not well defined but 25% would appear generous - this allowance has been indicated on Fig. 12.1 for purposes of comparison. For small-bore systems CP3006 recommends a margin to allow for intermittent operation of 10-20% in the case of gas, oil, and solid fuel gravity fed boilers and 20-30% in

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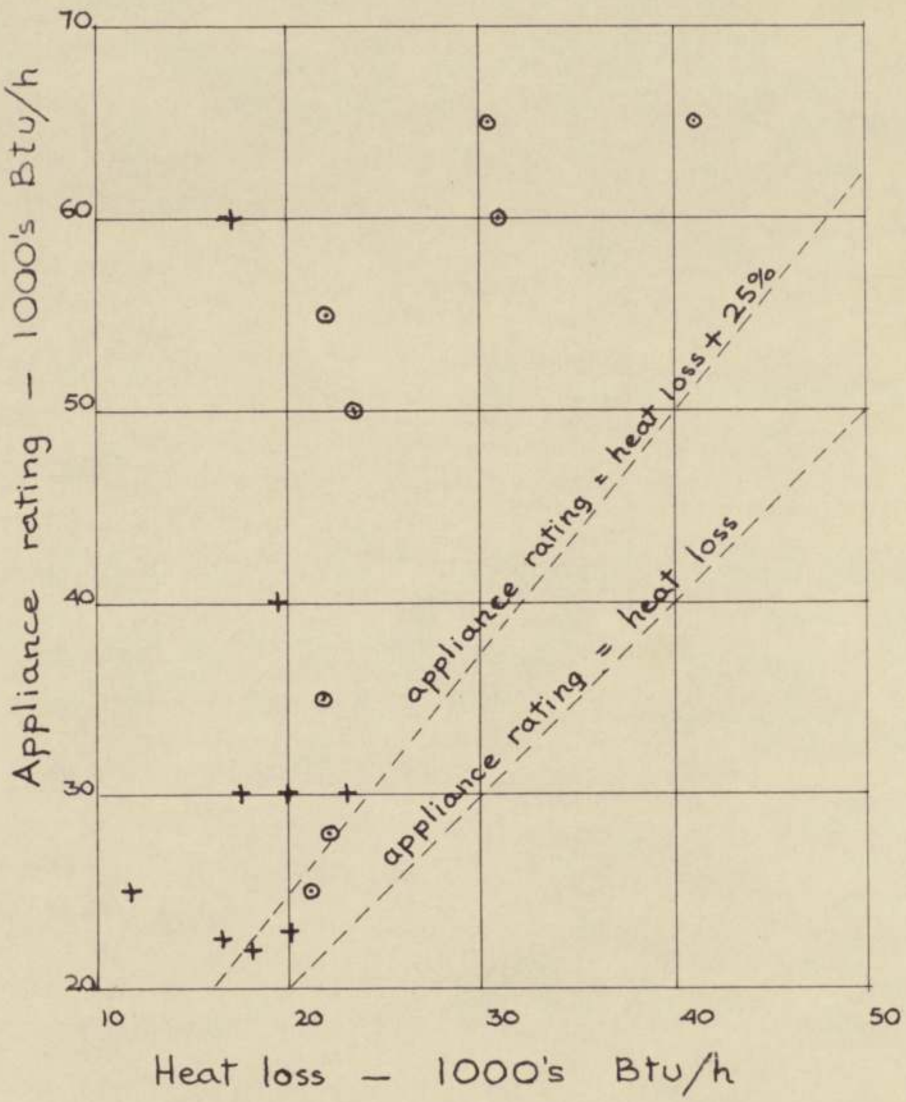
* Based on recommendations in CP3006:Part 1:1969.

Whole house warm-air heating

Gas-fired furnaces

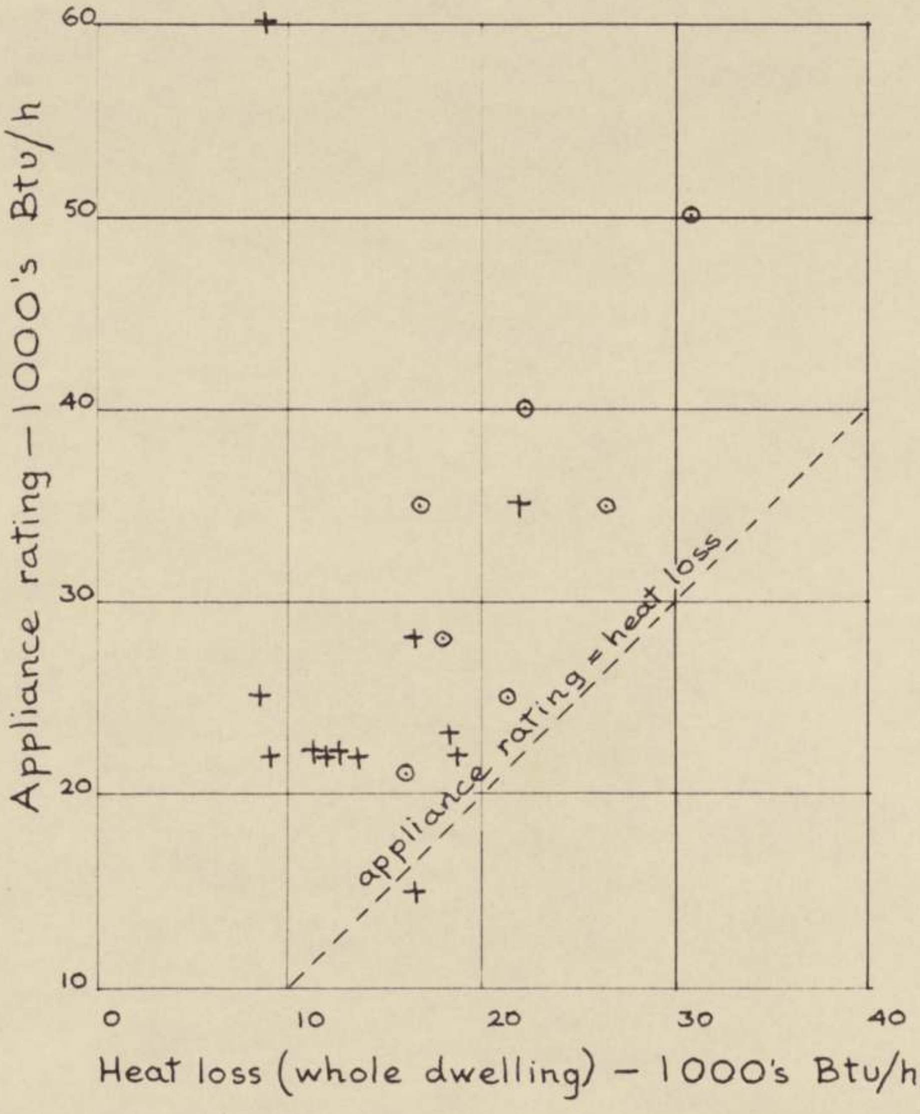


⊙ = speculative
+ = municipal

Fig 12·1

Whole house, but one room, warm-air heating

Gas-fired furnaces



o = speculative
+ = municipal

Fig 12·2

Part house (lower floor only) warm-air heating

Gas-fired furnaces

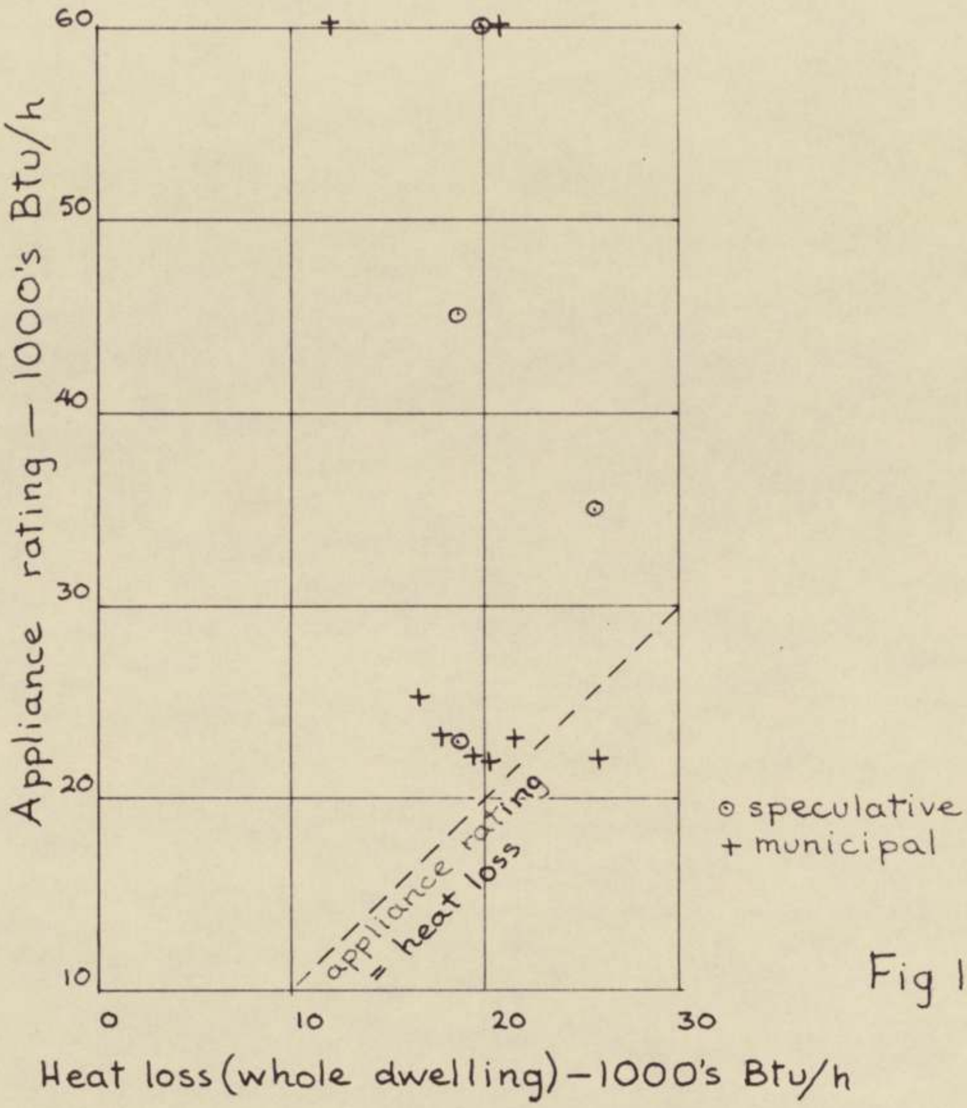


Fig 12·3

Small-bore pipe heating

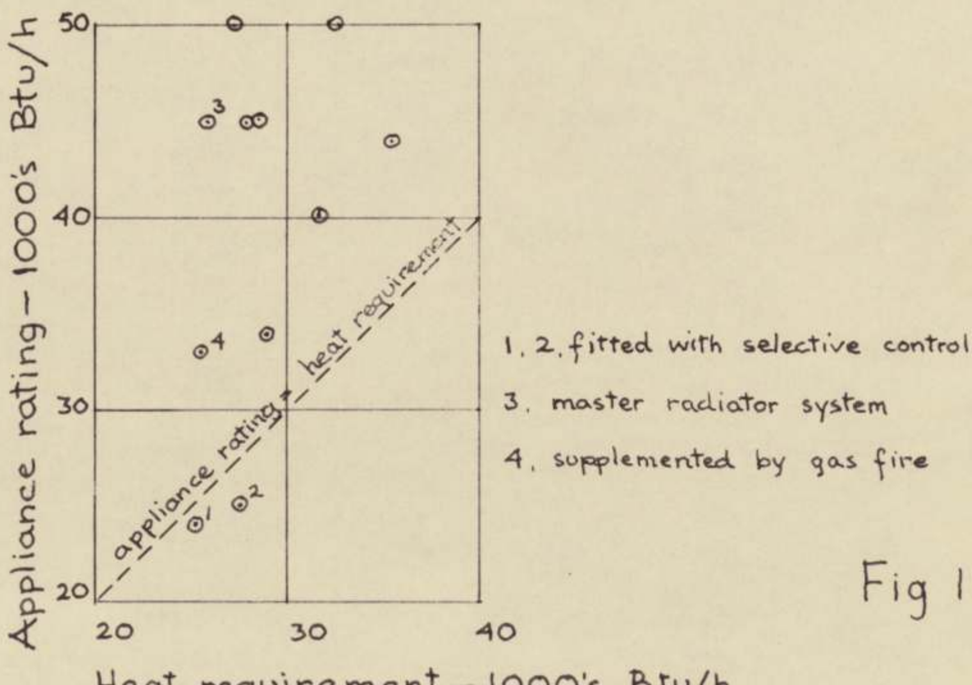


Fig 12·4

the case of solid fuel sectional and pot type boilers.

In eight speculative dwellings with small-pipe systems the area of the radiators was measured. From these measurements the total heat emission was calculated assuming the radiators emitted 210 Btu/h ft^2. This figure for radiator emission was based on 192 Btu/h ft^2 from steel single panel radiators when the difference between the mean temperature of the radiators and the room temperature was 100 degF. Assuming a mean radiator temperature of 170°F and using a temperature difference factor of 1.10 to adjust for the house design temperature of 62°F gave 210 Btu/h ft^2. The total emissions contrasted with calculated heat losses are shown in Table 12.4

TABLE 12.4

Sizing of small-bore heating systems

Calculated heat loss Btu/h	Appliance rating Btu/h	Heat emission from radiators Btu/h	Heat emission as percentage of heat loss
Whole house heating			
19,500	33,000	15,500	80
22,000	45,000	33,400	150
22,100	45,000	18,300	80
23,000	34,000	22,800	100
23,000	Unknown	27,100	120
26,500	50,000	28,800	110
29,500	44,000	17,000	60
Selective heating			
25,700	40,000	23,000	90

It should be noted that one dwelling had a selective heating control so not all of its radiators were intended to be used at the same time. The ratings of the boilers (all were gas fired) is also given in the Table. When comparing the rating with the heat loss or heat emission, allowance must be made for the heating of domestic hot water which was required of all the boilers.

In spite of the apparent insufficiency of radiators in some of the examples given, the only occupier to say that rooms were cold was the one with the selective control. His house, however, had particularly ill-fitting windows and, therefore, probably a higher ventilation heat loss than allowed for when calculating the heat loss.

The theoretical temperature rise possible (obtained by dividing the calculated heat loss of the dwelling per ^{o}F into the rating of the appliance) was as high as 216^{o}F in one case where gas-fired warm air heating was used, in another it was 160^{o}F even though the system was intended to heat only half the dwelling. Something was seriously at fault in the latter example because the occupier said that the living room and bedrooms were cold.

To test the hypothesis that an oversized appliance would be inefficient in the use of fuel and hence expensive to run, use was made of Kendall's Rank Correlation.[(4)] Thirty of the dwellings where the whole or all but one room of the dwelling was heated by warm air from gas-fired furnaces and where the occupiers had expressed their opinion as to whether the cost of heating was expensive were ranked according to the theoretical temperature rise possible with the appliance. The ranking and the occupiers opinion is shown in Table 12.5.

TABLE 12.5

Theoretical temperature rise possible with gas-fired warm air heating and occupier's opinion of whether the cost of heating is expensive

Rank	Temperature Rise °F	Heating expensive		Continued	
1	216	No	15½	52	Yes
2	112	No	17½	51	Yes
3	78	Yes	17½	51	Yes
4	68	Yes	19	50	No
5	67	Yes	20	47	Yes
6½	66	No	21½	43	No
6½	66	No	21½	43	Yes
8	65	No	23	42	Yes
9	62	No	24½	40	No
10	58	Yes	24½	40	No
11½	57	No	26	39	Yes
11½	57	No	27½	38	No
13	54	Yes	29	37	No
15½	52	No	30	29	Yes

Kendall's Rank Correlation (τ) for the special case where one quality provides a ranking and the other a dichotomy was calculated from the data. This gave $\tau = \pm 0.026$, a very small value which confirms what is really apparent from the Table - that the occupiers opinion of whether or not the cost of heating is expensive is not affected either way by the difference between the appliance rating and the calculated heat loss. The same method of analysis also failed to reveal any relationship between the surplus capacity of the appliance and occupiers statements that the rooms were cold.

It is generally accepted that single fires are inadequate for warming a dwelling and this was confirmed by the fact that 25% of occupiers with these fires even found the living room cold (Table 12.6).

TABLE 12.6

Failure of heating to warm living room adequately

Heating System	(a) Occupiers interviewed	(b) Occupiers finding living room cold	(b) as a percentage of (a)
Single fires	61	15	25
Radiators heated by			
boiler	14	2	14
master radiator	1		
Ducted warm air	68	19	28
Underfloor	25	4	16
High output back boiler	20	2	10
Central boiler	3		
Totals	192	42	22

What is perhaps surprising is that ducted warm air heating was no better in this respect, in fact quite a few occupiers would have been more satisfied with single fires. Many said they would like a fire they could see thus reflecting the need for a source of radient heat.

One old lady who suffered from arthritis said she had to use an electric fire to warm her feet. Other people said they felt cold at first but were better when they bought an electric fire. Some said that the warm air heating was not enough in itself or would only warm one room at a time. Another old lady who had bronchitis and asthma complained bitterly about the cold, she said she was not bothered about anything else but keeping warm, the warmest place was in the hall, the kitchen and bedroom were all right but sometimes the heater blew cold air into the living room.

There were other complaints about heaters blowing cold air and causing draughts. One occupier said that hot air blew from the upper registers and cold air from the lower. On the other hand some said they disliked warm air heating because it was stuffy. It was also said that it aggrevated chest complaints.

There were two cases where the fan had stopped and the furnace overheated blistering the paint on its casing.

Many occupiers found warm air heating expensive and in some cases it was the cause of real hardship. An old age pensioner said she put aside £2 weekly for heating and because of that had not bought "as much as a shoelace" since she moved into her flat 12 months ago - and she was still not warm!

Although the incidence of failure to warm the living room adequately was less with electric underfloor heating than in the forms of heating already discussed there was a lot of dissatisfaction where this system was installed. This is well illustrated by what was observed in one multi-storey block of flats.

Four flats were visited, one on the ground floor, two on intermediate floors and one on the top floor. Only the living room and hall floors were wired for heating. The ground floor tenant used the living room heating regularly but not the hall, one intermediate floor tenant never used any of the underfloor heating. He said a one-bar fire was enough for him and his wife. The other intermediate floor tenant switched on the underfloor heating for one night only whereupon it consumed 80 units; afterwards she used an oil heater and considered it the cheapest and best form of heating. The top floor tenant used his underfloor heating for nine weeks and found that he had run up a bill of £32, after that he could not afford to use it. When he used it he said it had not warmed him. It was all right first thing in the morning but by 10.30 a.m. the room was cold.

Occupiers of some flats were fortunate in being kept warm by their neighbours, one in an intermediate flat in a multi-storey block had never used the central heating. Another said she had been quite comfortable since the man below had had central heating fitted.

Some ten occupiers said that rooms were too hot - this was not associated with any particular form of heating. The 192 occupiers interviewed included 64 who said bedrooms were cold. Eight of these had whole house central heating, all warm air systems, four gas and four electric heating. There were 40 occupiers with cold kitchens.

Thirteen people said they thought the cost of heating cheap. Again this was not associated with any particular system or fuel.

The proportion of occupiers finding different fuels expensive as shown in Table 12.7 reflects the cost per useful therm of these fuels.

Out of 183 designs, 15 municipal, 22 speculative and 4 other dwellings had heating in the bathroom - 17% and 26% respectively in the case of municipal and speculative dwellings. One occupier with an unheated bathroom was a Swiss housewife living in Birmingham. She could not understand why this lack of heating provision . In her Swiss house the bathroom floor had been heated as well as the air warmed.

CONCLUSIONS

The greater proportion of central heating in municipal dwellings is probably due to the greater proportion of flats and the difficulties associated with solid fuel single fires in them, together with the influence of the Parker-Morris report on municipal building.

The investigation showed that the standard of heating in dwellings is far from satisfactory. The days of a heat source in one room only

TABLE 12.7

Kind of fuel considered expensive for heating

Fuel	(a) Occupiers interviewed	(b) Occupiers finding heating expensive	(b) as a percentage of (a)
	Central Heating		
Solid	22	3	14
Oil	3		
Gas	73	26	28
Electricity	33	11	33
Totals	131	40	31
	Single Fires		
Solid	37	21	57
Oil			
Gas	13	1	8
Electricity	6	1	-
More than one	5	3	-
	61	26	43

and of unheated bathrooms in centrally heated buildings should be behind us. Where central heating is installed, too often it does not work efficiently. More care is needed in sizing appliances. The need to choose from a limited range of sizes does not account for the wide variation between heat loss and appliance rating. Equally well, the differences in provision of radiators shows either a lack of care or lack of knowledge of well established procedures. The use of approximate methods is not a sufficient explanation of the variations observed. This is confirmed by the lack of agreement between radiator provision and boiler rating in small pipe systems.

As the size of warm air appliances provided is usually more than sufficient to make good heat losses, the inability of ducted warm air to provide a comfortable temperature must lie in the distribution, although there is a good case for providing a source of radient heat with such systems.

The case for compulsory background heating in flats was supported.

The way that thermostats were used as switches showed that many people did not know how to get the best economical use out of their heating systems.

SUGGESTIONS FOR FURTHER WORK

Reasons for the divergence in rating of appliances and the heat loss they are required to make good warrant investigation; this might be coupled with further study of radiator provision in small bore systems.

Work might be undertaken to see whether electric underfloor heating also shows a lack of agreement with heat loss.

The failure of warm air systems to distribute heat effectively might be subjected to further investigation and analysis.

CHAPTER 13

VENTILATION

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V E N T I L A T I O N

SUMMARY

Ventilation requirements in dwellings are described and factors influencing ventilation in 183 dwellings of different design and location are reported together with the opinions of 199 occupiers as to whether they experienced unwanted ventilation in the form of draughts.

INTRODUCTION

Air will flow into a building under the influence of wind pressure and stack pressure. It enters and leaves not only through vents provided for the purpose but also through cracks around window sashes and doors, and the ventilation obtained varies with the force of the wind and the difference between inside and outside temperature. Unless mechanical ventilation is employed, the system cannot be expected to give the desired ventilation rates in all weathers, it must be designed to be satisfactory for a significant part of the time and given flexibility by means of adjustable openings.

The presence of floors and partitions restricts the flow of air in dwellings and makes it difficult to calculate the air change accurately. Overall ventilation, as well as ventilation of individual rooms, is also affected by the opening and closing of internal doors. When there is no provision for ventilation other than by opening a door or window the ventilation rate may fall well below recommended standards when the room is closed.

The ventilation rate[1] for a flueless room in a brick built building with normal windows and door without weatherstripping is 300 - 800 ft^3/h or about ½ air change/h in a room of 1000 - 1500 ft^3. This is increased to 600 - 1200 ft^3/h or about ¾ air change/h if a single wall ventilator (9" x 6") of 10 in^2 free area is provided. The flow of air is affected by the presence of openings for the air to leave; weatherstripping of doors and windows may reduce the flow considerably.

Air change rates are based on the cubic content of rooms but because of the mixing of fresh air with air already in the room this does not mean that all the air in the room will be completely changed the number of times stated as the rate.

STATUTORY REQUIREMENTS

The Building Regulations 1965

Means of ventilation (Regulation K4)

Habitable rooms including kitchens and sculleries and rooms opening into an enclosed verandah, conservatory or similar place (room and other place considered together) must have a hinged opening or other means of ventilation which opens directly to the open air. The total area of the means of ventilation provided must be equal to not less than 1/20 of the floor area of the room, and some part of such area must be not less than 5 ft 9 in above the floor

A door is deemed to be a ventilation opening if it contains a ventilator with an area of not less than 15 in^2 capable of being opened independently of the door, or if a similar ventilator is contained elsewhere in the room.

Ventilation openings on to courts (Regulation K5)

Ventilation openings so situated as to open on to enclosed courts must be at least 50 ft (or not less than half the vertical distance between top of the opening and the top of the wall containing the opening) from the opposite side of the court. Similar restrictions apply to courts open on one side together with restrictions on the position of ventilators in the sides adjacent to the open side of the court.

Ventilation of Larders (Regulation K6)

Larders are required to have:

(i) One or more windows fitted with a durable fly proof screen and having an area of not less than 130 in^2 capable of being opened, or

(ii) Two or more ventilators capable of being closed, one in the upper part and one in the lower part of the larder, permitting when open the passage of air through an opening having an unobstructed area of not less than 7 in^2 and either situated in an external wall or separately connected with the external air by a duct not less than 25 in^2 in cross-sectional area and having a smooth internal surface.

Ventilation of Common Stairways (Regulation K7)

Any part of a stairway which is -

(a) intended for common use within any building constructed for occupation as separate dwellings by more than one family;

(b) above the ground storey;

(c) not open to the external air,

shall have adequate means of ventilation.

Sanitary Accommodation (Regulation (P3(3)(c))

A room which contains water closet or urinal fittings must have openable means of ventilation equal to at least 1/20 of the floor area or mechanical ventilation which effects not less than 3 air changes/h.

RECOMMENDED STANDARDS

Recommended minimum rates of fresh air supply to houses and flats given in CP3: Chapter I(C):1950 Ventilation[1] are as follows:

Bathrooms and W.C.s	2 air changes per hour
Halls and passages	1 air change per hour
Kitchens (cooking for not more than 6 persons)	2000 cu.ft. per hour
Living rooms and bedrooms:-	
300 cu.ft. per person	720 cu.ft. per hour per person
400 cu.ft. per person	600 cu.ft. per hour per person
500 cu.ft. per person	420 cu.ft. per hour per person
Pantries or larders	2 air changes per hour

About 600 ft^3 per hour per person of fresh air is generally recognised as being the minimum necessary for reason of health and to attain a reasonable standard of comfort. The Egerton Committee (1945)[2] based their recommendations on this figure, it being what they felt would keep the space occupied free from body odours. The amount of air space per person was assumed to be 360 ft^3 from which it may be seen that the CP3 recommendations are perhaps a little higher.

The high rate of ventilation in kitchens needed to remove steam, heat and fumes generated in cooking and washing will not be necessary when the kitchen is not used for these purposes. Simple control by fanlights is possible but attention is drawn to the precautions recommended to limit condensation given in "Condensation", p. 3.10 .

The Building Standards (Scotland) Regulations 1963 require 6 air changes/h in kitchens if mechanical means of ventilation are used (the CP3 recommendation of 2000 ft^3 represents about 4 air changes/h). A bathroom with W.C., and a separate W.C., must each have 3 air changes/h. There is no clear indication that mechanical ventilation should operate continuously and it is probable that authorities will permit operation during occupation only[(3)].

Building Research Station Digest 78 (second series)[(4)] suggests that when internal bathrooms and W.C.s are mechanically ventilated the fan should operate while the compartment is occupied and for at least 20 mins. thereafter. Extraction during a single operation should be at least 750 ft^3 of air from a W.C. or bathroom without a W.C. pan, or 1500 ft^3 of air from a bathroom with W.C. pan. When a common duct system is used for flats it is necessary for the fan to be operated continuously.

Flues generally cause excessive ventilation, with an ordinary open fire in a room in an average house the air flow is in the order of 7500 ft^3/h when the door and windows are closed rising probably to something like 15,000 ft^3/h when the door is open[(5)]. CP403 (1952) recommends that the throat of an open fire should be reduced to what amounts to about 50 in^2. Further permanent reduction is not practicable because of the difficulty of sweeping but as 50 in^2 would still cause excessive ventilation it recommended that special provision is made for restricting the throat.

The Parker-Morris Committee[6] reported "Most of the evidence on ventilation implied that the problem is normally to keep unwanted ventilation within reasonable bounds, and we think that this is right, though more information on the rates of air change in flueless dwellings should be obtained".

CP3 Chapter I(C) 1950 states that it is undesirable to rely upon fortuitous leakage of air around doors and windows to obtain necessary ventilation, that weatherstripping should be used and that openings for ventilation should be specially provided.

PREVIOUS WORK

Measurements of air change rate in houses were made by Dick[7](1949-50), With Thomas[8](1951) he observed the window opening habits of tenants; subsequently (1960) the Building Research Station[9] stated that for conditions of normal exposure a general average of two air changes per hour can be assumed to take place in houses. When research into heating in flats was made by Dick, Madge and Craig[10](1961) they assumed a figure of 1½ air changes/h.

Thomas and Dick[11] (1953) showed that it is possible to predict the flow of air through gaps around windows with reasonable accuracy from the formula

$$P = \frac{0.30 \times 10^{-6}}{a^2} (V + 0.02V^2)$$

where P - Pressure (in w.g.)

V - Volume flow (in c.f.h. per ft)

a - mean face clearance of lipped sash.

A survey by the Building Research Station in 1960[12] showed that 25% of tenants interviewed were dissatisfied with mechanical ventilation of internal bathrooms and W.C.s.

Tenants opinions on the performance of a mechanical ventilation system making use of p.v.c. pipes designed by the Building Research Station for a 17-storey block of flats showed that acceptable conditions prevailed in nearly all cases (1968)[13].

EXAMINATION OF DWELLINGS

It was not, of course, possible to measure the ventilation rate in the dwellings visited, assessment of the standard of ventilation was generally confined to observations as to whether fortuitous ventilation was excessive and unwanted. Windows within reach were examined from outside where the fit of the lipping of opening lights could be seen and from inside where the fit against the rebate was visible. If windows had been draught-proofed or some form of draught exclusion had been resorted by the occupier (such as stuffing cracks with newspaper) this was noted.

Occupiers were asked if any rooms were draughty and the entrance doors at front and back were inspected to see if they had been draught-proofed by builder or occupier.

Whenever possible where flues for open fires had been provided they were inspected to see if the throat was restricted. If mechanical ventilation had been provided in the kitchen when the dwelling was built this was noted.

DEFINITION

Although no measurements of air currents were taken and, certainly occupiers were not given a definition of what constituted a draught when they were asked if they experienced any in their homes, it may be helpful to give a definition here.

As it is said(3) that "In winter currents of air whose temperature is at or slightly below the average air temperature moving with a velocity greater than about 40 ft/min. and striking the face or ankles lead to discomfort owing to local chilling" such an air current may be defined as a draught.

RESULTS

There was a good deal of unwanted ventilation causing draughts. Out of 199 occupiers interviewed 101 (51%) said that one or more rooms were draughty. No significant difference was apparent between municipal and speculative dwellings with draughty rooms, the figures were 55 of of 119 for municipal dwellings and 44 out of 72 for speculative dwellings (the other two complaints arose in dwellings otherwise classified.

In two cases, one municipal and the other speculative, the cause of the draught was all too obvious - daylight showed through a gap under the window sill. The municipal dwelling where this was observed was a flat on the 15th floor of a multi-storey block, the gap was in the living room and the occupier said it made the room too cold to use in windy weather. He and his wife had to live in the kitchen. The fit of opening lights of windows is reported in Chapter Surface Finish, 18.

Occupiers observations on whether rooms were draughty applied mostly to the living room but some said more than one room was draughty and others that all rooms were. The frequency with which they found rooms draughty was as follows: living rooms 74, kitchens 35, halls 26, bedrooms 25. It is to be expected that draughts would be noticed more in a living room than elsewhere.

Several occupiers said that they intended to fit draught excluder on windows and doors but having many things to do in a new house they had not got around to that particular job. Only two occupiers of speculative dwellings had put draught excluder on windows. Eight tenants in municipal dwellings had done so. At least some of the larger proportion in municipal dwellings was probably due to the greater number in exposed situations as on the upper floors of multi-storey flats. Only one example of draught-proofing of windows by a builder was observed. This was on a multi-storey block where the contractor had fitted draught excluder to the windows on the West side of the block.

Front entrance doors had been draught-proofed by tenants in seven municipal dwellings and by householders in eleven speculative dwellings, back doors by three municipal tenants and eleven householders. One builder of the speculative dwellings examined had fitted draught excluder to a front door and three had fitted it to back doors. It appeared that this had usually been done as a result of complaints made by the occupier. The figures in municipal dwellings for doors draught-proofed by contractors were three in the case of front doors and five in the case of back doors.

Wooden pivot hung windows of the standard type where fitted were usually the source of complaints of draughts and sometimes of letting in water. The lack of fanlights or ventilators was inconvenient, people who lived in ground floor flats said that they could not have windows open at night for fear of intruders. The same objection was raised to top-hung casement windows. There were some dwellings where opening a pivot-hung or large top-hung casement was the only way of ventilating the kitchen. This was most unsatisfactory as it meant either too much ventilation or none at all. In one multi-storey block the housewife said she could not open the pivot-hung window in her kitchen because of the wind.

Complaints about ventilation in internal W.C.s and bathrooms were rare. In a block of maisonettes naturally ventilated it was said that cooking smells passed from one dwelling to another via the ventilation duct, and in a multi-storey block of flats with mechanical ventilation one tenant said she got other peoples cooking smells in her bathroom.

Dwellings fitted with an extract fan in the kitchen at the time of building were few, there was only one in a municipal dwelling, two in speculative, one in a self-built house and one in a housing association flat.

It was not easy to determine with certainty when the fire was alight whether or not open fires had flues with restricted or unrestricted throats but so far as this could be ascertained it appeared that out of 25 municipal, 31 speculative, and one other dwelling with open fires, 15 municipal and 13 speculative had flues with some degree of restriction in the throat.

CONCLUSIONS

The standard of ventilation in the dwellings observed was more than adequate, in fact, the problem was generally unwanted ventilation, although the use of pivot-hung and large top-hung casement windows limited desired ventilation under certain conditions.

Even though half the occupiers of recently constructed dwellings have draughty rooms they are slow to fit draught excluder to doors and windows. Rarely is draught excluder fitted during construction, occasionally a builder may fit it to an entrance door after occupiers have complained.

Ventilation of internal W.C.s and bathrooms is generally satisfactory although there are cases where smells pass from one dwelling to another. More could be done to restrict excessive ventilation from open fires.

SUGGESTION FOR FURTHER WORK

Attention is drawn to the suggestion made by the Parker-Morris committee that more information on the rates of air change in flueless dwellings be obtained.

CHAPTER 14

SOUND INSULATION

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S O U N D I N S U L A T I O N

SUMMARY

Dwellings in 183 different situations are classified with respect to traffic and other sources of noise, and the disturbance caused to occupiers of 200 dwellings in these situations is noted.

Room layouts which might affect the sound insulation in 166 multiple dwellings are described together with occupants' response to noise from other dwellings. Details of separating walls and floors are given for dwellings where they were obtainable.

Sources of noise originating in 200 occupants' own dwellings and found disturbing by them are recorded.

The position and construction of the W.C. compartment in 183 different designs of dwelling is described; the standard of sound insulation of internal partitions in these 183 dwellings is also given.

INTRODUCTION

A reasonable measure of sound insulation has been defined as "one that will ensure that the occupants of one house are not seriously disturbed by the noise from another and that they themselves do not have to restrict unduly their own mode of living so as to avoid causing annoyance to their neighbours".[1] Evaluation of the amount of disturbance by neighbours noise of tenants of local authorities was used when standards of insulation between dwellings were formulated but although noise from neighbours can be more irritating than noise from impersonal sources, traffic noise and other sources causing disturbance must be considered.

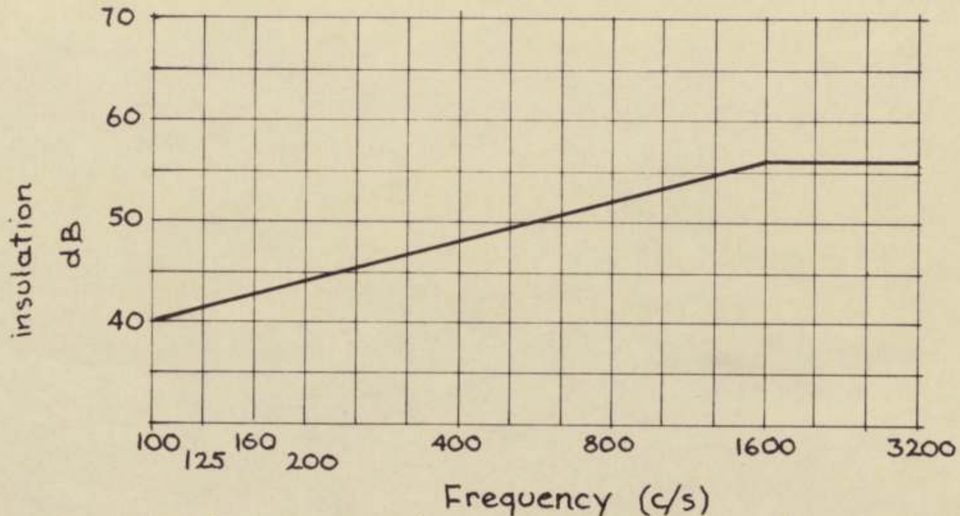
Internal noise originating in the home is a less serious problem than external noise. Most internal sources will be under the control of the householder but noise from W.C.'s, storage tanks, domestic power appliances and other sources may cause annoyance.

DEFINITIONS

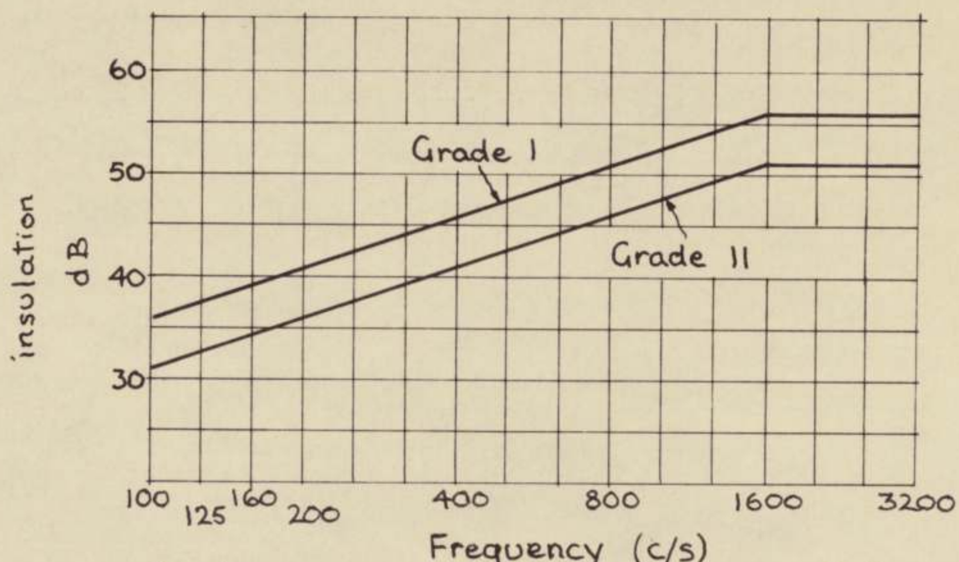
Grades of sound insulation

Following research[2] into tenants reactions to noise from neighbours, a system of grading related to economic forms of construction currently in use was established. Because insulation above average at one frequency cannot compensate for insulation below average at another it was not satisfactory to prescribe a standard of insulation between dwellings in terms of average insulation over a given range of frequencies. Grade curves over the frequency range 100 - 3200 c/s were used. These are shown in Fig.14.1.

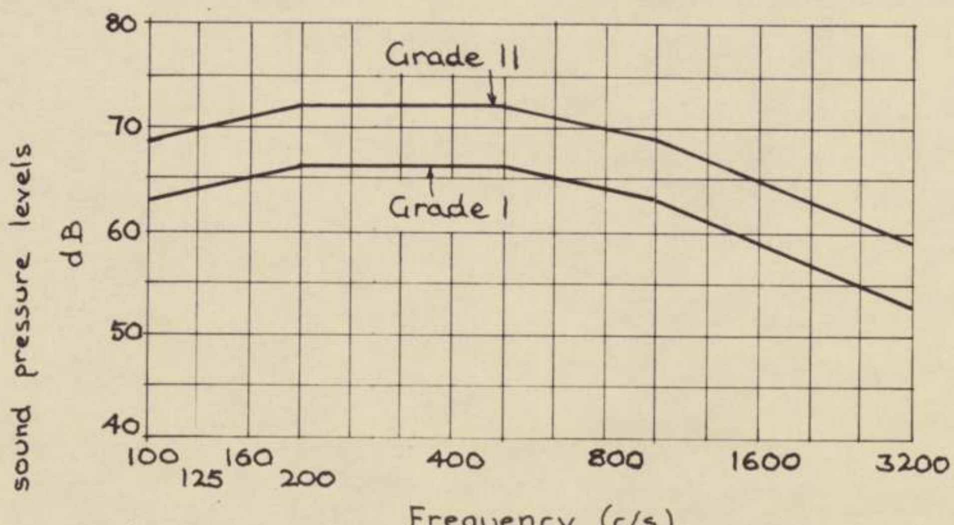
The house party-wall grade is based on the performance of a 9 in brick party-wall. Grade I is based on the performance of a structural



Air-boure sound insulation between houses



Air-boure sound insulation between flats



Impact sound insulation between flats

Fig. 14.1

concrete floor with a floating floor on top. With Grade II insulation the noise from neighbours was considered by many of the tenants to be the worst thing about living in flats, but even so about half were not seriously affected. Insulation which does not attain the standard of the above grades is described as "worse than Grade II". If the insulation between flats is 8 dB worse than Grade II then noise from neighbours is often found to be intolerable.

To qualify for a particular airborne sound grading, the insulation should not be less than the value shown at each frequency in A or B, Fig.14.1 (subject to a suitable tolerance). To satisfy an impact grading the measured noise levels in the receiving room when a standard impact machine is operated on the floor above should not exceed the value shown at each frequency in C, Fig.14.1. Wall constructions are required to meet the grade for airborne sound only; floor constructions must be satisfactory for both airborne and impact sound insulation.

For partitions within dwellings a lower standard is acceptable and in this case an average sound reduction factor is usually quoted.

Noise climates

The Wilson Report[3] and subsequently B.R.S. Digest 38 (second series) defined various noise climates with respect to traffic noise. These are included in Table 14.1.

STATUTORY REQUIREMENTS

The Building Regulations 1965

Sound insulation of walls and floors (Regulations G.1 and G.3)

Walls and floors separating one dwelling from another dwelling or building or from a machinery or tank room or other place (except a place used for occasional repair or maintenance) not used exclusively with the dwelling are required to be so constructed as to provide adequate resistance to the transmission of airborne sound. In addition floors must provide insulation against impact sound if there are dwellings below.

Deemed-to-satisfy provisions for walls of the type mentioned above demand a standard of about House Party-Wall Grade, those for floors a standard of about Grade I with respect to both airborne and impact noise.

The Scottish Building Regulations (Part VIII) require that the sound insulation of a wall or floor separating a house forming a part of a building from any other part shall provide the equivalent of Grade I with regard to airborne sound and in the case of floors, impact sound. The regulation invokes proof by measurement in accordance with BS 2750: 1965[4] in actual dwellings (unless the construction is covered by a deemed-to-satisfy specification). The English Regulations are not so strong as the Scottish because the former appear under the Public Health Acts, which if proof by measurement was required would prevent the building being occupied if it failed to comply. Moreover, if failure occurred after the building was erected in accordance with drawings approved by the local authority then the local authority might be liable for the cost of bringing the building up to the required standard[5].

Walls between refuse chutes and dwellings (Regulation G.2)

These must have a minimum weight of 270 lb/ft^2 if adjacent to a habitable room, otherwise 45 lb/ft^2.

RECOMMENDED STANDARDS

Standards of structural insulation given in CP3:Chapter III (1960) Sound Insulation and Noise Reduction are as follows:

Walls separating houses from one another	House party-wall grade (airborne)
Walls separating flats or maisonettes from one another Walls separating flats or maisonettes from lift shafts or main stairs Walls separating bedrooms or living rooms of flats or maisonettes from common approach halls or corridors	Grade I (airborne)
Floors separating flats from one another Floors separating maisonettes from one another Floors of common approach balconies or corridors which are over living accommodation	Grade I (airborne and impact)

Floor separating flats and maisonettes from laundries, stores and service rooms planned underneath	Grade I (airborne)
Partitions between W.C., compartments and living rooms or bedrooms in the same dwelling	35 dB* sound reduction (airborne)

Desirable limits for intrusive noise (expressed in dB(A)+) which are likely to be acceptable for a number of typical situations are given in BRS Digest 38 (second series). They are as follows:

Bedrooms in urban areas	35 dB(A)
Living room in country area	40 "
Living room in suburban area	45 "
Living room in busy urban area	50 "

Because windows, even when closed, are normally the weakest points in the barrier against external noise they should be of a standard sufficient to bring the noise level down to the values given above. The type of window required for various noise climates is shown in Tables 14.1 and 14.2. This is based on average values of insulation for typical windows not exceeding half the area of the external facade in tradition building structures with rooms of average size.

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* BRS Digest 7 (second series) recommends partitions at least equal to 3 in clinker block plastered both sides (insulation 41 dB Slope B, according to CP3:Appendix D).

\+ A reading of dB(A) represents the response of a sound level meter when using a "weighting network" which approximates the responses of the ear to noises spread over a wide range of frequencies, e.g. traffic noises.

TABLE 14.1

Noise climates and type of window recommended

Group	Location (where noise measured)(1)	Noise climate(2) dB(A)		Type of Window(3)	
		Day (8am-6pm)	Night (1am-6pm)	Bedrooms	Living Rooms
A/B	Arterial roads with many heavy vehicles and buses (kerbside). Major roads with heavy traffic and buses. Side roads within 15-20 yds. of above.	80-63	68-48	Double	Sealed Heavy
C	Main residential roads. Side roads within 20-50yds. of heavy traffic routes. Courtyards of blocks of flats screened from direct view of heavy traffic.	70-60	54-44	Double	Sealed Light
D	Residential roads with local traffic only	65-57	52-44	Sealed Heavy	Openable Light
E	Minor roads. Gardens of houses with traffic routes more than 100 yds. distant	60-52	48-43	Sealed Light	Openable Light
F/G	Parks, courtyards, gardens in residential areas well away from traffic routes. Places of few local noises and only very distant traffic noise	55-47	46-40	Openable Light	Openable Light

(1) Traffic noise predominating
(2) The range of noise level recorded for 80% of the time
(3) Based on noise levels exceeded for 10% of the time. See also Table 14.2

TABLE 14.2

Window insulation requirements

Light	-	single glazing
Heavy	-	¼" plate glass, edges of window well sealed
Double	-	fully treated double glazed windows, sealed with large (8") airspace and absorbent reveals

Different facades of a building will be in different noise climates. There may be a reduction of 5 - 10 dB(A) at back compared with front facing to road.

In addition to performance standards CP3:Chapter III and BRS Digest 7 (second series) make many recommendations concerning construction and planning to mitigate both outdoor and indoor noise. A summary of such of these recommendations as were examined in this work is given below.

Outdoor sources

Mitigating planning: Screens. Grassed areas. Discouragement of speeding. Siting of rooms most sensitive to noise on quieter sides of building.

Undesirable planning: Narrow hard paved courts.

Indoor sources

(a) Noise from other houses or flats

(i) direct from occupants, radio or T.V.

(ii) from equipment of building, e.g. plumbing, lifts, refuse chutes.

Mitigating planning: Rooms adjoining party walls and party floors of similar use. Staircase, hall and kitchen adjoining on each side of party wall.

Undesirable planning: Soil pipe passing through kitchen without adequate protection. Soil pipe passing through living room without adequate protection*. W.C. over living rooms or bedrooms. Refuse chutes next to living rooms or bedrooms.

(b) Noise from stairs and access corridors or balconies

Mitigating planning: Internal passages and bathroom between corridor and living rooms or bedrooms

Mitigating construction: Standard of insulation of walls.

(c) Noise originating inside dwellings

(i) W.C.

Disturbance caused:

Mitigating planning: W.C. not adjacent to living room or bedrooms.

Mitigating construction: Wall between W.C. and bedrooms at least equal to 3 in. clinker block plastered both sides (41 dB slope B) Heavy door (solid core) on W.C. especially if it faces another door. Quiet value (Garston type) especially if cistern fills direct from the mains. Syphonic trap and close

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* For soil pipes passing through kitchens a simple and reasonably air-tight covering, out of contact with the pipes and having a weight of 2 - 5 lb/ft^2 (for instance, blockboard or 1 in woodwork slabs, plastered is usually adequate). BRS Digest 7 (second series)

Ducts carrying soil pipes next to living rooms or bedrooms must have a solid wall without inspection openings (CP3).

coupled cistern.

Undesirable planning: W.C. over living room or bedroom

(ii) Cold water storage tank

Mitigating construction: Quiet value and long silencing pipe.

Undesirable planning: Tank over bedroom.

(iii) Noise transmitted along pipes, (including water hammer) or direct from central heating installation

Mitigating construction: Well designed quiet fittings. Firm fixing. Avoidance of sharp bends and abrupt changes in bore. Flexible piping in flow and return pipes near boiler. Sleeves where pipes pass through walls if central heating used intermittently.

(iv) Slamming doors

Mitigating construction: Closer with check action. Resilient strip.

PREVIOUS WORK

Research on sound insulation in dwellings has been largely concerned with occupants response to noise. A survey by Chapman(1948), the fieldwork for which was carried out in 1943, formed the basis for later investigations by the Building Research Station. Houses were surveyed in 1950 and flats in 1952-53. Subjective response in the houses and flats was related to objective measurement of the insulation and from this work the grading system was developed. The studies which led to the development of the system are described by Gray, Cartwright and Parkin (1958) and Parkin, Purkis and Scholes (1960).[6]

Extensive field measurements by Parkin, Purkis and Scholes (1960) led to the publication of sound insulation data of 464 floor and wall constructions.

In the Wilson report (1963) Traffic Noise Climates were defined and it was revealed that in the London Noise Survey carried out in 1961-62, 56% of individuals interviewed were disturbed by noise at home. In view of the findings of the writer it is especially interesting to note that the above-mentioned survey found that people were disturbed by only one source of noise originating in their own homes, namely "domestic/light appliances", and that this was confined to only 1% of those interviewed.

Griffith and Langdon (1968)[7] made a study of road traffic noise in the London area and proposed a measure of dissatisfaction called Traffic Noise Index (T.N.I).

Experiments in insulating buildings against aircraft noise by means of double glazing were made by the Building Research Station for the Wilson Committee in 1962. This work was continued by Scholes and Parkin (1968)[8] on traditional houses; they found that overall insulations of 35 - 40 dB were obtainable, providing transmission through roofs and down flues was also reduced.

RESULTS

The nature of the examination precluded physical measurement of sound insulation, furthermore, in most cases it was not possible to ascertain the nature of construction of separating walls and floors. Principally the investigation was concerned with planning to mitigate noise originating outside the dwelling, the construction of internal partitions and arrangement of W.C.'s to mitigate noise originating within the dwelling, together with the occupiers' assessment as to whether they were disturbed by noise.

Some of the items mentioned under "Recommended Standards" which were investigated were found impossible to determine with a meaningful result, e.g. planning to mitigate outdoor sources of noise; other items did not occur, e.g. soil pipe from another dwelling passing through kitchen or living room. The recorded results contain only those items which it was possible to examine and interpret with effect.

Disturbance was classified as slight or more than slight; the latter being defined as sufficient to give cause for complaint.

Out of 114 municipal tenants interviewed 61 (54%) said they were disturbed by noise originating from one or more sources. In speculative housing 37 out of 78 (47%) were disturbed, in other types of housing the figure was 5 out of 8 interviewed, in all a total of 103 out of 200.

Outdoor sources

On the whole, speculative dwellings were located in quieter traffic noise climates than municipal dwellings. This is shown in Table 14.3 which also shows the disturbance caused to occupiers. It was noticeable that people were generally very tolerant of traffic noise. Some said they had got used to heavy traffic, others that they had always lived on a busy road. Only one of the dwellings examined was near a railway, the lines were not far from the back garden and the housewife said that sometimes it sounded as though the trains were coming through the house.

Like traffic noise, constant or regular noise from other outdoor sources was accepted with tolerance, the most notable example of this being a house within 40 yds. of the exhaust of a machine at a works. This exhaust gave a loud bang every second continually but the housewife said it caused her and her family only slight disturbance and even so before answering she had to think a while to decide that it was even slight. She said that it was very disturbing for about two days after they moved in, thereafter they did not notice it - except when it stopped!

The frequency of disturbance by outdoor noise other than traffic is shown in Table 14.4. The location of municipal housing coupled with a greater range in the age of people living in such housing probably put tenants in a situation more likely to give them cause for complaint than occupiers of private housing would have.

Access balconies with asphalt paving makes a noisy playground for children. Children also play in quiet roads and near to the windows of flats which have no gardens to keep them at bay.

Garage doors disturbed people when they were banged at night. This

TABLE 14.3

Traffic noise climate and disturbance
from traffic experienced by occupiers

LOCATION	NOISE CLIMATE										
	A/B		C		D			E			F
	Municipal	Speculative	Municipal	Speculative	Municipal	Speculative	Other	Municipal	Speculative	Other	Other
No special features	21	8	6	8	60	21	3	19	31	2	1
						(showhouses 3)					
Disturbance:											
Slight	6		1		6			1			
More than slight		2		1	1	1	1				
Near vicinity hilly or otherwise needing gear change	4		2	2	2	5	2		3		
				(1)		(2)					
Disturbance:											
Slight						1					
More than slight	2				1						
Total (inc. showhouses)	25	8	8	11	62	31	5	19	34	2	1
Percentage totals (inc. showhouses)	22	10	7	13	54	37		17	40		

TABLE 14.4

Disturbance by outdoor noise other than traffic

Source	Municipal N=114		Speculative N=78		Other N=8	Total N=200
	Disturbance					
	Slight	More than Slight	Slight	More than Slight	Slight	Any
Children playing	1	5			1	7
Factories	1	1		3		5
Garage doors	2	2	1			5
Public houses	2	2				4
Dogs	2	1				3
Other	4					4
Totals	12	11	1	3	1	28

was particularly disturbing to municipal tenants who lived near a row of lock-up garages. A superintendent of flats who lived on the ground floor of a multi-storey block which had a car park for tenants use just outside his windows said that he could not get to sleep until 2 a.m. every morning because of the noise from cars.

People living near public houses complained about noise generally but in particular mentioned cars, especially doors banging and engines starting at closing time.

Three examples of double glazed windows were observed but these did not come into the category of double windows as required for sound insulation. All other windows observed were of the 'openable light' class.

Indoor sources

Noise from other houses or flats

In all, 37% of occupiers said they were disturbed by noise from other houses or flats. Not surprisingly people in flats were more disturbed than people living in houses. The figure for flats was 44% and the figure for intermediate terraced houses 39% compared with 26% for semi-detached and end terraced houses.

Tables 14.5, 14.6 and 14.7 have been arranged with the layout of rooms shown in the order of what might be expected to be their efficacy in sound insulation with the best at the top. Generally the frequency of occupiers disturbed seems to confirm this arrangement although the numbers are too small to show whether they are significant.

In spite of the fact that it has been known since 1956 that a cavity party wall has no advantage over a one-brick solid wall, 13 of the municipal designs observed had cavity party walls. These were from 8 different architects departments. This includes one design in which each house in a terrace had its own cavity wall where the houses adjoined. The independent walls were provided because of a danger of mining subsidence. The tenants said they could not hear a sound from next door. This design was not included in Table 14.6.

TABLE 14.5

Mitigating planning and disturbance by noise from other dwellings experienced in semi-detached and end terraced houses and bungalows

LAYOUT OF ROOMS	MUNICIPAL			SPECULATIVE		
Adjoining on each side of party wall:	Number of dwellings	Disturbance: Slight	Disturbance: More than slight	Number of dwellings	Disturbance: Slight	Disturbance: More than slight
Rooms of similar use and hall and kitchen	14			2		
Rooms of similar use and part of hall and kitchen	3			5	1	2
Rooms of similar use and garage				3	2	
Rooms of similar use	13	1	2	26*	5	4
Rooms of dissimilar use and part of hall and kitchen	2		1			
Rooms of dissimilar use	4	1		6	1	
Totals	38	3	3	42	9	6

* Including one showhouse, unoccupied.

TABLE 14.6

Mitigating planning and disturbance by noise from other houses experienced in intermediate terraced houses

LAYOUT OF ROOMS	MUNICIPAL			SPECULATIVE		
Adjoining on each side of party wall:	Number of dwellings	Disturbance: Slight	Disturbance: More than slight	Number of dwellings	Disturbance: Slight	Disturbance: More than slight
Rooms of similar use and hall and kitchen	4		1			
Rooms of similar use	1			2		1
Rooms of dissimilar use	5		2	6	2	1
Totals	10		3	8	2	2

In four houses where occupiers said they were disturbed by neighbours noise it was established that the party wall was built of clinker or lightweight concrete blocks. In one house the occupiers had to sleep in their second bedroom, leaving their best room empty, because of noise from next door - they said that normal speech was intelligible through the wall. In another house the housewife was disturbed by the W.C. next door. She said that all the neighbours complained about this (they lived in houses of the same design). Remarkably the W.C. was not on the party wall but at the other side of the house.

TABLE 14.7

Mitigating planning and disturbance by noise originating in other dwellings experienced in flats and maisonettes

LAYOUT OF ROOMS		MUNICIPAL			SPECULATIVE		
Internal passages and bathroom between corridor and living rooms or bedrooms:		Number of dwellings	Disturbance		Number of dwellings	Disturbance	
			Slight	More than slight		Slight	More than slight
Top floor	Yes	5		1			
	No	17	8	2	3		
Bottom floor	Yes	4					
	No	20	4	6	1	1	
Intermediate floor							
	Yes	2		1	1		
	No	15	3	4			
Totals		63	5	14	5	1	

Tenants in flats were disturbed by people above rather than below or on the same level. Complaints were usually about children or couples arguing, the latter mostly at night. Several said they did not think the people above had any carpets on their floors. One houswife said she once thought there was a party in the flat over hers but found to her surprise that it was two floors above. A caretaker of one block said that many tenants slept with a broom by the bed for banging on the floor or ceiling as necessary - presumably a form of counterattack.

Of eight multi-storey blocks where the floor construction could be ascertained, seven had floating screeds on either glasswool or cellular polystyrene. The other block, so far as could be determined, had a 2 in screed on a 6 in reinforced concrete slab without an absorbent layer between screed and slab.

In other municipal flats and maisonettes details of the construction of the separating floors were obtained in 14 cases. Two were of concrete without an absorbent layer under the screed. In both of these only top floor tenants were interviewed so it is not possible to say whether the sound insulation was found to be satisfactory. Six flats had floating screeds on glasswool or cellular polystyrene, three of these were on ground or intermediate floors, and two out of the three tenants were disturbed by noise from other dwellings. In one case, however, not directly by the neighbours but by the sound made when they turned on their water taps.

Four blocks had floorboards on wood fillets fixed to a concrete slab with 'acoustic' clips. Ground floor tenants were interviewed in all these and none of them was disturbed by noise from other flats.

Two municipal blocks and one speculative block had joist-and-board floors. All occupiers interviewed lived on the top floor. The municipal tenants were not disturbed but the occupier of the other flat said that the sound insulation was so poor that they could hear the slightest sound from below. In one of the municipal blocks, 3 in of slagwool or glasswool supported between joists by hardwood was specified to be used as pugging. What was actually used was not ascertained, 3 in of high density slagwool (12-14 lb/ft^3) would have had the requisite weight to be of some use but if glasswool was used it would have little value. None of these joist-and-board floors would meet the deemed-to-satisfy provisions of the Building Regulations now in force.

In one block of reinforced concrete frame construction three out of four tenants in flats in different parts of the block were disturbed by noise from the rubbish chute: a complaint which did not occur elsewhere. Only one flat was adjacent to the chute, the others were well away from it. There were also complaints in this block about bangs from the lift, and the tenants of a top floor flat said that they were kept awake at night by the noise of the fans in the ventilation duct.

A ventilation duct in a block of maisonettes gave cause for several complaints. Internal bathrooms were naturally ventilated and noise passed from one dwelling to another along the duct. The Local Authority had attempted to alleviate the trouble, without success, by putting absorbent material in the duct.

The wide divergence of sensibility which makes judgement of an acceptable standard of sound insulation difficult is exemplified by two remarks made by ladies living in flats: (i) "The sound insulation is so poor, you are frightened to have company", (ii) "Noise doesn't worry us, we are the noisy ones".

Noise originating inside dwellings

Approximately one-fifth of occupiers interviewed were disturbed by noise originating within their own dwellings, precise figures are shown in Table 14.8. Plumbing was the most frequent cause of disturbance - so

TABLE 14.8

Occupiers disturbed by noise originating within their own dwelling

Item	Municipal	Speculative	Others	Total
Interviewed	114	78	8	200
Disturbance:				
Slight	10	10		20
More than slight	9	7	2	18
Main complaint:				
Plumbing	9	9		18
Heating	2			2

TABLE 14.9

Position and type of W.C. provided in houses and maisonettes

Item	Municipal	Speculative	Others	Total
Examined	45	73	8	126
W.C. over living room*	7	10		17
Occupiers disturbed by this	1	3		4
Couple-coupled cistern and siphonic trap to W.C.		8 (3 where W.C. over living room)		

* Including kitchen-dining room

far as it was possible to classify sources. Many people mentioned noise from heating appliances but most said they had got used to it.

Water hammer or other noises from pipes were often mentioned. Taps were described as sounding like 'bulls' (i.e. steam siren), and on one occasion like 'the Queen Mary'. One housewife said the taps were driving her mad. In several cases the fault had received attention but the trouble persisted. In one house where the housewife said the taps shook, the reason for it could not be found because the taps would not shake when the men came to look at them.

Ticking noises from plastic soil pipes led to complaints, this noise was due to expansion when hot water was run to waste. This noise seemed to be particularly annoying, so much so that in one house where the soil pipe ran through the kitchen the housewife said she was thinking of moving because of it. There was also a complaint about ticking noises from plastic rainwater gutters, the occupiers said they could hear it when they lay in bed.

Apart from ticking noises there was only one other complaint about a soil pipe. This one was unencased in the bathroom of a flat and it was said that the noise of water in it was sometimes disturbing at night.

Only one water storage tank caused trouble. This tank was in a cupboard in the childrens bedroom and the noise of it filling disturbed them.

In a municipal house, the architect had concealed pipework and W.C.

cistern behind a panel. This he claimed made the W.C. quieter than normal. Unfortunately it appeared to have exactly the opposite effect as the occupier said that flushing the cistern woke up the baby.

A surprisingly high proportion of W.C.'s were over living rooms (Table 14.9), this did not cause as much disturbance as might have been expected. Only one occupier said it was embarassing and classed the disturbance as more than slight. In addition to the number of dwellings shown with siphonic W.C.'s shown in Table 14.9, one flat was provided with this type of W.C.

TABLE 14.10

Position and construction of W.C. compartments

Description	Municipal	Speculative	Other	Total
	N=91	N=84	N=8	183
Adjacent to living room or bedroom	60	71	6	137
Wall at least equal to 3 in clinker block, plastered (41 dB, slope B).	27	23	3	53
Door facing other door	34	33	2	69
Heavy door provided	1	4	1	6

Table 14.10 shows that in 75% of dwellings the W.C. compartment (which includes bathrooms containing W.C.'s) was adjacent to a living room or bedroom.

Where this occurred only 40% had partitions with the recommended degree of sound insulation. In 38% of all dwellings the door of the W.C. compartment faced another door, some of these compartments were fitted with heavy doors but their use is thought to be incidental with respect to sound insulation.

More plasterboard partitions, generally confined to upper floors, were found in speculative dwellings than municipal dwellings. On the whole, partitions tended to be more substantial in municipal dwellings. Particulars of partitions are given in Table 14.11. It was not possible to find any relationship between the sound insulation of partitions and disturbance to occupiers.

DISCUSSION OF RESULTS

Either little account is taken of noise, or economic pressures and shortage of land compel both local authorities and speculative builders to build in noisy situations. They take few precautions to mitigate external noise, again this may be on economic grounds when construction such as double windows is considered but when it is a matter of siting car parks or footpaths it often appears to be due to lack of thought.

It is difficult to say what consideration is given to layout of rooms and position of W.C.'s to mitigate disturbance from noise but it is obvious that in many dwellings these have been ignored. A definite improvement could be made in this direction, particularly in terraced houses of the speculative class.

TABLE 14.11

Partitions in dwellings

Construction of partitions	Average Sound Reduction dB	Municipal		Speculative		Other
		Lower or Single Floor	Upper Floor	Lower or Single Floor	Upper Floor	Lower or Single Floor
2" Celotex	20	1	1			
$2\frac{1}{4}$" hollow slab of $2/\frac{3}{8}$" plasterboard with cardboard eggcrate core	26	5	5	6	21	
$2\frac{1}{2}$" ditto - $2/\frac{1}{2}$" plasterboard	29		1	1	1	
Stud, $\frac{3}{8}$" plasterboard both sides	30	3	3			1
Ditto and plaster skim coat both sides	32	1	1	3	6	
2" clinker block 1" plastered both sides	37-38	3	4	1	7	
$2\frac{1}{2}$" ditto	39	8	9		8	
3" - $3\frac{1}{2}$" aerated blocks plastered both sides	40	2	2		2	
3" clinker block plastered both sides	41	9	14	18	8	3
4" ditto	43	2	1	11	2	
$4\frac{1}{2}$" brick plastered both sides	45	47	2	20	1	
9" brick plastered both sides	50	1				
Totals		82	43	60	56	4

9 in brickwork seems to be accepted as adequate for party walls although there were some misguided attempts to improve sound insulation by the use of 11 in party walls. When expedient, speculative builders use clinker blocks for party walls. This is, however, acceptable under a deemed-to-satisfy clause of the Building Regulations if the wall is of cavity construction and the blocks of a minimum density.

No attempt appeared to have been made to provide any construction better than Grade 1 for separating walls of flats. Similarly, floors were no better than Grade 1, some observed were worse but these would not now be allowed under the Building Regulations. Partitions and doors in all dwellings are generally quite ineffective in preventing the transmission of sound within the dwelling.

Although prevention of disturbance from outdoor sources is not amenable to easy solution, much could be done to limit the incidence of indoor noise by greater attention to sources originating in plumbing.

SUGGESTIONS FOR FURTHER WORK

Grades of sound insulation of walls and floors are based on opinions of local authorities tenants. Further opinions should be sought, especially since the use of television, radio, record players, tape recorders and electronic musical instruments has greatly increased since the grades were formulated.

The effect of room layout, perhaps in conjunction with heavy partitions in certain positions, in mitigating noise should be further investigated.

Where the demands of sound insulation are in conflict with other desirable qualities, such as thermal insulation, an attempt might be made to evaluate the relative advantages.

CHAPTER 15

NATURAL AND ARTIFICIAL LIGHTING

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N A T U R A L   A N D   A R T I F I C I A L   L I G H T I N G

SUMMARY

Daylighting of stairways and rooms in 183 dwellings of different design and location is examined subjectively and the quality of lighting assessed.

Minimum periods of sunlight in rooms are measured and the results compared with what might be expected from windows orientated at random.

The provision of points for artificial lighting is investigated.

P A R T   I   -   D A Y L I G H T I N G

INTRODUCTION

Of recent years, several factors have caused increases in size and number of windows in dwellings: the more pleasing outlook from a window unobstructed by bars or mullions has led to a fad for 'picture' windows and the desire for more light to set off a higher standard of decoration, coupled with the association of good lighting with a healthy outdoor life, has also played its part. Changes in methods of construction have fostered the demand for bigger windows, as for example, in cross-wall construction where infilling panels are easily formed with large glazed areas. Improved heating makes good heat losses and combats down-draughts, and the acceptance of venetian blinds in modern decor has enabled them to be used to control excess sunlight.

Quality as well as quantity of light is important. Lighting from one side only of a room can cause glare because of too high a contrast between the bright window and the wall surrounding it. When lighting can be arranged from windows in adjacent walls, light will fall on the wall around each window and glare be reduced. If, however, light is too well distributed, from overhead lighting perhaps, it will give a flat effect without the interesting definition of shapes which is characteristic of good lighting. The most pleasing modelling usually results when the light comes predominately from one window supplemented either by a good reflected component or by secondary direct light from another window[1].

STATUTORY REQUIREMENTS

The Building Regulations 1965

Open space outside windows of habitable rooms (Regulation K1)

There are no regulations specifying lighting (natural or artificial) in buildings, in fact, there appears to be nothing to prevent any habitable room being constructed without windows, but if a window is provided then there must be a minimum zone of open space outside it. This minimum zone is an upright shaft of space wholly open to the sky (except that certain projections are permitted), it is imagined to have four sides, the inner one coinciding with the external surface of the wall containing the window, the outer one at 12 ft from the wall, or at a distance one-half of that between the top of the window and the top of the wall, and the other two sides placed so that they join the extremities of the inner and outer sides. The width of the inner side is required to be equal to $^{1}/10$th room area ÷ window height and may be wider than the window. The width of the outer side is to be equal to its distance from the wall. It is not necessary for the whole of the outer side to be directly opposite the window though some part of it must be. The base of the shaft is formed by a plane inclined at 30 deg. to the horizontal from the bottom of the window or 4 ft from the floor, whichever is higher.

Where there are two or more windows in a room the open space may be provided outside any one of them; alternatively it may be distributed between them.

Projections, such as the structure of a bay or oriel window, a conservatory or a verandah with either a glass roof or a maximum projection of 5 ft, are permitted in the open zone.

RECOMMENDED STANDARDS

Fig. 15.1 summarises the recommendations of CP3: Chapter I: Part 1[(1)]. The minimum daylight factor is to be provided over at least the area shown in the respective rooms and the zone must extend at least half the depth of the room facing the main window in living rooms and three-quarters of the depth in bedrooms. Other recommendations are -

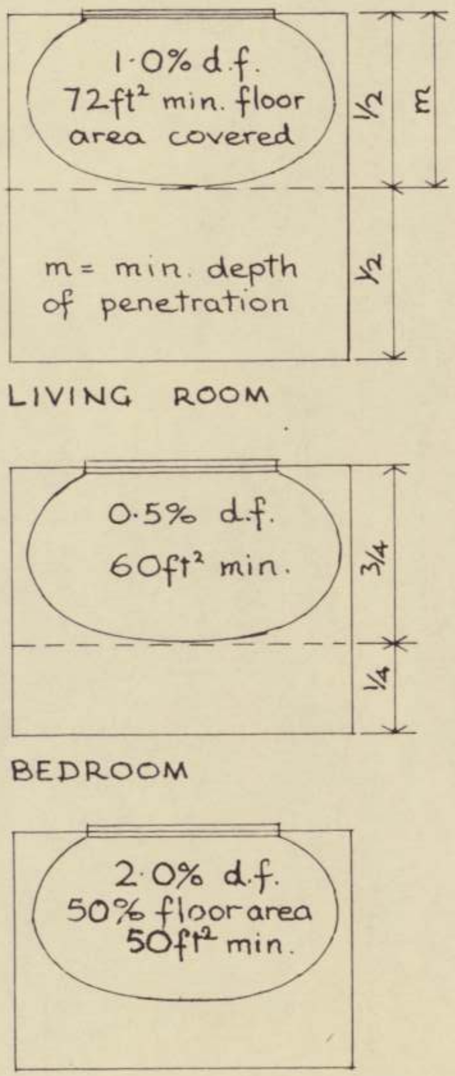
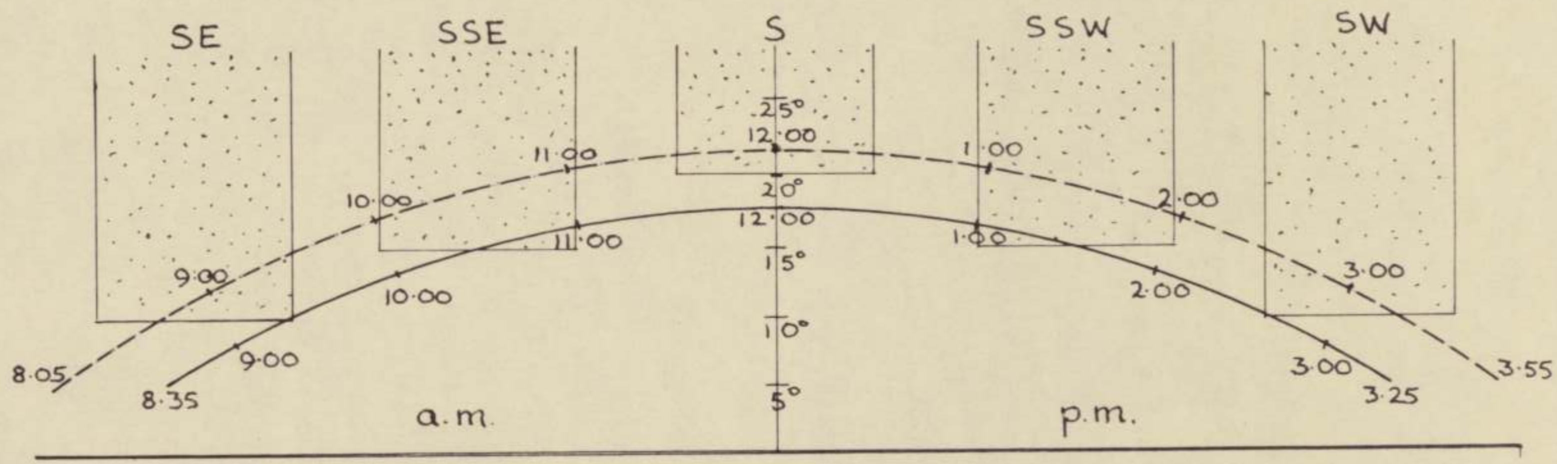
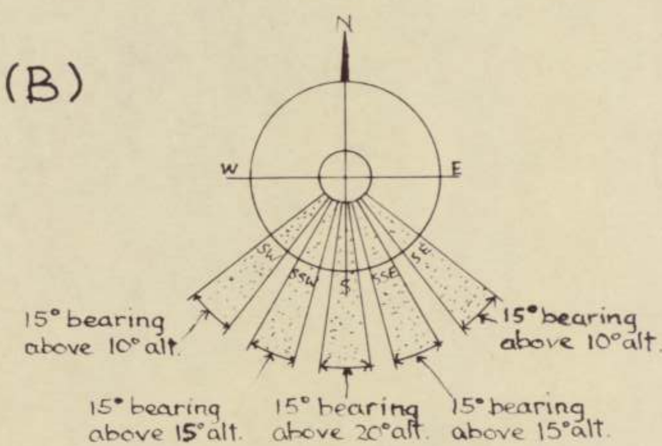


FIG 15·1 MINIMUM DAYLIGHT



(A)

altitude of the sun throughout the day on
——— January 21st and November 22nd
– – – February 6th and November 6th



(B)

FIG 15·2 SUNLIGHT

(i) Living Rooms: If the room is an unusual shape or the main window is at one end of the room, the provision of light from windows in more than one wall will assist a satisfactory distribution of daylight and be a definite aid towards good quality lighting.

(ii) Bedrooms: A good distribution of daylight with no dark corners is more important than a high level of daylight.

(iii) Kitchens: The cooker, sink and preparation table should be well within the zone of minimum daylight factor. If the sink is not placed under the window, particular care should be taken to avoid the housewife being obliged to stand in her own light. Where the working surface is placed directly under the window, the sill should not be more than 6 in above it.

(iv) Dual purpose rooms: Rooms to be used for more than one main purpose (e.g. kitchen-living rooms) should be lighted to the more exacting of the relevant recommendations.

PREVIOUS WORK

A survey of daylighting in flats was made in 1942 and a further survey of the lighting of houses was carried out for the Lighting Committee of the Building Research Board which reported in 1944(2). This work was on housing of a different era and is not relevant to these times.

EXAMINATION OF DWELLINGS

An E.E.L. daylight factor meter was carried and used on occasions but results are not quoted as the necessary condition of a completely overcast sky never seemed to pertain when wanted. Moreover, many doubts have been expressed about the accuracy of such instruments.

The examination covered the adequacy of lighting on stairs within dwellings, the arrangement of the windows in rooms and how well the housewife could see to work in the kitchen.

DEFINITIONS

Daylight in interiors is specified by the daylight factor. This is the ratio of illumination within a room to that simultaneously available outside in an unobstructed position. It is usually expressed as a percentage. An absolute unit would be impracticable because of the constant variation of intensity of daylight; expressing the interior illumination as a percentage of the exterior illumination means that the factor remains constant, furthermore, because the eye adapts to the brightness of its surroundings, the daylight factor gives a better idea of the subjective effect than would be obtained by giving the illumination level at any one time. However, occasionally it will be useful to compare the daylight factor with artificial lighting recommendations. For this purpose the illumination provided by the sky is generally assumed to be

500 lumens/ft^2.

NOTE ON DESIGN

Determination of the daylight factor at the design stage requires, firstly, the calculation of the direct light received in the room from the sky, known as the sky factor, and, secondly, the calculation of indirect light reflected from exterior buildings and the ground, and inter-reflected from the surfaces of the room. Plotting diagrams, tables, special protractors and slide rules are available to simplify the calculations. The Building Standards (Scotland) Regulations 1963 Schedule 8, provides tables of minimum sizes of windows for rooms in houses; these should be read in conjunction with the Regulations and Explanatory Memorandum II, Scottish Development Department, H.M.S.O.

RESULTS

Areas of windows expressed as ratios of floor areas and of wall area are given in Chapter 11. In most rooms light from the windows appeared to be adequate but stairways were often rather dark. Exactly half of the 44 municipal dwellings containing stairways which were appraised had stairs where the natural lighting was considered inadequate. In speculative dwellings the proportion was approximately one-third (24 out of 75). With two out of five dwellings otherwise classified included, the total of stairs inadequately lighted was 48 out of 124 (39%).

As the assessment of the adequacy of lighting on stairs was the subjective judgement of an individual it cannot be regarded as more than a guide to the degree of natural lighting present. The stairs appeared dark when lighted only from a small window in the hall or from a glazed door which was not opposite the foot of the stairs. Landings were particularly dark when at a turn from the stairs, usually a little borrowed light was obtained through fanlights over the doors but this provided little more than a glimmer. Many halls in flats, notably those in multi-storey blocks had no natural lighting at all, except perhaps what little was obtained from a glazed or half-glazed entrance door fronting a corridor. Internal bathrooms and W.C.'s were of course without windows. Several occupiers said they found such conditions depressing.

Living rooms with the good quality of lighting obtained by having windows on adjacent walls, numbered 11 out of 91 dwellings of the municipal class. There were also 7 like this out of 84 speculative dwellings and 2 out of 8 others, in all 19 out of 183. In addition, 16 municipal, 21 speculative and 2 others had living rooms with windows on opposite walls. Although it was obviously impracticable with some designs to provide windows on more than one wall there were those where it could have been done without difficulty.

If a separate dining room is provided the layout of rooms will not generally permit windows on opposite walls in either living room or dining room: only one example occurred in the case of living rooms in the dwellings examined and none at all with the dining rooms. Windows on adjacent walls were observed in only one case out of 14 municipal dwellings with separate dining rooms. There was also only one out of the 24 speculative dwellings with dining rooms.

Kitchens were generally well lit, only three out of 183 designs were below standard. In two of the cases (both speculative houses) this was due to the kitchen window facing a narrow space not more than two yards wide between the house examined and the one next door. Another dwelling (a municipal maisonette) had its kitchen darkened by the tower which housed the stairway leading to the access balcony of the block. The requirements of the Building Regulations in respect of zones of open space will prevent such examples in future.

The positioning of the cooker, sink and preparation table so that the housewife was noticeably in her own light when standing at them occurred rarely. In only one dwelling were all items opposite the window and at such a distance as to make the shadow of the person using them annoying. The cooker was at fault in one municipal dwelling and two speculative, the sink in three municipal one speculative and one other dwelling, the preparation table in three municipal and three speculative dwellings.

Often the working surface in the kitchen was under a window either wholly or partly. The recommended maximum height of the sill above the working surface of 6 in was exceeded in 11 municipal dwellings and 10 speculative, usually by not more than 4 in, seemingly without detrimental effect.

CONCLUSIONS

Much of the natural lighting of stairways and landings is below standard. The level of lighting within rooms is generally satisfactory but little attention appears to have been paid to the quality of daylighting.

PART II - SUNLIGHT

INTRODUCTION

It is stated in CP3: Chapter I(B)[3] that in Great Britain sunlight in and around buildings is very desirable: that it is an aid to cleanliness, an important source of warmth and has germicidal qualities. Other reasons why sunlight is desirable might be put forward but one of the best is that people like it.

RECOMMENDED STANDARDS

The only recommendations are those of CP3: Chapter I(B). Two principal recommendations apply to housing:

(i) "In living rooms and, where practicable, in kitchens and bedrooms also, one of the windows forming the main source of daylight should be so placed that sunlight can enter for at least one hour at some time of the day, during not less than the 10 months of the year from

February to November. It is preferable for sunlight to enter living rooms in the afternoons and bedrooms in the morning."

(ii) "Larders should be sited so that they are protected from the heat of the sun".

Only useful sunlight should be considered and this is defined in CP3 as being the period during which the sun has an altitude of more than 5 deg. A further qualification is that sunlight should not be considered to enter a room if the horizontal angle between the sun's rays and the plane of the window is less than 22½ deg.

In Birmingham (latitude approximately 52° 30'N, longitude approximately 1° 55'W) the sun is 5 deg. above the horizon at approximately 8.55 a.m. and 3.45 p.m. (GMT) on 21st January; the corresponding times on 22nd November are 8.30 a.m. and 3.20 p.m.* This gives a possible 6 hours 50 mins of useful sunlight. For the 10 months between 21st January and 22nd November the number of hours when the sun is more than 5 deg. above the horizon will always be greater. The sweep of the sun on these dates will be 94° 30' and the rate of horizontal travel will vary from approximately 12 deg. per hour in the early morning to 15 deg. per hour at

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* Sun path diagrams and sunlight indicators are usually in Local Apparent Times (L.A.T); these are the times which would be given by a clock which was adjusted each day to read 12 noon when the sun was due south of it. Two factors would make daily adjustment necessary; one is the elliptical rather than circular orbit of the earth, the other is the tilt of the earth's axis. A further variation between LAT and GMT occurs with longitude. LAT at Birmingham on January 21st is found by subtracting 19 minutes from GMT. Adjustments on November 22nd is made by adding 6 minutes (see Fig. 15.2(a)).

noon decreasing again to 12 deg. per hour in the late afternoon. Therefore, if there is an unobstructed view of the sun between 47° 15' East of South and 47° 15' West of South of approximately 15 deg. bearing from a window at least one hour of useful sunlight can enter the room. Design is usually based on the assumption that on any day between 21st January and 22nd November the possible sunlight will be greater but this may not be so on the rare occasions when the sun enters a room through a gap between high buildings because as the day lengthens the rate of horizontal travel increases until at midsummer the sun travels through nearly 30 deg. in one hour in the middle of the day.

The altitude of the sun above the horizon on 21st January and 22nd November (Apparent Local Time, Latitude 52° 30') is shown in Fig. 15.2(a). At (b) are shown the altitudes above which, according to CP3 from which the drawing was taken, a clear view of the sky through a bearing of 15 deg. will satisfy the recommendations by giving approximately one hour of useful sunlight through a window. Altitude is measured from the sill of the window and CP3 states that the sky should be clear of obstructions above 10 deg. if the view is towards the south east or south west; above 15 deg. if the view is towards the south-south-east or south-south-west; and above 20 deg. if the clear view is towards the south.

It is apparent from Fig.15.2(a) that CP3's specification does not satisfy its own minimum recommendation. The sun would appear only in the clear views to the south-south-east and south-south-west and then merely briefly. Even over 9 months of the year a possible full one hour of useful sunlight would not be obtained if the clear view was to the south-east or the south-west.

To determine accurately whether or not the sun will be obstructed use may be made of the Standard Sunlight Indicators devised by the Ministry of Housing and Local Government[4]. These are protractors for use on the plan of a site to show the distances at which obstructions of various heights will prevent the rays of the sun entering a window on 21st January and 22nd November.

PREVIOUS WORK

The recommendations of CP3 are based on a survey carried out during the last war by Chapman and Thomas[2], in which housewives were asked where and when they preferred sunlight in their rooms. There was a tendency for them to show a preference for what they were used to, but notwithstanding what has been described as the 'quite limited evidence'[5] of the survey, the recommendations have been generally accepted and they provide a guide to minimum standards.

EXAMINATION OF DWELLINGS

A check was made of the times when sunlight would enter rooms on 21st January and 22nd November. This was done by obtaining the orientation of the windows and reading the times off the Standard Sunlight Indicator. When there was any sign of obstruction of sunlight by neighbouring buildings or other obstacle then the reading was made insitu using the specially made sunlight indicator shown in Plate 15.1. This was so constructed that when it was placed centrally on the inner sill of a window and correctly orientated the path of the sun on 21st January and 22nd November could be sighted through the window and thus a reading of the times when the sun would be visible obtained.

RESULTS

Some of the buildings in which sunlight readings were taken contained multiple dwellings but the readings were taken only in the first dwelling visited. It was felt that the method of selection would ensure that a true picture of sunlight in dwellings of different designs and in different locations would be obtained but some doubt existed with regard to large blocks in which flats might be found in four different aspects. To remove this doubt the frequency of living rooms receiving the minimum recommended sunlight in all municipal dwellings was compared with the frequency in municipal dwelling with large blocks of flats excluded as shown in Table 15.1.

The percentage frequency was virtually the same so no distinction was subsequently made between the different types of municipal dwelling.

Full details of rooms observed as receiving at least the recommended minimum amount of sunlight are given in Table 15.2. The part of the day indicated first in the table includes that part said to be preferable in CP3, for instance in the case of living rooms the afternoon is preferred.

TABLE 15.1

Useful sunlight in living rooms of municipal dwellings

Part of day when sunlight is received	All dwellings	Excluding large blocks of multiple dwellings
Morning and afternoon or afternoon only	45 (50%)	33 (49%)
Morning only	21 (23%)	16 (24%)
None	25 (27%)	19 (28%)
	91	68

In early morning or late afternoon on 21st January and 22nd November the sweep of the sun necessary to give one hour of sunlight in a room is 12 deg. If the horizontal angle between the plane of a window and the first rays of the sun when it is at an altitude of 5 deg. above the horizon at the beginning of the day is approximately 34 deg. then one hour of useful sunlight will enter the room (sunlight is discounted if the angle between the sun's rays and the plane of the window is less than 22½ deg.). As the position of the sun when the first rays of useful sunlight enter the room is 45° 15' East of South, the plane of the window that will give one hour only of useful sunlight will be 47° 15' minus 34°, say 13° East of South. Similarly the plane of a window that will give one hour only of useful sunlight at the end of the day will be 13° West of South. Any window between these two bearings would give more than

TABLE 15.2

Useful sunlight in rooms

Part of Day	Municipal	Speculative	Others	All
Living Rooms (excluding dining rooms)				
Morning & Afternoon or Afternoon only	45 (50%)	48 (57%)	7	100 (55%)
Morning only	21 (23%)	15 (18%)		36 (20%)
None	25 (27%)	21 (25%)	1	47 (26%)
	91	84	8	183
Kitchens				
Morning and/or Afternoon	49 (54%)	45 (54%)	5	99 (54%)
None	42 (46%)	39 (46%)	3	84 (46%)
	91	84	8	183
Bedroom 1				
Morning & Afternoon or Morning only	45 (50%)	43 (51%)	4	92 (50%)
Afternoon only	11 (12%)	11 (13%)	2	24 (13%)
None	35 (38%)	30 (36%)	2	67 (37%)
	91	84	8	183
Bedroom 2				
Morning & Afternoon or Morning only	25 (35%)	31 (37%)	3	59 (36%)
Afternoon only	12 (17%)	13 (15%)	1	26 (16%)
None	35 (49%)	40 (48%)	2	77 (48%)
	72	84	6	162

Continued/

TABLE 15.2 Cont.

Part of Day	Municipal	Speculative	Others	All
	Bedroom 3			
Morning & Afternoon or Morning only	25 (53%)	32 (48%)	2	54 (50%)
Afternoon only	5 (13%)	9 (13%)		14 (13%)
None	13 (34%)	26 (39%)	2	41 (38%)
	38	67	4	109

one hour of useful sunlight, barring obstructions. Therefore, if the orientation of a window is defined as being at right-angles to its plane, the range of orientation that will give at least one hour of useful sunlight is from 77^{o} East of North to 77^{o} West of North, i.e. 206 deg.

If all rooms had but one window and the windows were orientated at random then $\frac{206}{360}$ or 57% would be expected to have at least one hour of useful sunlight .

Individually the frequencies observed in kitchens and bedrooms differ from the expected frequencies by amounts which might be expected to arise by chance but taken together and bearing in mind that kitchens and second bedrooms are usually at the back of houses and first and third bedrooms at the front they give reason to believe that there is some tendency to build houses to face the sun.

The additional sunlight recorded for living rooms probably arises largely from some of them having windows on more than one wall. It has previously been recorded that 19 out of 183 living rooms had windows on adjacent walls and 39 had windows on opposite walls. Windows on adjacent walls will increase the range of orientations receiving at least one hour of useful sunlight by 90 deg. making it 296 deg. The chance of living rooms with windows on adjacent walls receiving at least the minimum amount of sunlight is, therefore, $\frac{296}{360}$ or 82%. Living rooms with windows on opposite walls are certain to receive at least one hour of useful sunlight from one direction or the other.

Using the percentages of expected sunlight calculated above the probability of the observed living rooms receiving at least one hour of useful sunlight if they were orientated at random can be predicted as follows:

Location of windows	Frequency of rooms receiving at least one hour of sunlight
One wall only	125 x 57% = 71
On adjacent walls	19 x 82% = 16
On opposite walls	39 x 100% = 39
	Total 126

Probability of receiving sunlight in living rooms = $\frac{126}{183}$ = 69%.

The observed percentage of living rooms receiving sunlight given in Table 15.2 is 75%. To see whether this indicates a tendency for selective orientation of living room windows the chi-square test is used.

	Living Rooms	
	With sun	Without sun
Observed frequency	136	47
Expected (predicted) frequency	126	57

$$\chi^2 = \sum \frac{(O-E)^2}{E} = 2.55$$

$$0.25 > \alpha > 0.10$$

The test shows that the difference between the observed and expected frequencies is not statistically significant and might well have occurred by chance. However, the observations support the belief suggested by the findings for other rooms that there is some tendency for the main rooms to be placed where they receive the most sunlight.

At least three municipal houses had been specially planned to get sunlight in the living room, there may have been others but it was not obvious. Some speculative houses appeared at first sight to have been built with the living room sited to get the most available sunlight. For instance, some had the kitchen at the front, but inspection revealed that houses of the same design were built with quite the opposite aspect. Consideration of possible sunlight in rooms may have been given when estates were laid out but this could not be confirmed by inspection.

No account has been taken of possible obstructions in comparing observed and expected frequencies of rooms receiving sunlight. In practice these were found to be few. There were two examples of building both municipal developments where sunlight had been blocked out of rooms. In a maisonette where the living room faced due south the full sweep of the sun, as shown by the sunlight indicator, had been obstructed by another block recently built on the same site. In a three storey block of flats, sunlight to 6 out of 9 flats was reduced from a possible minimum of 2 hours to ½ hour by walls on the balconies.

CONCLUSION

Some consideration is probably given to obtaining sunlight in rooms, but even so a quarter of all living rooms do not receive even the minimum amount recommended and only a little more than half get it at the most desirable time.

PART III - ARTIFICIAL LIGHTING

INTRODUCTION

The quality of artificial lighting in a dwelling depends not only on the luminous intensity of the source of light but also on the type of fitting and its position. The occupier can vary the luminous intensity by using a different size of lamp, usually the fitting will also be his choice but he will have little control over its position. Careful planning of lighting points and their switches is therefore desirable. Elaborate calculation of lamp sizes and spacing is not required for the small rooms of dwellings but the lighting should be arranged to give pleasing illumination and ensure that people do not get in their own light when engaged on a task.

RECOMMENDED STANDARDS

There are no statutory requirements regarding the provision of artificial light in domestic buildings in England and Wales. The Scottish Building Regulations require at least one point for lighting in every room (Reg. 194) and if a light is on a terminal landing of a stairway, switches controlling the light must be provided on the landing itself and on any other terminal landing.

Principal sources of reference for desirable values of illumination are CP3[(6)] and the I.E.S. Code[(7)]. Published in 1945, CP3 includes details of sizes of gas mantles but these have been omitted from the summary of recommendations which follows in Table 15.3: sizes of electric lamps, quoted in CP3, have also been omitted because of the variation between the illumination recommended by the two bodies.

TABLE 15.3

Recommended Values of Illumination

Column Number 1 - Location

2 - Recommended illumination at height 2 ft 9 in above floor, lm/ft^2, from CP3[(6)].

3 Recommended illumination to be maintained on task lm/ft^2 from I.E.S. Code [(7)].

4 Recommended number and position of lighting points from CP3.

1	2	3	4
Working kitchens and sculleries Kitchen plus dining only	6 to 10	20	Two separately controlled lights conveniently disposed to avoid shadowing of sink, cooker and table.
Living rooms:			
Casual reading	6 to 10	15	
Sustained reading	10 to 15	30	One or two fixed points for general lighting. Three plug points for local lighting.
Sewing	15 to 25		
Combined kitchens and general living rooms	As for living room		As for living rooms with additional point for sink and cooker.
Bathrooms	6 to 10	10*	One ceiling light or wall bracket above the mirror.
Bedrooms	4 to 6		(a) Where position of furniture can be defined One bedhead light in fixed position One light in position suitable for dressing table but serving also as general room light One plug point (b) Where position of furniture cannot be defined One general light from ceiling Two plug points. (c) Where lavatory basin and mirror are installed in a bedroom One light should serve the mirror.

*Supplementary local lighting should be provided at mirrors.

W.C.'s		One point over the W.C.
Stairs within a house or flat	10	One point arranged at or near the head of each flight of stairs so that as far as possible each tread throws a shadow covering between 25% and 75% of the width of the tread beneath. Lamps should be controllable both from near the top and near the bottom of the stairway.
Halls and passages		Light preferably out of field of vision of person descending stairs but, if this is not practicable, the fitting should have a brightness not exceeding 10 candles per sq. in. in any direction within the field of view of person descending stairs.
Cupboards, larders		Usually served by general lighting of room but special light to be provided where necessary. Attention should be given to lofts, fuel stores, meters and fuseboards.
Utility rooms and wash houses		One point suitably placed in relation to the appliances
Front and back doors		Special lighting unless adequately lit from other sources, such as through glass panels. Illumination for the name or number and lighting of the approach and steps are desirable.
Communal stairs, access corridors and balconies	10	Lights for stairways should be placed at fairly frequent intervals, depending upon the type of stair and should be arranged so that each tread throws a shadow covering between 25% and 75% a.b. Decoration should be as light in colour as possible. Where the nosing of every step can be in a light coloured material the illumination at tread level should be at least 0.2 f.c. otherwise the minimum illumination should be 0.5 f.c. Passages corridors and balconies should have a minimum illumination of 0.2 f.c. at ground level. For communal stairs and passages satisfactory maintenance of lighting is particularly important.
Garages	7	

PREVIOUS WORK

Chapman and Thomas[2] were concerned with artificial lighting in dwellings when they made their wartime survey. They made a detailed analysis of the lighting of the 'main downstair rooms' and how well people thought they could see by artificial light in their homes. This work influenced the recommendations of the Lighting Committee (1944) and Code of Practice Committee (1945).

EXAMINATION OF DWELLINGS

Examination was limited to observing the number of lighting points in each room at front and back entrance. The number of power socket outlets available for lighting purposes was also observed.

RESULTS

One of the items the buyer of a speculative house purchases as an extra is additional lighting and power points. For this reason the number provided in speculative dwellings of the same design may fluctuate. The provision for lighting recorded here is that provided when the house was built, regardless of whether or not it was regarded as an extra.

Lighting points in kitchens, as in other rooms, were placed approximately centrally. About 13% of kitchens (see Table 15.4) had two

TABLE 15.4

Lighting points in kitchens

Class	No. of dwellings	Two points	Separately Controlled
Municipal	91	9[(a)]	3
Speculative	84	13	
Others	8	1	
Total	183	23	3

(a) Two had distinctly separate dining areas

lighting points; in these the points were spaced to be approximately in the centre of each half of the room. No special consideration appeared to have been given to avoidance of shadow at sink, cooker and table. Separate control of two lighting points was hardly ever provided.

In almost exactly half of the dwellings of different design which were examined, the living rooms (excluding dining rooms) had more than one lighting point. This is shown in Table 15.5. The proportion was rather higher in speculative dwellings than in municipal dwellings.

Power socket outlets, the provision of which is also shown in Table 15.5 are used for other purposes than lighting. Allowing just one socket for, say, television a minimum of four would be required to meet the recommendations of CP3. If this figure is taken as the indicator then 78% of municipal dwellings and 83% of speculative dwellings were below standard in respect of artificial lighting of living rooms. Considering all designs together, 83% were below standard.

TABLE 15.5

Provision for artificial lighting in living rooms

Lighting Points	Socket outlets						Total
	One	Two	Three	Four	Five	Six	
Municipal							
One	8	19	18	10	1		56
Two	1	14	11	7	2		35
Total	9	33	29	17	3		91
Speculative							
One	16	9	8	1			34
Two	4	20	10	5	1		40
Three	3	3	3		1		10
Total	23	32	21	6	2		84
Others							
One	1			1	1	1	4
Two			3				3
Three		1					1
Total	1	1	3	1	1	1	8
All Dwellings							
One	25	28	26	12	2	1	94
Two	5	34	24	12	3		78
Three	3	4	3		1		11
Total	33	66	53	24	6	1	183

In those dwellings where there was more than one lighting point provided in a bedroom, provision was confined to the first bedroom. They were few in number - one municipal, four speculative and one other. The largest bedroom with only one lighting point measured 21 ft 9 in by 11 ft 6 in on plan.

Power socket outlets in bedrooms are shown in Table 15.6. In a few bedrooms access was not convenient at the time of inspection and the number of sockets could not be recorded because the housewife interviewed was not sure how many there were. One only of the bedrooms observed was without a socket outlet: this was the smallest bedroom in a speculative house.

Taking the minimum requirement as two socket outlets in addition to the lighting points, which under CP3 recommendations does not allow a socket for other use, bedrooms below standard in provision for lighting are as follows:

Bedroom 1: 63% municipal, 78% speculative, 68% all.

Bedroom 2: 69% municipal, 86% speculative, 79% all.

Bedroom 3: 80% municipal, 94% speculative, 90% all.

The number of fourth bedrooms observed was considered too small for a record of their lighting provision to be of value.

Special lighting at the front door was perhaps seldom essential because light was obtained usually from a glazed door. However, eleven speculative houses (about 13%) had a lighting point provided. Of 75

TABLE 15.6

Power socket outlets in bedrooms

Number of Outlets	Municipal	Speculative	Other	All
Bedroom 1				
One	55	65	2	122
Two	26	19	5	50
Three	5			5
Four	2		1	3
Total	88	84	8	180
Bedroom 2				
One	49	72	6	127
Two	19	12		31
Three	2			2
Four	1			1
Total	71	84	6	161
Bedroom 3				
One	29	66	4	99
Two	7	4		11
Total	36	70	4	110

municipal dwellings entered from outdoors, as distinct from flats entered from corridors, two had lighting points over the front door. Three dwellings of other types out of six where it was applicable had such points. At the back door four municipal, two speculative and three other dwellings had special lighting points.

CONCLUSION

Provision for artificial lighting is generally below the standard desirable but an improvement can be expected as the recommendations of the Parker-Morris Committee regarding socket outlets are implemented.

CHAPTER 16

POWER FACILITIES

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POWER FACILITIES

SUMMARY

The number of power socket outlets provided and some aspects of their positioning in 183 dwellings of different design and location is examined.

INTRODUCTION

Apart from the mere recording of the type of fuel used for cooking, the work described in this chapter is limited to the provision of electric power sockets. The number of electrical appliances used in the home has increased greatly of recent years and from the point of view of safety and convenience sufficient power socket outlets to cope with the increased use are desirable.

RECOMMENDED STANDARDS

Based on a survey of 120 local authority houses made by the Building Research Station in 1958(1) the Parker Morris Committee made recommendations in 1961 in respect of power socket outlets in various rooms. The N.H.B.R.C. followed somewhat later with a 'Technical Requirement' relating to power points which applied to dwellings whose foundations were concreted on or after 1st January, 1969. The principal recommendations of these two bodies are given in Table 16.1.

TABLE 16.1

Recommended power socket outlets

Part of Dwelling	Parker-Morris		N.H.B.R.C.
	Desirable provision	Minimum provision	Technical requirements
Kitchen	4	4	4
Dining area or room	2	1	2
Living area	5	3	3
First (or only) double bedroom	3	2	2
Other double bedroom	2	2	2
Single bedroom	2	2	2
Hall or landing	1	1	1 [(a)]
Store/Workshop/Garage	1		

(a) In addition to one socket outlet in the hall one should be provided on landings at each storey level.

PREVIOUS WORK

As well as the 1958 B.R.S. survey, a survey was carried out by National Opinion Polls for N.H.B.R.C. in 1968. This showed that although in the majority of new houses the provision of power points fell below the recommended standards most people were well satisfied with the provision made.

EXAMINATION OF DWELLINGS

The number of power socket outlets in each room was noted. In bedrooms it was observed whether or not the outlet was conveniently positioned for use with a bedside lamp. This was only done when the room was furnished with a bed, no assumptions were made about the probable position of the bed if the room did not contain one except that cots were accepted as beds if they were thought to be in the position where a larger bed would obviously be placed. In kitchens, means of cooking were noted and particular attention was paid to the position of socket outlets to see if any were positioned badly for convenience and safety in use.

RESULTS

Details of the number of socket outlets in living rooms and bedrooms have been given in Tables 15.5/6 in the preceeding chapter. Living rooms with less than the recommended number of three outlets were found in 46% of municipal dwellings, 66% of speculative dwellings, 54% of all dwellings inspected. These percentages may be compared with the 64% of living rooms in the N.H.B.R.C. survey with less than the recommended number of outlets. If the recommendations for lighting are taken as the criterion then the standard of provision in living rooms is even worse, as has been shown in the preceeding chapter.

Bedrooms with less than two outlets have already been expressed as a percentage of those inspected (p. 15.29). The comparable percentages in the N.H.B.R.C. survey were Bedroom 1 - 60%, Bedroom 2 - 67%, Bedroom 3 - 72% from which it can be seen that the sample detailed in chapter 15 is well below even the inadequate standard revealed by N.H.B.R.C.

Power socket outlets in kitchens, excluding distinctly separate dining areas, are given in Table 16.2. The recommended minimum is four outlets; the percentage falling below this in municipal dwellings was 85%, in speculative dwellings 88%, in all dwellings 85% compared with 63% in the N.H.B.R.C. survey.

TABLE 16.2

Power socket outlets in kitchens

No. of sockets	Municipal	Speculative	Other	All
One	7	8	4	19
Two	44	37		81
Three	26	29	1	56
Four	9	6	1	16
Five	3	3	1	7
Six or more	2	1	1	4
	91	84	8	183

Outlets in halls or on landings, enumerated in Table 16.3 were not recorded separately but it may be assumed that when only one outlet was provided it was in the hall. That there were few dwellings with an outlet on the landing is shown by the small number with more than one outlet. The percentages of dwellings with no outlet at all in the hall are municipal 73%, speculative 69%, all 70% compared with 61% in the N.H.B.R.C. survey.

TABLE 16.3

Power socket outlets in halls (including landings).

No. of outlets	Municipal	Speculative	Other	All
None	64	58	4	126
One	22	25	3	50
Two	2	1	1	4
	88	84	8	180

In response to the question "What amenity would you be prepared to pay more for?" ten persons, all occupiers of speculative houses answered "More plug points". These ten people comprised 13% of the 78 occupiers of speculative dwellings who were asked this question. This indicates a high level of dissatisfaction with the provision of power points considering the many other items which might have been selected, and the fact that many people were not prepared to pay more for anything.

The positioning of outlets did not seem to have improved since the Parker-Morris Committee commented that they had "obviously been located with a view more to saving wire than with the aim of putting them in the place where they are most likely to be needed". In bedrooms, for example, outlets appeared to be most commonly used for bedside lamps but only half of the bedrooms observed which contained a bed had an outlet in a position suitable for a lamp (Table 16.4). Perhaps it was felt that an electric fire was more likely to be used and the outlet was kept away from the bed position for that reason. It is believed that this is a mistaken assumption and that bedside lamps and electric blankets are more used.

TABLE 16.4

Socket outlet positioned by bed

Item	Municipal	Speculative	Other	All
Yes	94	108	13	215
No	99	106	9	214
	193	214	22	429

In many bedrooms flex was run under the carpet or around the skirting to bring power to the bedside. In others the outlet was in the centre of the wall where the bed stood so that it was inaccessible behind the bed head. In small bedrooms where the only position for the bed was behind the door the outlet was commonly placed on the opposite wall just where the door opened.

Kitchens were apparently wired for an electric cooker in almost all cases. A panel incorporating a cooker control and a socket outlet was frequently observed above the cooker even though this was fired by gas (Plate 16.1). More often when a gas cooker had been installed a single socket outlet had been fitted instead of a cooker control. Sometimes the splashback of the cooker partially or wholly covered the outlet and the plug could only be put in the socket with difficulty.

When the outlet above a cooker was used, if the user was careful the flex of the appliance was pushed behind the splashback, otherwise it hung down the front over the burners which if on, would more likely than not be alight with naked gas flames. Often the appliance used was an electric kettle which stood on the cooker while the water was heated. Although there was no direct acquaintance with an accident arising out of this practice a housewife said that on one occasion her next door neighbour had had the flex of her kettle burnt off.

The number of socket outlets badly positioned in kitchens is given in Table 16.5. Almost all these were behind cookers but the figures include some, such as shown in Plate 16.1, which were so positioned that appliances could not be stood nearby safely or used without danger of the flex getting across burners.

Out of interest the type of fuel used for cooking is recorded in Table 16.6.

TABLE 16.5

Socket outlets badly positioned in kitchens

Item	Municipal	Speculative	Other	All
Examined	91	84	8	183
Badly positioned	55	58	5	118

TABLE 16.6

Type of fuel used for cooking

Fuel	Municipal	Speculative	Other	All
Electricity	36	35	1	72 (39%)
Gas	50	44	7	101 (55%)
Not recorded	5	5		10 (5%)
	91	84	8	183

CONCLUSIONS

The provision of socket outlets is well below recommended standards in all rooms. This will improve as Parker-Morris recommendations are implemented by local authorities and N.H.B.R.C. but careful attention will need to be given to the positioning of outlets particularly in kitchens.

SUGGESTIONS FOR FURTHER WORK

The suggestion of the Parker-Morris Committee that research is needed into methods of arranging wiring so that it can conveniently service future outlets might be followed up. Work might also be done to find the most convenient positions to place outlets: this might be less important as the number provided increases but there remains the possibility that their use will increase proportionally.

CHAPTER 17

WATER SUPPLY

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WATER SUPPLY

SUMMARY

Following a brief look at water supply in general, domestic hot water requirements are considered and the provision of hot water and associated items examined in dwellings of 183 designs.

STATUTORY REQUIREMENTS

The Public Health Act 1936, Part II, Sanitation and Buildings, Section 137 requires that a house erected in accordance with the Building Regulations shall be supplied with sufficient piped wholesome water for domestic purposes from a supply provided by the local authority or other statutory undertakers, or if that is not reasonable, by otherwise taking water into the house. If neither of the alternatives can reasonably be required then a supply of water within reasonable distance of the house must be provided.

Byelaws are made under section 17 of the Water Act 1945 by water undertakers for preventing waste, undue consumption, misuse or contamination of water supplied by them(1).

RECOMMENDED STANDARDS

Consumption

CP3 Chapter VII (1950)(2) recommends that provision should be made for the supply of at least 30 gallons per head per day in houses and at least 20 gallons per day in flats.

Hot Water Requirements

An installation capable of supplying 250 gallons of water per week at 140 deg.F was recommended by the Egerton Committee in 1945. Subsequent research (1952)(3) showed that the average weekly consumption of hot water at 140 deg.F of a family of four persons was less than 100 gallons when no appliance was installed but rose to more than 400 gallons where a direct supply was laid on. The overall average was 300 gallons. Nevertheless the Parker Morris Committee used the figure of 250 gallons per week at 140 deg.F (assuming a temperature rise of 90 deg.F) when working out fuel costs in 1961.

250 gallons a week for a household of four persons means 9 gallons a person daily, however, CP342 quotes the much higher quantities shown below.

Hot Water Demand, Storage and Boiler Power

Building	Max. Daily Demand (gal. per person)	Storage (gal. per person)	Boiler Power (gal. per person per hour)
Dwelling Houses			
Low rental (n.e. 950 ft^2)	See particular requirements (below)		
Medium rental (950 - 1500 ft^2)	25	10	3.0
Higher rental (exc. 1500 ft^2)	30	10	4.0
Flats, blocks of			
Low rental	15	5	1.5
Medium rental	25	7	2.5
High rental	30	7	3.0

Particular requirements for small single family dwellings of about 950 ft^2 floor area are:

(a) a storage vessel of not less than 25 gallons actual capacity to enable 3 gallons of hot water to be drawn off at the kitchen sink at a temperature of not less than 140 deg.F immediately prior to two baths taken in succession. (The two baths are defined in CP 403.101 (1952)[5] which makes similar recommendations, as being of 25 gallons each at 110 deg.F with an interval of 30 minutes between them).

(b) means for warming the linen cupboard: generally sufficient heat is given off by an insulated hot tank to maintain a cupboard warm and dry.

(c) a heated towel airing pipe or heated towel rail.

(d) A water heater capable of heating the effective contents of the storage vessel from 50 deg.F to 15 deg.F in 4 hours, while heating at the same time the other connected loads such as a towel rail*.

CP 342 falls short of a strict definition of temperature but gives what is described as "generally acceptable temperatures" at draw-off points, these are as follows:

Baths	110 deg.F - 140 deg.F
Showers	110 deg.F
Basins	110 deg.F - 140 deg.F
Kitchen sinks	140 deg.F

---

* The Code recommends that the heating surface or output of water heaters for small dwelling houses should not be less than the following values.

Solid-fuel boilers, back	2.5 ft^2 (a)
Solid-fuel boiler, independent	2 ft^2 (a)
Gas boilers	1200 Btu/h
Electric immersion heaters	2 - 3 kw

(according to the location of the immersion heat in the vessel and to the standard of insulation adopted).

(a) The rating should be taken as not more than 6000 Btu/ft^2 of heating surface per hour. Further details of design performance are given in CP 403.101: 1952.

Even if allowance is made for the lower temperatures quoted, the quantities are generous compared with other recommendations. 250 gallons at 140 deg.F if used at 110 deg.F would provide 362 gallons in winter, with a cold water temperature of 43 deg.F[3], and 400 gallons in summer, with a cold water temperature of 60 deg.F.

Rates of Flow

There is general agreement in the rates of flow recommended in the various codes even though they differ a little in their descriptions of the fittings. The recommended rates of flow for which installations should be designed are summarised below:

Recommended Rates of Flow at Various Fittings or Appliances

Fitting or appliance	Rate of flow (gal./min.)			
	CP310 hot & cold	CP3 cold,	CP3 hot	CP342 hot
W.C. flushing cistern	1½	1*		
Wash basin tap	2	2	1½	1½
Basin spray tap	½			
Bath tap ¾"	4)	4	5	5
Bath tap 1"	8)			
Shower (with nozzle)	1½	1½	1½	1½
Sink tap ½"	2½)			
Sink tap ¾"	4)	3	4	4
Sink tap 1"	8)			

* or refill in not more than 3 minutes.

EXAMINATION OF DWELLINGS

The examination was confined to observation of the hot water system. The type of fuel used for heating water was noted and occupiers were asked if they got enough hot water. The provision of a towel airing pipe or water heated towel rail was noted. Also recorded was the provision, or not, of a warmed airing-cupboard.

It was not practicable to measure the rate of flow of hot water but to obtain guidance as to whether it was satisfactory the head of water in the storage tank above the bath hot water tap was obtained. Common practice puts the storage tank in the airing cupboard. Where this was so or where the tank was otherwise below ceiling level the occupier was asked if the hot water tap on the bath ran slowly.

RESULTS

The frequency with which different types of fuel were used as the principal means of heating water in 181 different designs of dwelling is shown in 17.1. In addition, in several dwellings where the water was heated by the appliance used for space heating, electric immersion heaters had been fitted, some at the time of construction, others subsequently.

Occupiers in eleven designs of municipal dwellings and four designs of speculative dwellings said that they did not get enough hot water. Five of the fifteen used electricity to heat water and in four cases the

TABLE 17.1

Type of fuel used for heating water

Fuel	Municipal	Speculative	Others	All
Electricity	37	53	5	95
Gas	26	18	2	46
Solid	27	12		39
Oil		1		1
	90	84	7	181

deficiency of which they complained appeared to be due to their reluctance to switch on the heater. One old couple said that they never used their immersion heater because it was too expensive.

Some multi-dwelling blocks used off peak electricity for water heating; one is numbered amongst designs where occupiers did not get enough hot water. Four flats were visited in this block: in two each occupied by a married couple, one with a small child, they said that they had enough hot water, in another the tenant said it was not enough for her living alone, the other tenant complained that he could never have a really hot bath in the evening. In another block using off-peak electricity, which consisted of maisonettes in four storeys, only one intervew was conducted. In this the housewife said that she had adjusted to the use of the water so it was assumed that she had enough hot water, however, her husband complained that it was not enough for him.

There were five occupiers out of those who used gas for water heating who said that they did not get enough hot water. Four of these had instantaneous heaters, the other one complained because she had no separate appliance for water heating in the summer. There were other complaints about instantaneous water heaters - generally that the water had to run for a long time before hot water was obtained but in one case the complaint was that the heater had exploded!

The solid fuel class of user also accounted for five occupiers who did not get enough hot water. Generally their trouble seemed to be inefficient working of back boilers. Two other users of solid fuel said they had had pipes connected the wrong way round but that subsequently the fault was corrected and a satisfactory supply ensured.

Particulars of towel airing pipes or heated towel rails provided in bathrooms are given in Table 17.2 and of the provision of warmed airing cupboards in Table 17.3.

TABLE 17.2

Heated towel airing pipes or heated towel rail

Item	Municipal	Speculative	Others	All
Dwellings examined	91	84	7	182
With heated pipes or rail	4	13	1	18

TABLE 17.3

Warmed airing cupboards

Item	Municipal	Speculative	Others	All
Dwellings examined	90	84	7	181
With airing cupboard	74	80	7	161

The head of water above the hot water tap of the bath, obtained to get some indication as to whether the recommended rates of flow were being achieved, is shown in Table 17.4

TABLE 17.4

Head of water above bath hot water tap

Position of tank	Head of water	Municipal	Speculative	Others	All
Below ceiling	3'0"		3		3
	3'6"	1			1
	4'0"	7	4		11
	4'6"	24	21	1	46
	5'0"	26	8	2	36
	5'6"	3		1	4
Above ceiling	7'6" and above	18	42	2	62
Total		79	78	6	163

The arrangement whereby the storage tank of the hot water system is fitted together with the cylinder in the airing cupboard will produce sufficient head of water to give the recommended discharge of 4 gal/min at the bath tap providing the pipe run is not too long.

The loss of head due to friction in a straight length of pipe is given by the formula [6]

$$Lf_{100} = \frac{k \times v^{1.8}}{d}$$

where:

Lf_{100}	=	loss of head due to friction per 100 ft of pipe
k	=	coefficient of friction
d	=	internal diameter of pipe in inches
v	=	velocity of water in ft/sec.

In practice the designer usually works in terms of discharge in gal/min rather than velocity in ft/sec.

Given the arrangement shown diagramatically at Fig. 17.1 the minimum

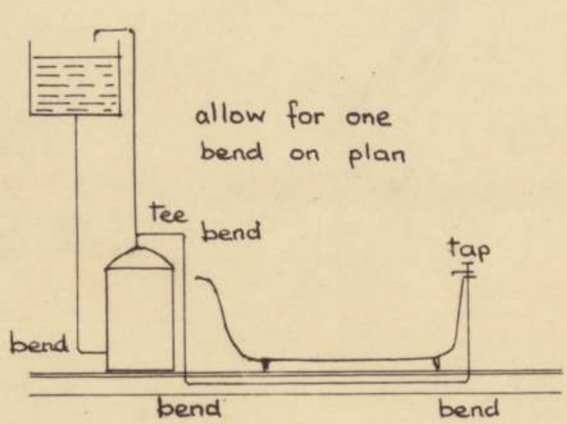

Fig. 17.1

head of water to give a discharge of 4 gal/min may be calculated as follows:

		ft
Length of $\frac{3}{4}$" diam. pipe, say		20
Equivalent length of pipe allowed for fittings:	ft	
Tee	3.75	
Bends (5)	3.20	
Tap	2.75	
	9.70	9.70
		29.70

Loss of head due to friction per 100 ft of $\frac{3}{4}$" diam. copper pipe, flow 4 gal/min = 10.85 ft.

Therefore, minimum head to give flow of 4 gal/min for equivalent pipe run of 29.70 ft = 3.2 ft.

If say, another 10 ft of pipe were necessary the required head would be 4.3 ft. As a general rule the head appeared to be sufficient and the rate of flow satisfied occupiers, there was one exception where the occupier had the tank moved into the roof space because he found the discharge too slow. In each of three other cases where occupiers said the water ran slowly the head was 5 ft. In two bathrooms the flow was intermittent, the fault, therefore, probably lay in the cold water feed. In the other case there was no obvious explanation.

CONCLUSION

Although generally domestic hot water systems are satisfactory there are dwellings where they are below standard. Some dwellings are being constructed without heated airing cupboards, few dwellings have heated towel rails.

CHAPTER 18

SURFACE FINISH

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SURFACE FINISH

SUMMARY

Methods of judging the standard of surface finish are developed and the quality of work found in an examination of 183 dwellings is illustrated. Comparisons are made between standards of surface finish in dwellings of different type, price and class.

INTRODUCTION

It is widely accepted that there has been a deterioration in craftsmanship in the post-war years. The housing sector of the building industry has never attracted the best craftsmen because they have cared neither for the type of work nor the quality demanded, and what has never been a very high standard of work has dropped even lower. This lowering of standard has been accepted with little resistance: by purchsers because they have had a limited choice of suitable new houses, and by local authorities because they have been under pressure to provide more housing. In surface finish not only is craftsmanship immediately apparent, but its demerit is a lasting reproach to the perpetrators and a source of irritation to householders. Some improvement may be possible on re-decorating but the work can never be put right.

RECOMMENDED STANDARDS

There are few particularised recommendations for surface finish; most authorities cajole the builder to do the work in a neat and workmanlike manner or use some similar ill defined phrase. When a British Standards Committee drew up B.S. 1168 and defined standards for quality of workmanship in joinery[(1)] they found themselves unable to develop a precise method of specification for surface finish which they thought would be generally acceptable and had to restrict themselves to making the following requirement:

"Unless otherwise specified, surfaces of joinery intended to receive the final decoration shall be such that if properly finished with a matt paint, imperfections in manufacture will not be apparent."

"Note It is recognised that such joinery is often decorated with a gloss paint, but with such paints defects may remain apparent unless a superior quality of finish is ordered."

Features which the Committee were able to specify and which are concerned with finish as considered in this investigation were the fit of framed members as seen from the face of the work and the fit of doors, sashes and drawers. The relevant parts of the specification are given below:

Framed joints between the several members of frames, doors, sashes and similar structures

"The faces of the members joined shall be flush with one another unless otherwise required by the design."

"On the face of the work the end of the one member shall be in close contact with the edge of the other throughout the length of the shoulder, except that defects caused by slight tearing of the end grain shall be permitted to an extent not exceeding $^{1}/16$ in in depth and ⅛ in along the length of the member."

"The mouldings on the edges of the members joined shall be in alignment within a tolerance of $^{1}/32$ in."

"On a shaped scribe or a square shoulder the two surfaces shall not at any point be more than $^{1}/64$ in apart."

"In a mortice and tenon, combed or halved joint, where part of the end grain of another member shows upon the finished face of the work, it shall be flush with that face."

Moving parts of doors and sashes (hinged or pivoted)

"In work which is to be painted where the edges of a door or sash are rebated to overlap the surrounding framework, there shall be, between the lip of the door or sash and the face of the surround, a gap of not less than $^{1}/16$ in and not more than $^{3}/32$ in. In work which is not to be painted the gap should not exceed $^{1}/32$ in."

"In work which is to be painted, where the door or sash is fitted into (that is not rebated over) its surrounding framework, the gap between the edge of the door or sash and the surround shall not be less than $^{1}/16$ in and not more than $^{3}/32$ in. In work which is not to be painted, these gaps shall not exceed $^{1}/32$ in. When necessary the closing edge of the door or sash shall be slightly bevelled to enable it to open freely with the limited clearance."

<u>Drawer fronts</u>

"Where a drawer front is rebated over the edges of an opening, the face of the rebate shall not at any point be more than $^{1}/32$ in from the face of the framing."

"Where a drawer front is fitted into an opening, the length of the drawer front shall not be less than the width of the opening by a greater amount than $^{1}/16$ in and the height of the drawer front shall not be less than the height of the opening by a greater amount than $\frac{1}{8}$ in in the case of drawers over 5 in high or $^{1}/16$ in in other cases."

Although the specifications of B.S. 1186 are intended to define the standard of workmanship which is considered acceptable for general housing it is doubtful if the Committee responsible had room doors in mind when they drew up the requirements for the fit of doors. It is true that the traditional clearance is a "penny joint" but, alas, today that is a joke - sixpenny worth of coppers are required to measure the joint. In the present state of the joiner's craft the B.S. requirements are more suited to kitchen cabinets and similar items.

Guidance on one facet of surface finish of timber, that of cutter markings, is given by the Forest Products Research Laboratory who say that for normal joinery work 8 - 10 cutter marks per inch are acceptable but for high class joinery and cabinet work 12 - 20 marks are normally acceptable. (See Plate 18.1).

Sizes of knots and other defects in timber and plywood are covered by grading rules but it is the finished surface after decoration that we are concerned with here.

GRADING

Consideration was given to various methods of defining standards so that the workmanship observed could be judged against a precise definition of quality. It was realised that even if it were possible to define items such as the smoothness of the surface by means of a numerical specification checking would be extremely tedious. And would it be necessary? - as long as a plastered wall, for example, looks flat and smooth that is sufficient. The difficulty is that although the surface looks flat in daylight it may not in artificial light. Plates 18.2 and 18.3 show the effect of the direction of lighting on the appearance of a plastered surface. Experiments were made to see if it would be possible to define a standard lighting under which surface finish could be judged. It was thought that it might be possible to say that if a blemish did not show up when it was illuminated by light at a certain angle of incidence then it would be acceptable. It is perhaps a feasible method but the work was not concluded as it was realised that application of such a method in the survey would be a further imposition on householders who had consented to have their homes examined, requiring as it did drawing curtains, trailing a flex around rooms and using the householders' electricity.

A method involving the matching of observed defects with photographs of graded samples proved unsatisfactory because of the failure of the eye to adjust to the scale of the photograph: colour was a further complicating factor.

Eventually it was decided that the standard of surface finish should be defined by indicating the type and extent of defects present. Detailed descriptions would be provided and defects classified as slight or bad. Their extent would also be classified - as covering either a small area (or length) or a large area, or being present throughout the surface or length. The difficulty of lighting would be overcome as much as possible by close inspection. Elements of the building, for example, external walls rather than the work of trades, would be appraised so that comparisons could be made between different buildings.

The descriptions of defects are given in the Appendix. It was found more convenient to group them under headings of materials rather than elements. Not all materials, or defects, could be covered, those that were not were judged when necessary by the standard of a similar material.

Where an element consisted of parts fitted together "dry" such as trim - skirtings, architraves, door linings, window boards - assessment of its quality was made under two headings (i) finish (ii) fit of parts. Doors and windows were also assessed in this way, the fit in their case being that between the opening unit and its surround. This distinction between finish and fit was made to discriminate between the quality of finish in the component supplied and the skill of the craftsman who fitted it. With doors, for instance, if a single assessment had been made it would not have been clear whether or not poor quality was the fault of the maker of the door (or perhaps the decorator) or the carpenter who hung it. Only one assessment was made for elements such as walls where although they consisted of parts put together on the site most of the parts, like bricks or tiles, were manufactured with an acceptable surface which did not require further treatment. Damage to the surface such as chipping of bricks was regarded as lack of craftsmanship.

Defining the extent of defects is more difficult than defining the defect itself. If it is said that a small area is up to say 10% of the total area this may be misleading because usually the defects do not cover a definite area but occur here and there over the whole surface. In practice it did not prove difficult to decide whether or not to classify an area as small or large, or to decide that the defects occurred throughout. An attempt has been made in Fig. 18.1 to give a visual impression of the different classifications of area. It is felt that this is more explanatory than a written description but it must be appreciated that to an experienced observer defects will appear to "hit him in the eye".

Each of the three classifications of slight defects was combined as required with each of the three classifications of bad defects. With "good throughout" this gave 16 classifications as shown in Fig.18.2 and 18.3. Some of the classifications were little used, for instance, if bad defects were found over a large area this would not usually be in

EXTENT OF DEFECTS

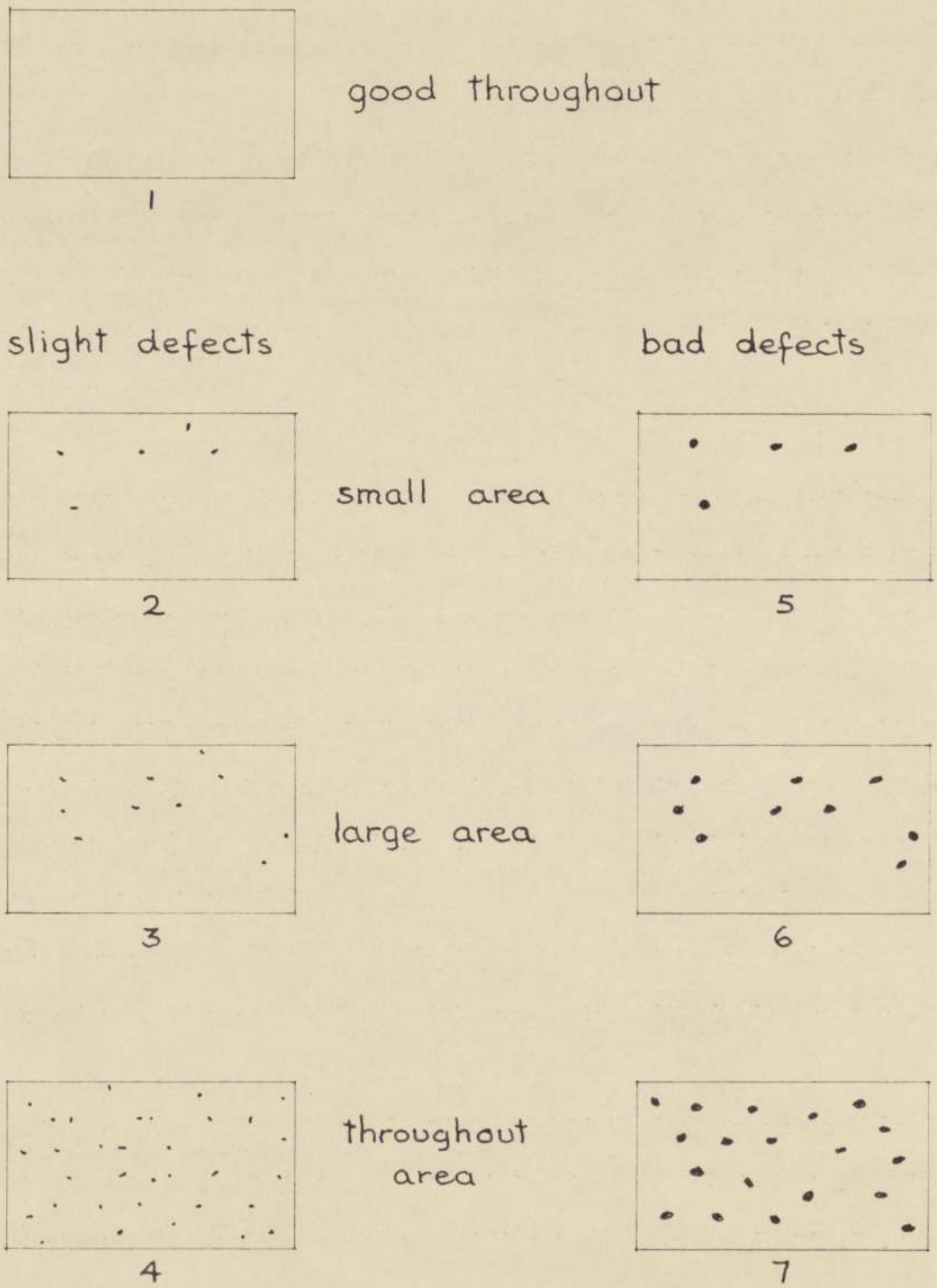

Fig. 18·1

GRADING OF FINISH

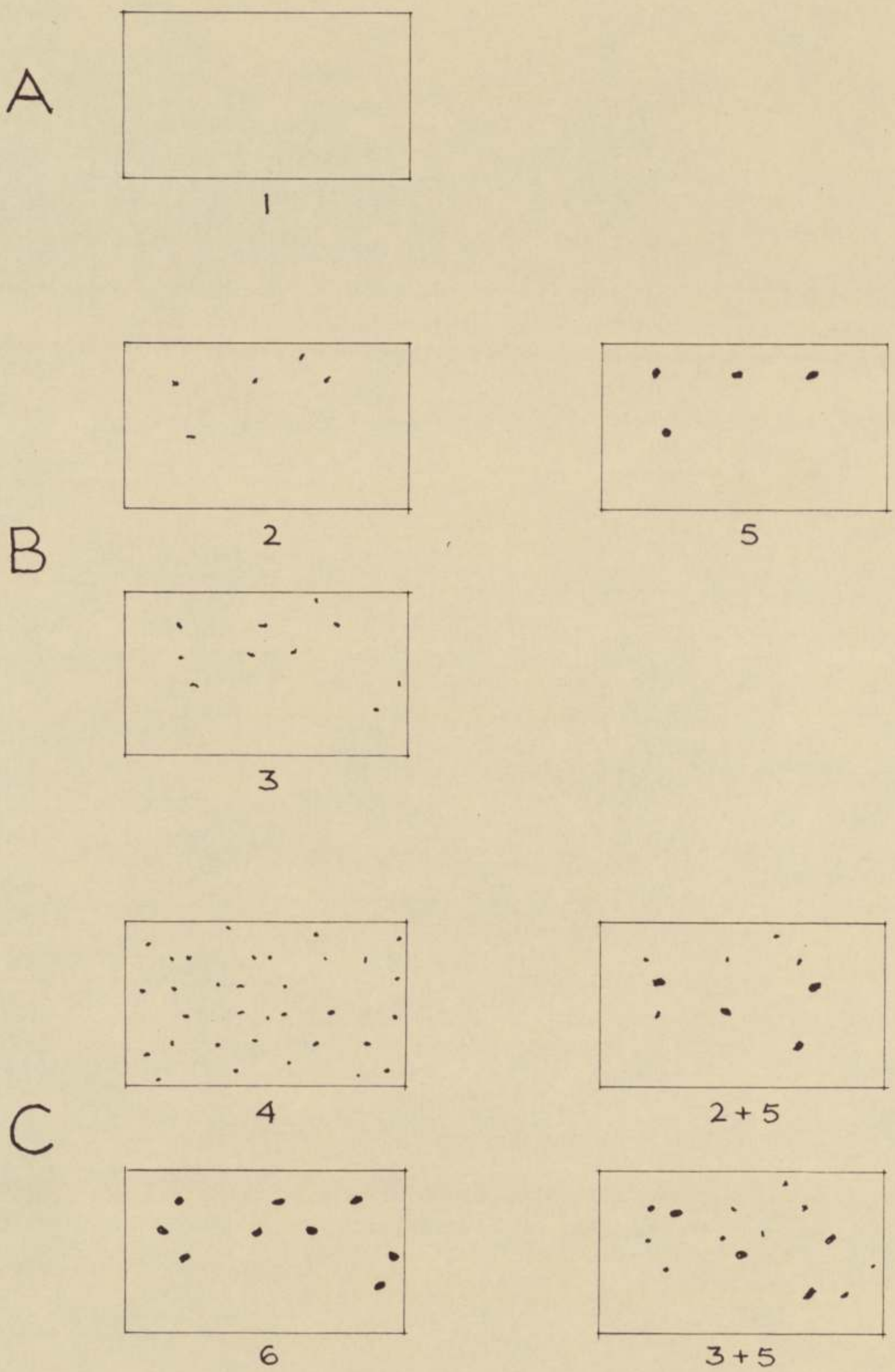

Fig. 18·2

combination with slight defects over a small area, the slight defects would be more likely to be found over a large area. The classifications seldom used are on the right of Figs. 18.2 and 18.3. Sixteen classifications gave too fine a grading so they were grouped according to the severity of defects into five grades, from A to E.

On examination each element was allocated one or two of the classifications, 1 to 7, as necessary to describe its surface finish. This was later converted to a lettered grade. The system proved simple to use and it was felt that judgement was more consistent than would have been the case if a five-point scale had been used directly.

A surface graded A in the investigation would not necessarily be a perfect surface (if that exists) it might contain defects below the minimum of the "slight" classification and even one or two slight defects themselves: for these would not be considered to constitute a small area.

An important element which was not examined was the floor. This had to be omitted because it was usually covered by carpet or other floor covering and close examination was not possible.

RESULTS AND ANALYSIS OF DATA

Assessment and grading

Surface finish was examined in 183 different buildings, six of these were showhouses, and, as it was felt that their finish might not be typical, they were excluded from Table 18.1, which gives the frequencies of grades

TABLE 18.1

Surface finish in all dwellings
(excluding showhouses)

Grade	External				Internal			
	Pitch roofs	Walls	Windows		Ceilings	Walls	Trim	
			Finish	Fit			Finish	Fit
A	63	16	15	18	4	6		9
B	75	104	136	134	94	96	43	123
C	2	35	20	5	51	40	75	35
D		12	1	2	17	24	30	6
E		8		1	10	8	29	3
Total	140	175	172	160	176	174	177	176

Grade	Internal							
	Doors		Windows		Stairs		Kit cupboards	
	Finish	Fit	Finish	Fit	Finish	Fit	Finish	Fit
A	28	6	9	12	6	13	52	55
B	85	104	122	152	43	80	83	97
C	56	45	35	7	47	19	37	23
D	8	16	6	1	14	3	3	1
E		5	3	3	11	2	1	
Total	177	176	175	175	121	117	176	176

awarded to different elements. Apart from municipal and speculative dwellings, eight other dwellings have contributed to the Table; these comprised two self-built houses, a flat in a block erected by a housing association and five privately rented dwellings of various types. When more than one dwelling was visited in multi-dwelling buildings the entry made was a single assessment for the dwellings seen.

Not every element could be graded in all dwellings, flat roofs were not usually accessible and sometimes pitched roofs could not be seen - as on one or two occasions when they were covered with snow. Windows in flats could not always be seen well enough for assessment from outside. In a few dwellings the occupiers had papered walls throughout or carried out remedial work: elements so treated could not be considered, as only builders' work was assessed.

Tiling, whether on roofs or walls, was almost always well done. If pitched roofs were not graded A, in nearly every case this was because of the finish or fit of the fascias, soffits and barge boards, occasionally it was because of the flashings (see Plate 18.4), seldom was the tiling at fault. Brickwork was less satisfactory, frequently it was disfigured by mortar splashes (Plate 18.5), chipped bricks, and pointing spreading on to the face of the bricks (Plate 18.6). Other faults in brickwork included wavey bed joints, irregular bonding and perpends considerably out of line. The frequency of faults is reflected in the grading of walls shown in Table 18.1, where one-third were graded C or under, but in considering this it must be remembered that not all walls were of brick or wholly of brick. Even so brickwork may be held chiefly responsible for the lower grades:

this is an assessment which receives support from the fact that walls of non-traditional construction (14 in number) fell entirely into the two upper grades. It must be emphasised that a grading of C does not mean that the brickwork is merely disfigured by a few mortar splashes which will soon weather off, it means that what can be seen looks a pretty poor piece of work, and what cannot be seen is undoubtedly worse.

Windows did not vary much, their examination was often limited: on the outside because it was not possible to get close to all of them and on the inside because lace curtains covered the entire window. This means that those graded C or under were extremely badly finished or very ill-fitting.

With internal finishes there was a lot of poor work, some of it very bad. Ceilings and walls were generally plastered and although it is true to say that it will be possible to disguise many of the defects by wall-papering, the plastered surface with its customary coat of emulsion paint is supposed to be a finished surface, if it is not then it should be covered in some way as are the walls of dwellings constructed of smooth surfaced concrete which are finished with wallpaper. The more unfortunate occupiers in traditionally constructed dwellings will have to use very "textured" or heavily patterned paper if they hope to hide defects such as those shown in Plate 18.7. Fine cracking was common in all dwellings but unless it covered a large area it was usually ignored when assessing the quality of the finish.

In three speculative houses a large part of the dwelling had been re-plastered while the occupiers were in occupation.

A few ceilings had been covered with a textured plastic compound applied straight onto plasterboard. This was quite well done but sometimes irregularities in the background showed through. Also if the surface had been made good because of cracking or damage the patch did not blend in with the original pattern.

Most plasterboard partitioning was skimmed with plaster. The joints between partitioning panels sometimes showed up because the panels were not in line, this was particularly noticeable in long halls as found in some flats, it also occurred where the panels joined brickwork or blockwork as on a stairway where the ground floor partitions were of brickwork (Plate 18.8). A few plasterboard ceilings and dry linings were taped at the joints but not wall papered, these had a very displeasing appearance; in one municipal house, round-headed nails had been used for fixing the ceilings and these and the tapes were left showing in the bedrooms.

Plywood linings to walls and ceilings formed an uncommon but not wholly satisfactory finish in one industrialised building. The plywood had been painted with fire-retardant paint but the grain was rather open and it showed through the paint.

Door linings were generally the worst finished of joinery items. Torn and woolly grain (Plate 18.8) was common and often almost all varieties of timber-finishing defects were present. Raised grain (Plate 18.10) was particularly prevalent, not only in linings but also in other joinery: it is probably caused by blunt or "over-jointed"* planing cutters. It is thought that the linings were generally of lower quality than items like door frames and windows because they had been bought from timber merchants rather than joinery manufacturers.

Other items of trim - skirtings, architraves, window boards and the like - were also poorly finished and in addition they were badly fitted. As well as having gaping joints they did not lie flat against the background, or perhaps showed hammer marks, or were not flush where two members met. When stopped ends were required and the timber had been cut across the grain the end grain was seldom cleaned up but left from the saw with whiskers hanging along the edge. One lady who lived in a house where the last mentioned fault occurred often, and the woodwork was otherwise badly finished, said she was frightened to let her little girl go around the house on her own in case she got splinters in her fingers.

The fit and finish of balustrades were assessed with staircases and are given in Table 18.1 under the heading of stairs. The amount of timber in the balustrades varied considerably, for instance, if the stairs were between two walls, it might be confined to the handrail (also very little of the stairs would be visible). When the balustrade was of timber put together on the site, more often than not the work was badly done.

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* The author is indebted to Mr. C.G. Allman, F.B.I.C.C., M.I.M.Wood.T., for suggesting that over-jointing is responsible. "Jointing" is a process whereby the cutting edges of the cutters in a block are ground down so that all run in the same cutting circle. This forms a heel on the cutting edge and if the jointing is overdone the surface of the wood will be slightly compressed as it is planed, probably the summerwood is pushed into the less dense springwood, then later as the surface recovers from the compression the summerwood rises above the springwood.

There were some good doors, hardwood veneered and naturally finished; there were also a lot of poor ones of light construction with hardboard facings (Plate 18.11). Few doors appeared to have been shot to fit the jamb linings: gaps $\frac{3}{8}$ in wide were often found.

Kitchen cupboards and fitments often displayed the sort of finish one would have liked to have seen everywhere; although there were some manufactured cabinets of poor quality the contrast between manufactured fitments and work done on site was markedly to the disadvantage of site work.

It was seldom that paintwork gave the impression that the background had been appropriately prepared to receive the paint. The work did not appear to have been rubbed down or properly stopped and often dust and grit had been worked into the paint film.

Quality and price

One question which arises when considering the quality of surface finish is, "Does it vary with price?" In examining this, only speculative dwellings can be considered because it was not possible to obtain sufficient reliable information concerning municipal dwellings to allow them to be included. All local authorities were asked for details of prices but some found themselves unable to disclose them, others quoted figures which appeared to relate to their original optimistic estimates rather than real building costs. However, as local authorities are generally obliged to accept lowest tenders their costs should be fairly uniform, and restricting the examination to speculative dwellings should not be disadvantageous. With speculative dwellings the price was obtained from the most reliable source - the purchaser.

The date of purchase of the dwellings examined ranged over a period of just over three years, during which time the average price of new private houses rose by 24%. Allowance was made for this increase by raising all prices to those prevailing at the latest date of purchase - May 1968. As the exact purchase date was not determined, it was assumed to be the same as the date of occupation.

Index numbers used to standardise prices are shown in Table 18.2, these are based on the index of average prices of new private houses in Great Britain compiled by M.H.L.G. and published quarterly.

TABLE 18.2

Index of average prices of new private houses

Year	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
1965	81	82	84	86
1966	87	89	90	90
1967	93	95	95	96
1968	98	100		

The variety of types and sizes of dwellings made it necessary to limit the comparison of prices and quality to houses. Even then it was necessary to adopt various methods of minimising the influence of factors of size, location, and type on price.

To remove the effect of size, the price per ft^2 of floor area within the external walls was obtained. This raised the problem of how to treat the garage area: the prices available were inclusive of garages where these were provided. There was no way of separating the price of the garage from the remainder of the house when the structure of the garage was an integral part of the building - as many were - yet it was felt that costs per ft^2 of the garage area would be less than those of the residential area and this would be reflected in the price charged. Halving the garage area before dividing price by total floor area seemed to be a reasonable method to adopt and its validity was confirmed when prices of freehold semi-detached houses with and without garages were compared. It was necessary to confine the comparison to this type of house because it was the only type where a large enough sample was available. Even then there were only 14 with garages and nine without to compare; their frequency of prices per ft^2 of floor area is given in Table 18.3. The mean price was 88/- for houses with garages and 87/- for houses without garages. A larger sample would have been preferable but as the data available supported an hypothesis based on practical experience the method of halving the floor area of the garage was adopted.

The next problem which arose was the affect of land prices on the house prices under consideration. Stone[(2)] has shown that apart from purely local influences, the price of housing land seems to be most affected by the density of dwelling per acre and the distance from the dominant town in the region. Within the area covered by the survey, local influences are the most important, the density per acre did not appear to vary greatly

TABLE 18.3

Prices, per ft^2 of floor area, of freehold semi-detached houses with and without garages
($1\ ft^2$ garage area = $\frac{1}{2}\ ft^2$ residential area)

Price (shillings)	With garage	Without garage
70 - 75		1
75 - 80	3	
80 - 85	2	1
85 - 90	3	5
90 - 95	4	1
95 - 100		1
100 - 105	1	
105 - 110	1	
	14	9

and, in any case, Stone's work showed that prices per dwelling do not fall proportionally to reductions in density and, of course, small sites tend to occur most frequently where price per acre is high. Zonal and regional trends given by Stone and the National Building Agency(3) are unimportant compared with the local desirability of sites within the relatively small area investigated. Assessment of land values for individual dwellings could not be undertaken, hence, the influence of the desirability of the site remains in the price which is to be compared with quality.

Some houses were on leasehold land but comparison of prices as shown in Table 18.4 failed to confirm the belief that leasehold houses would be cheaper than freehold, in fact, the tendency seemed to be the other way. The reasons for this and whether it is generally applicable could not be pursued within the scope of this work but it was decided that the available evidence did not justify a distinction between prices of leasehold and freehold houses so far as this investigation was concerned.

As is shown in Table 18.4, detached houses cost more per ft^2 of floor area than semi-detached, this is to be expected because of the additional structure required. But, it is possible that better work is put into detached houses because purchasers who are willing to pay for the convenience of having a house on its own may also be willing to pay extra for good workmanship. This argument may be extended to include terraced houses. On the other hand the different types of houses were often found in the same development, all had been built at around the same time with the same materials, and presumably by the same men. Whether there was, in general, a different quality of finish in the different types of house was tested by comparing the grades awarded for external walls, internal walls, and finish of trim in detached, semi-detached and terraced houses. The three elements used in the comparison were chosen because they are amongst the most noticeable parts of a building and because the data showed a great deal of variation in the grading of their finish. The frequency of each grade in the different types of house is shown in Table 18.5. Grades with low frequencies have been grouped together, as indicated by brackets, for the application of chi-square tests and to facilitate comparison of standards. The comparison is further assisted by the provision of percentage frequencies of the grouped categories.

TABLE 18.4

Comparison of prices, per ft^2 of floor area, of freehold and leasehold houses

Price (shillings)	Detached		Semi-detached		Terraced			
					End houses		Inter houses	
	Free-hold	Lease-hold	Free-hold	Lease-hold	Free-hold	Lease-hold	Free-hold	Lease-hold
60 - 65								2
65 - 70								
70 - 75	1		1	2				
75 - 80			3	2		1	2	
80 - 85			3	2				
85 - 90			8	2		2		2
90 - 95	3		5	2	2			
95 - 100	2	1	1	2		1		
100 - 105		1	1	2		1		1
105 - 110	1		1	1		1		
110 - 115	1	1				1		
115 - 120	2	2						
120 - 125	1	1						
125 - 130	2							
Total	13	6	23	15	2	7	2	5
Mean	106	112	88	89	94	96	77	8

TABLE 18.5

Comparison of surface finish in different types of speculative houses

Grade	Det.	Semi-det.	Terr.	Percentages and probability (> α		< α)	Det.	Semi-det.	Terr.	Percentages and probability (> α		< α)
	External Walls						Internal Walls					
A	1							1				
				67	60	88				67	50	81
B	9	22	14				10	17	13			
C	5	9	1				2	11	1			
										33	50	19
D		4		33	40	12	3	7	2			
E		2	1									
Total	15	37	16	(0.25		0.10)	15	36	16	(0.10		0.05)

Grade	Det.	Semi-det.	Terr.	Percentages and probability (> α		< α)
	Trim Finish					
A						
B	6	8	2			
				60	60	75
C	3	14	10			
D	3	10	2			
				40	40	25
E	3	5	2			
Total	15	37	16	(0.75		0.50)

Inspection of Table 18.5 indicates that terraced houses had the best external wall finish, probably because in intermediate houses there was very little wall to be seen; detached and semi-detached do not appear to differ very much. With internal walls, terraced houses were again the best; between detached and semi-detached houses, detached were slightly the best. The finish of trim showed very little difference between detached and semi-detached but again terraced houses seemed to have a slight superiority. That terrace houses should surpass the others in all three finishes was unexpected; whether it was statistically significant was determined by means of the chi-square test, the null hypothesis H_o being that there was no significant difference between the frequencies of grades awarded for the three types of house. The chi-square formula used was as follows:

$$\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{k} \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

where:

O_{ij} = observed number of cases categorised in i-th row of j-th column

E_{ij} = number of cases expected under H_o to be categorised in i-th row of j-th column.

The probability of rejecting H_o if it is true is denoted by α. For each test made the probability level associated with it is given in the Table.

The chi-square test is applicable to data in a contingency table only if the expected frequencies are sufficiently large. No cell should have an expected frequency of less than 5, except that when there are more than two degrees of freedom in the table, the test may be used if fewer than 20% of the cells have an expected frequency of less than 5 and no cell has an expected frequency of less than 1[4]. Where these requirements were not met by the data, adjacent categories were combined as indicated by brackets in the Table.

The tests showed that there was no reason to suppose the null hypothesis to be false, accordingly, it was accepted that there was no significant difference between the quality of work in the three different types of house.

Having, as far as possible, established that the general quality of surface finish was the same in different types of houses, it became permissible to adjust their prices to make them all equivalent to one type. Excluding showhouses, the average price per ft^2 of floor area for detached houses was 108/-, for semi-detached 88/-, for intermediate terraced 79/- and for end terraced 96/-. Semi-detached houses were the most common so they were left unaltered while the others were reduced to make them equivalent (e.g. detached house price x $\frac{88}{108}$ = semi-detached house price).

With prices standardised to one type of house it was possible to use data from all houses to compare grades of finish at different categories of price. Again, the comparison was confined to external and internal walls, and finish of trim; the data are shown in Table 18.6. As before, the chi-square test was used to determine whether there was statistically a significant difference in the grading of the various categories. It was necessary to reduce the price categories to two, $\leq$ 90/- and $\geq$ 90/-, as indicated by the division of the Table, in order to ensure that expected

TABLE 18.6

Price and surface finish compared
in speculative houses

Grade	Price per ft^2 of floor area (shillings) 60-70	70-80	80-90	90-100	100-110	110-120	Percentages and probability (> α	< α)
External Walls								
A				1				
							76	52
B	2	10	17	10	3	1		
C	1	2	3	6	3			
D		1	1	3			24	48
E			1		2			
Totals	3	13	22	20	8	1	(0.10	0.05)
Internal Walls								
A			1					
							53	75
B	2	6	11	14	6	1		
C		6	3	3	1			
D	1	1	7	2	1		47	25
E								
Totals	3	13	22	19	8	1	(0.25	0.10)
Trim: finish								
A								
B		3	7	4	2		26	21
C	2	3	10	9	2	1	40	41
D	1	3	4	5	2			
							34	38
E		4	1	2	2			
Totals	3	13	22	20	8	1	(0.90	0.75)

frequencies were sufficiently large for the chi-square test to be meaningfully applied. Where categories of grade were combined this is indicated by brackets. The data relating to external and internal walls had to be reduced to two lines as well as two columns so forming a 2 x 2 table with only one degree of freedom. This reduction of degrees of freedom to one necessitated Yates' correction for continuity being employed as follows:

$$\chi^2(\text{corrected}) = \sum_{i=1}^{r} \sum_{j=1}^{k} \frac{(|O_{ij} - E_{ij}| - 0.5)^2}{E_{ij}}$$

The findings gave no reason to suppose that on the whole there was any significant difference in the quality of surface finish at different price categories.

Certificated and non-certificated dwellings

Sufficient data was available to allow a useful comparison of speculative dwellings carrying a N.H.B.R.C. certificate with those that did not. Of the 78 speculative dwellings, excluding showhouses, examined for surface finish, 42 occupiers said they had a certificate, 30 said they had not, six said they did not know. In the latter cases it was the wife of the householder who was interviewed and she had been uncertain of the details of the purchase. When a certificate had not been issued this was because the builder was not registered and not because the certificate had been refused.

Grades awarded for all elements examined, in both classes of speculative dwelling, are shown in Tables 18.7 and 18.8. Bungalows and flats as well

TABLE 18.7

Comparison of external surface finish
in certificated and non-certificated speculative dwellings

Grade	Cert'd	Non-cert'd	Percentages and probability* (> α	< α)	Cert'd	Non-cert'd	Percentages and probability (> α	< α)
	Pitched roofs				Walls			
A	22	12	52	43	1			
							74	60
B	20	16	48	57	30	18		
C					6	10		
D					3	2	26	40
E					2			
Total	42	28	(0.70	0.50)	42	30	(0.50	0.30)
	Windows: finish				Windows: fit			
A	2				5			
			93	70			100	93
B	37	21			33	25		
C	2	9				1		
			7	30				7
D	1					1		
E								
Total	42	30	(0.02	0.01)	38	27	(Not tested)	

* This is the probability associated with a two-tail chi-square test.

TABLE 18.8

Comparison of internal surface finish in certificated and non-certificated speculative dwellings

Grade	Cert'd	Non-cert'd	Percentages and probability (> α	< α)	Cert'd	Non-cert'd	Percentages and probability (> α	< α)
	Ceilings				Walls			
A	(1	1)			(	1)		
	(	)	81	57	(	)	68	57
B	(33	16)			(28	16)		
C	(6	9)			8	7	20	23
	(	)	19	43				
D	(2	3)			5	6	12	20
	(	)						
E	(	1)						
Total	42	30	(0.10	0.05)	41	30	(0.70	0.50)
	Trim: finish				Trim: fit			
A					(5	1)		
					(	)	85	80
B	14	8	33	27	(30	23)		
C	17	8	41	27	(5	5)		
					(	)		
D	9	6	21	20	(1	)	15	20
					(	)		
E	2	8	5	27	(	1)		
Total	42	30	(0.10	0.05)	41	30	(0.80	0.70)

Continued/

TABLE 18.8 Continued

Grade	Cert'd	Non-Cert'd	Percentages and probability (> α	< α)	Cert'd	Non-Cert'd	Percentages and probability (> α	< α)
	Doors: finish				Doors: fit			
A	13	1	31	3	(	1)		
					(	)	69	60
B	20	18	48	60	(29	17)		
C	(8	10)			(10	7)		
	(	)	21	37	(	)		
D	(1	1)			(3	3)	31	40
					(	)		
E					(	2)		
Total	42	30	(0.05	0.02)	42	30	(0.70	0.50)
	Windows: finish				Windows: fit			
A	(1	)						
	(	)	95	63			95	97
B	(39	19)			40	29		
C	(2	8)			(1	1)		
	(	)			(	)		
D	(	2)	5	37	(	)	5	3
	(	)			(	)		
E	(	1)			(1	)		
Total	42	30	(0.01	0.001)	42	30	(Not tested)	
	Stairs: finish				Stairs: fit			
A	(2	2)			5	3	14	12
	(	)	50	33				
B	(17	7)			32	16	84	64
C	14	11	37	41	(1	4)		
					(	)	3	24
D	(3	4)			(	2)		
	(	)	13	26				
E	(2	3)						
Total	38	27	(0.30	0.20)	38	25	(Not tested)	

Continued/

TABLE 18.8 Continued

Grade	Cert'd	non-Cert'd	Percentages and probability (> α	< α)	Cert'd	non-Cert'd	Percentages and probability (> α	< α)
	Kitchen cupboards: finish				Kitchen cupboards: fit			
A	21	12	50	40	19	9	45	30
B	(16	16)			(17	18)		
	(	)	50	60	(	)	55	70
C	(5	2)			(6	3)		
D								
E								
Total	42	30	(0.70	0.50)	42	30	(0.30	0.20)

as houses have contributed data to the Tables. Again categories have been grouped and percentage frequencies are given for the grouped categories. The chi-square test was used as previously described to test the null hypothesis that there was no difference between the grading of the two types of dwelling.

Except for the internal fit of windows, where the percentage frequencies are effectively the same, certificated dwellings have the edge over non-certificated dwellings in every element examined. The differences are not very great and the significance levels given by the chi-square tests indicate that, for most elements, if they were considered separately, the difference in the frequencies of grading might well have arisen by chance: the exceptions are external and internal window finish and internal door finish, where the significance levels are less than 0.05. But, taken collectively the results point so consistently in one direction that the research hypothesis must be that the higher grades occur more frequently in certificated dwellings. With the direction of the difference predicted, the alternative hypothesis H_1 to the null hypothesis becomes: a greater proportion of the higher grades is found in certificated dwellings than in non-certificated dwellings. This gives rise to a one-tailed test and the probability levels shown in Tables 18.7 and 18.8 are halved. Ceilings and finish of trim now come into the region where the difference between the classes may be considered to be significant.

The greater proportion of upper grades awarded to windows and doors seems to indicate that, on the whole, registered builders use superior joinery to non-registered builders; the quality of trim is also a little better on average (or perhaps one should say not as bad - nearly 70% is grade C or worse). Apart from ceilings, wherever quality depends upon work done on site as in external walls and fit of trim and doors registered builders' work does not show the same degree of superiority. No explanation suggests itself for the markedly better quality of work in ceilings.

There was no foreknowledge of whether a certificate had been awarded or not when a dwelling was examined, therefore, no bias entered into the assessment of quality for this reason.

Municipal and speculative dwellings

The final comparison between classes of dwelling which was made was between municipal and speculative dwellings. The data on which the comparison was based is presented, in the form used previously, in Tables 18.9 and 18.10. Except for the external finish of walls and windows, and

TABLE 18.9

Comparison of external surface finish in municipal and speculative dwellings

Grade	Mun.	Spec.	Percentages and probability (> α	< α)	Mun.	Spec.	Percentages and probability (> α	< α)
	Pitched Roofs				Walls			
A	23	36	39	47	14	1	16	1
B	(35	40)			47	51	53	66
	(	)	61	53				
C	(1	)			17	17	19	22
D					(6	6)		
					(	)	12	12
E					(5	3)		
Total	59	76	(0.50	0.30)	89	78	(0.02	0.01)
	Windows: Finish				Windows: Fit			
A	12	3	14	4	12	5	15	7
B	66	63	77	81	(65	62)		
					(	)		
C	(8	11)			(3	2)		
	(	)			(	)	85	93
D	(	1)	9	15	(	2)		
	(	)			(	)		
E	(	)			(1	)		
Total	86	78	(0.10	0.05)	81	71	(0.30	0.20)

the fit of windows, where municipal dwellings were better on average, speculative dwellings had the higher proportion of upper grades in all elements.

The superiority of municipal dwellings in respect of external walls

TABLE 18.10

Comparison of internal surface finish in municipal and speculative dwellings

Grade	Mun.	Spec.	Percentages and probability (> α	< α)	Mun.	Spec.	Percentages and probability (> α	< α)
			Ceilings				Walls	
A	(2	2)			(2	4)		
	(	)	41	70	(	)	52	66
B	(35	53)			(44	47)		
C	32	17	36	22	22	15	25	20
D	12	5	13	6	(13	11)		
					(	)	24	14
E	9	1	10	1	(8	)		
Total	90	78	(0.01	0.001)	89	77	(0.02	0.10)
			Trim: Finish				Trim: Fit	
A					(2	6)		
					(	)	69	82
B	16	24	18	31	(61	57)		
C	43	27	47	35	(22	11)		
					(	)		
D	14	16	15	21	(5	1)	31	18
					(	)		
E	18	11	20	14	(1	2)		
Total	91	78	(0.10	0.05)	91	77	(0.10	0.05)
			Doors: Finish				Doors: Fit	
A	9	16	10	20	(1	3)	57	67
					(	)		
B	42	39	46	50	(50	49)		
C	(34	21)			27	17	30	22
	(	)	44	30				
D	(6	2)			9	7)		
						)	13	13
E					3	2)		
Total	91	78	(0.05	0.02)	90	78	(0.50	0.30)

Continued/

TABLE 18.10 Continued

Grade	Mun.	Spec.	Percentages and probability (> α	< α)	Mun.	Spec.	Percentages and probability (> α	< α)
	Windows: Finish				Windows: Fit			
A	(8	1)			11		12	
	(	)	70	81				
B	(54	62)			71	74	80	95
C	(21	12)			(4	3)		
	(	)			(	)		
D	(4	2)	30	19	(1	)	8	5
	(	)			(	)		
E	(2	1)			(2	1)		
Total	89	78	(0.20	0.10)	89	78	(0.01	0.001)
	Stairs: Finish				Stairs: Fit			
A	(2	4)			5	8	11	12
	(	)	34	43				
B	(14	26)			27	52	60	77
C	21	26	45	37	(11	6)		
					(	)		
D	5	8	11	11	(	2)	29	12
					(	)		
E	5	6	11	9	(2	)		
Total	47	70	(0.80	0.70)	45	68	(0.10	0.05)
	Kitchen Cupboards: Finish				Kitchen Cupboards: Fit			
A	10	37	11	47	19	31	21	40
B	49	34	55	44	58	37	65	47
C	(27	7)			(12	10)		
	(	)			(	)	14	13
D	(3	)	35	9	(1	)		
	(	)						
E	(1	)						
Total	90	78	(0.001	)	90	78	(0.05	0.02)

was due to the good finish of non-traditional constructions. When walls of traditional construction only were compared as shown in Table 18.11 municipal dwellings lost their advantage. Internal non-traditional wall finish, also, was not graded lower than B. Windows in municipal dwellings showed a better grading, on average, due to the higher proportion of metal windows in this class of dwelling. These windows are more uniform in quality than wooden windows and really bad finishes and fits were not found amongst this type. They did not maintain their superiority when the internal finish of windows was judged: a finish satisfactory externally may not be suitable for interior use; also, some metal windows in multi-storey flats, where the outside could not be seen closely, had a very rough interior finish.

Although, apart from the exceptions just mentioned, the frequency of higher grades was greater in speculative dwellings, the levels of significance were such that the differences in grading would not normally be regarded as significant, except in the case of door finish, ceilings, and finish of kitchen cupboards. The use of better quality doors with a natural finish in some speculative housing may have accounted for the higher average grading in their case. Again, ceilings show the greatest difference in grading between classes of dwellings, perhaps the explanation is that marginally better craftsmanship in plasterers' work shows itself more in work on ceilings than on walls. The highly significant difference in kitchen cupboards was not unexpected because the provision of fitments was generally poor in municipal dwellings, although some multi-storey flats were, in fact, particularly well provided in this respect.

TABLE 18.11

Comparison of surface finish of walls of traditional construction in municipal and speculative dwellings

Grade	External				Internal			
	Mun.	Spec.	Percentages and probability (> α	< α)	Mun.	Spec.	Percentages and probability (> α	< α)
A	(7	1)			(1	3)		
	(	)	63	67	(	)	48	66
B	(40	51)			(39	47)		
C	17	17	23	22	22	15	27	20
D	(6	6)			(13	11)		
	(	)	15	12	(	)	25	14
E	(5	3)			(8	)		
	75	78	(0.90	0.80)	83	76	(0.10	0.05)

More than one local authority architect said that because he insisted on a high standard of workmanship the finish in his housing would be seen to be good. Inspection usually showed that he was badly mistaken. It was, in fact, remarkable what a low standard had been found to be acceptable. In speculative dwellings there seemed to be a standard below which the finish did not fall, bad as it was, but this was not the case in municipal dwellings.

Occupiers opinions

Occupiers were asked if they were satisfied with the quality of the finish in their homes, both externally and internally. The results of this inquiry are given in Table 18.12. In some cases the question was not put;

TABLE 18.12

Occupiers opinion of surface finish in their homes

Opinion	External finish				Internal finish			
	Mun.	Spec.	Other	All	Mun.	Spec.	Other	All
Satisfied	69	55	7	131	59	37	5	101
Not satisfied	5	22	1	28	27	40	3	70
Don't know	4			4	2			2
Totals	78	77	8	163	88	77	8	173

for instance, there seemed to be no point in asking tenants of flats in multi-storey blocks if they were satisfied with the outside finish.

It was to be expected that occupiers of speculative dwellings would be more critical than municipal tenants who were often pleased to have got any sort of home. Probably, also, the views of municipal tenants about the outside finish were influenced by the fact that external re-decoration was not their responsibility. The high level of dissatisfaction with internal finish was not unexpected, what was more surprising was how some people accepted a very poor finish with equanimity.

Some people obviously never wiped the paintwork down and did not notice what the finish was like. Others were frequently wiping and dusting and were continually catching their dusters on snags. One housewife in a municipal house said she was so tired of the rough finish that she was going to cover all the wood-work with wallpaper, at the time of inspection she had already made a start - with wood-grained paper.

Attempts to correlate the satisfaction or otherwise of occupiers and the observed grading of surface finish failed to show any clear relationship.

There was no significant difference between the number of occupiers dissatisfied in speculative dwellings without a NHBRC certificate and the number dissatisfied in certificated dwellings. Occupiers dissatisfied with the internal finish of non-certificated dwellings were 13 out of 30 and those dissatisfied in certificated dwellings were 22 out of 42. The chi-square test showed the significance level to be between 0.70 and 0.50.

CONCLUSIONS

The low standard of work is due mainly to the poor workmanship displayed on the site, rather than in the materials used, except that the finish of timber and timber products as supplied to the builder is often poor. The reason that quality does not vary perceptively with price or class of dwelling is probably because there is no choice to be had in the ability of the men who do the work or the care they are prepared to take. Lack of pride in the work is evident everywhere; many examples of poor work have nothing to do with the command of a high degree of skill, or with cost; dirty brickwork exemplifies this, often it shows marks where rain has splashed up from a scaffold board: a disfigurement which can be avoided by turning up the last board at night. Other examples of lack of care are to be found in damaged joinery, plaster splashes painted over, nails protruding and so on, to say nothing of lack of skill.

As the craftsman's skill and pride in his work is not there, methods which do not need a high degree of skill must be developed along with an efficient method of inspection.

SUGGESTIONS FOR FURTHER WORK

Many opportunities exist in this field for investigations into the effect of efficient supervision and methods of quality control on the standard of work. Methods of planning and carrying out the work could also be investigated together with the training necessary to ensure efficient working. A specification of surface finish, illustrated by examples, might be developed from that written by the author. If this were generally accepted there would be recognised grades of quality and it would be a useful research tool which might in time find its way into practice.

CHAPTER 19

GENERAL CONCLUSIONS

CHAPTER 19

GENERAL CONCLUSIONS

Looking back at the results, there is not very much difference to be seen between municipal and speculative dwellings. There are indications that what differences have been noted will tend to grow less as standards improve. The wider implementation of the Building Regulations and Parker Morris Committee recommendations will have its effect on both classes of dwelling. The spread of registration amongst speculative builders will remove the worst excesses in private developments. Safety on stairways and sound insulation is being improved by the requirements of the Building Regulations. Kitchen safety will be helped by new NHBRC requirements. Power socket outlets and W.C.'s will increase in both classes of dwelling and there will be further improvement in the provision of heating in municipal dwellings; although speculative dwellings will not be subject to additional NHBRC requirements in this respect, the use of central heating in them is undoubtedly growing. But, apart from a marginal improvement in ceiling insulation brought about by the universal application of regulations specifying maximum permitted thermal transmittance coefficients, two properties of dwellings that have been shown to be most in need of improvement will not be affected - namely thermal insulation and surface finish.

One of the factors which led to the topic of thermal insulation being dealt with in depth was the distress caused to occupiers by the expense and inefficiency of heating: the worry and discomfort to old age pensioners was particularly disturbing. It is hoped that the scope for more satisfactory yet feasible performance standards has been indicated. More efficient methods of heating may soon emerge and it may be possible to install them without too much disturbance to the structure of dwellings but it is feared that our successors will curse the inadequate thermal insulation of the dwellings we are now erecting.

Poor surface finish was naturally of more concern to people who were buying their own homes than to municipal tenants, but both tenants and owner occupiers will demand higher standards when they can make their preferences felt. The improvement in finish of kitchen fitments and furniture of recent years shows that the need is there, and the discontent expressed at the standard of 'builders' finish' will show up in a buyers' market.

Dwellings of non-traditional construction were not dealt with separately as this was not found necessary. Most of the items looked at did not differ from those in dwellings of traditional construction. Where there was a difference as in wall construction, for example, it was recorded in the results.

Although the research was concerned with the "mechanism" of residential buildings, and only one or two aspects of spatial planning, such as those affecting safety and sound insulation were considered, it was not possible to ignore planning during the examination of dwellings, for occupiers were quick to point out the inconveniences of bad design. While not intending to apportion blame for this it may be of interest to note that of 44 speculative dwellings where the name of the designer was obtained it was shown that architects had designed 40 of them; the other four were apparently designed by their builders. It is assumed that all the municipal dwellings were designed by architects.

When asked what in connection with their house they would be prepared to pay more for, nearly half the people interviewed said there was something they wanted, about half of these were municipal occupiers and half speculative. The most common requirement was more storage space, 15% wanted some sort of additional provision, this was often for a place to put outdoor clothes - in some houses there was just nowhere to hang hats and coats on the ground floor and they had to be taken upstairs. In other dwellings there were no cupboards tall enough to take a broom. There were several demands for an additional W.C., for an enclosed porch, a worktop in the kitchen and for more living space - one bathroom was so cramped that the washbasin overhung the bath. Most other needs were for the correction of some defect or lack of provision which has already been noted.

As pointed out in the first chapter, there were difficulties in obtaining a fair sample, and although it is thought that the sample obtained was representative of the population in technical matters, it is accepted that there would be a bias in occupiers' replies to questions because only people at home during the day were questioned. These were mostly women with small children, or old people. However, it was never intended to make a sociological survey and the questions were useful not only in relating peoples needs and opinions to expert judgement but also in winning help in the research - for most people were pleased to have someone to listen to their troubles and receive their opinions with interest.

The last question put to tenants of municipal dwellings was "Do you think this house (flat) is worth the rent you pay?". Their answers revealed that out of 105 asked, 82 thought their houses were worth the rent, 22 thought theirs were not and one did not know. Their dissatisfaction often had nothing to do with the subjects of the investigation and it is felt that there is little to be read into the result.

Occupiers of speculative dwellings were asked "Do you think you received value for money in this house?" Out of 76 asked, 66 said "Yes" nine "No" and one did not know. If they were doubtful they were pressed to make up their minds. When this was necessary they usually hedged their answers a remark such as "Well considering some I have seen".

More than the 13% of owner occupiers shown to be dissatisfied might perhaps have been expected in view of some of the findings, particularly those relating to surface finish. This raises again the argument that what is provided is what can be afforded. There is, of course, something in this, although the investigation did not show that quality of finish was dependent on price. As is often said, one cannot expect a Rolls-Royce for the price of a Mini, but unfortunately the prospective owner of a house who contracts to buy it before it is built does not know what sort of finish he is going to get. If grades of finish could be defined, on the lines that have been suggested, he could be told what to expect for his money and if the finish was not up to the specified standard he could object to paying the full price for it. Local authority architects could work in the same way. Grading of finish plus the development of adequate performance standards coupled with registration of builders and efficient inspection of their work would give hope for better standards in the future.

APPENDIX 1

Thermal Insulation: Chapter 11

Plans of flats

Estimated temperatures in unheated spaces

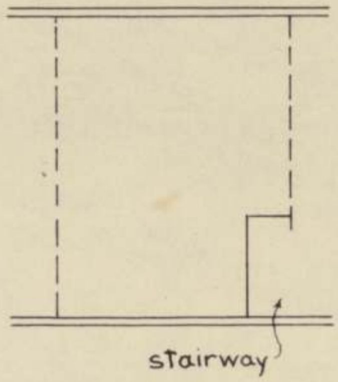
Construction and U values of elements

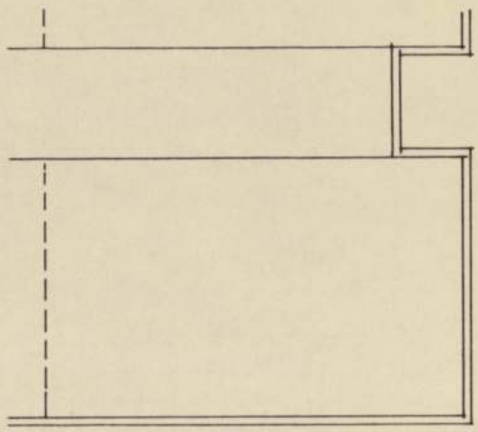
Suggested use of surface/floor ratios for obtaining approximate shell U value and floor index of thermal insulation

Surface finishes: Chapter 18

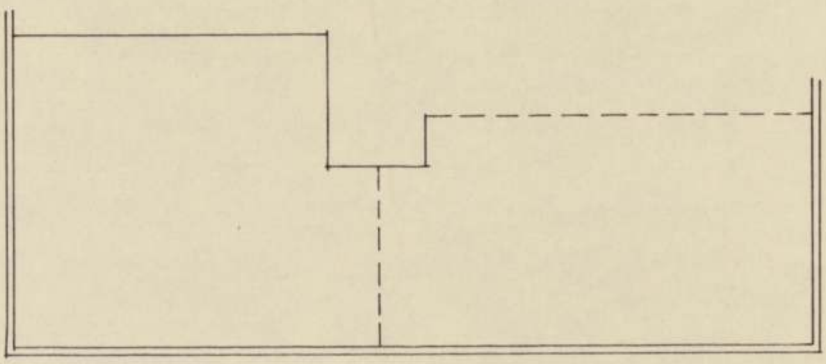
Classification of defects - Table A1.3

SOME PLANS OF FLATS WITH TWO EXTERNAL WALLS





Slightly more than two external walls (classified as two)



Flat with longest internal wall

Flat with shortest internal wall

Key

═══════ external wall

――――――― internal wall

– – – – – – party wall

Fig AI -1

ESTIMATED TEMPERATURES IN UNHEATED SPACES

Garages

Internal dimensions: 16 ft x 8 ft (4.800 m x 2.440 m)

Air temperatures: heated space adjoining garage 62°F (11°C), outdoors 30°F (-1°C).

TABLE AI.1

U values of assumed construction

Element	U value	
	Btu/ft^{2}h degF	W/m^2 degC
External wall:		
4½ in brick, 2 in cavity, 4½ in brick, ½ in plaster	0.30	1.70
Internal wall:		
4½ in brick, ½ in plaster	0.48	2.73
Floor:		
solid (as above)	0.12	0.68
Ceiling:		
skimmed plasterboard on joists with boarded floor above	0.22	1.25
Doors	0.45	2.56

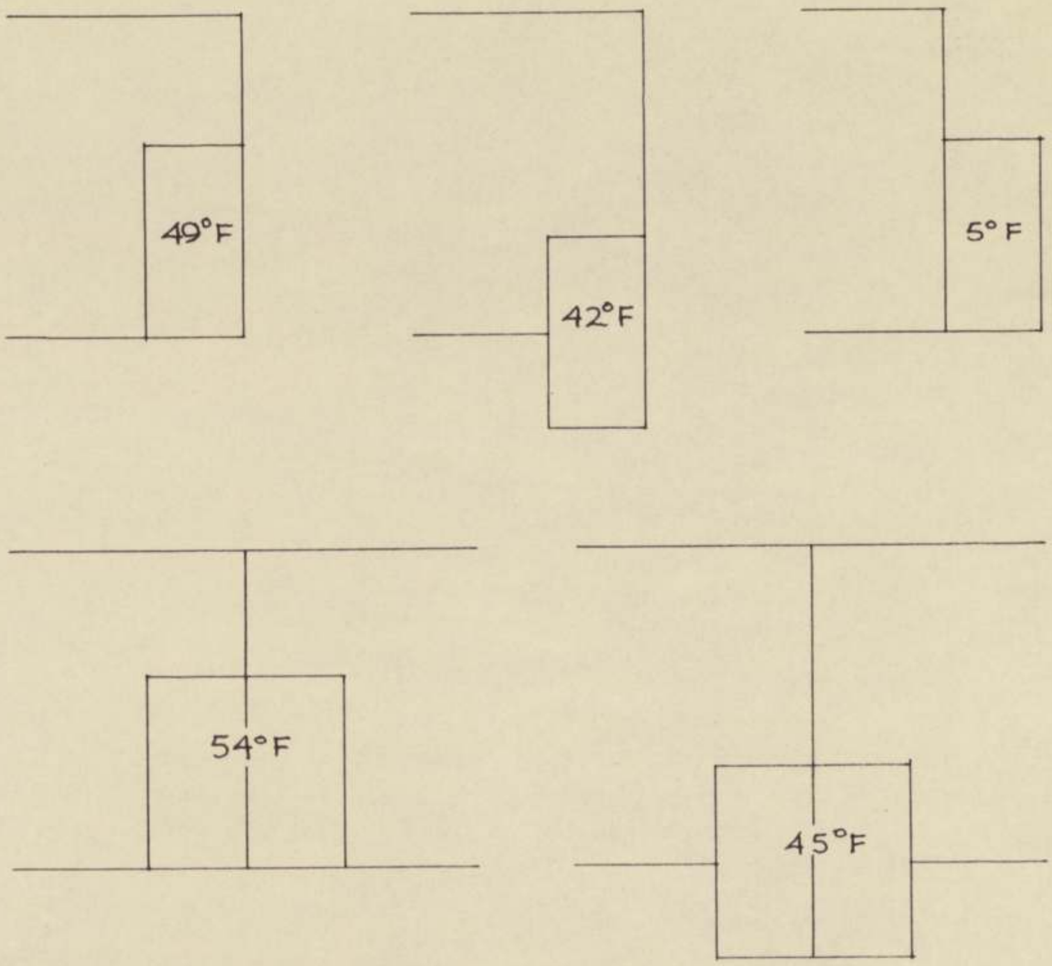
For estimated temperatures in garages see Fig. AI.2

Corridors in blocks of flats

Air temperatures: in flats 62°F (11°C), outdoors 30°F (-1°C), in corridors generally approximately half way between flat temperature and outdoor temperature, as in Fig. AI.2.

ESTIMATED TEMPERATURES

GARAGES



CORRIDORS OF FLATS

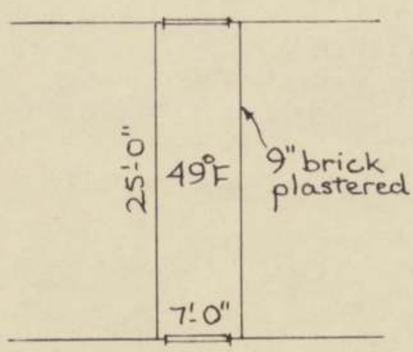


Fig AI - 2

TABLE AI.2

Construction and U Values of Elements

	U Value	
	Btu/ft^{2}h degF	W/m^2 degC
<u>External Walling and Feature Panels</u>		
4½ in brick, 2 in cavity +		
5 in dense concrete	0.32	1.82
4½ in brick, ½ in plaster	0.30	1.70
9 in brick, ½ in plaster	0.26	1.48
4 in clinker block, ½ in plaster	0.23	1.31
4 in Lignacite blocks, ½ in plaster	0.22	1.25
4 in aerated concrete (Thermalite, Celcon) blocks, ½ in plaster	0.17	0.97
5 in concrete, 1 in cellular polystyrene	0.14	0.79
1½ in mineral wool between two ¼ in plywood sheets on wood lattice	0.13	0.74
½ in rendering, 4 in clinker block, 2 in cavity, 3 in clinker block	0.20	1.14
3 in dense concrete, 1 in cellular polystyrene, 5 in dense concrete	0.17	0.97
Tile hanging on battens and felt +		
4 in studwork, 4½ in brick, ½ in plaster	0.27	1.53
4 in studwork, ⅜ in aluminium faced plasterboard skimmed	0.24	1.36
¼ in plywood, 3 in studwork, 2 in woodwool, ½ in plaster	0.16	0.91
1 in glasswool between 3 in studwork, ⅜ in plasterboard skimmed	0.15	0.85
Tile hanging on battens and building paper, 1 in glasswool between studwork 200g Polythene, ⅜ in plasterboard skimmed	0.14	0.79
Tile hanging on battens +		
9 in brick, ½ in plaster	0.33	1.87
3 in brick, 2 in cavity, 4½ in brick, ½ in plaster	0.27	1.53
6 in clinker block, ½ in plaster	0.23	1.31
4½ in brick, 2 in cavity, 4 in clinker block, ½ in plaster	0.20	1.14
3 in studwork, 3 in aerated concrete (Celcon) blocks, ½ in plaster	0.19	1.08
8 in clinker block, ½ in plaster	0.19	1.08
9 in clinker block, ½ in plaster	0.18	1.02

9 in clinker block, ⅜ in aluminium faced plasterboard skimmed on battens	0.13	0.74
Vinyl siding, studwork, aluminium faced plasterboard skimmed	0.29	1.65
⅞ in softwood boarding on battens +		
9 in brick, ½ in plaster	0.26	1.48
3 in brick, 2 in cavity, 4½ in brick ½ in plaster	0.22	1.25
½ in cellular polystyrene (between battens), 5 in concrete	0.21	1.19
6 in clinker block, ½ in plaster	0.20	1.14
8 in clinker block, ½ in plaster	0.17	0.97
⅞ in softwood boarding +		
felt, cavity, 1½ in Celotex panel	0.14	0.79
⅜ in plywood, 1 in glasswool between studwork, ⅜ in aluminium faced plasterboard	0.13	0.74
felt, 4 in studwork, 4 in clinker block, 1 in cellular polystyrene	0.11	0.62
13½ in brick, ½ in plaster	0.35	1.99
9 in brick, ½ in plaster	0.43	2.44
⅝ in rendering, 9 in brick, ½ in plaster	0.42	2.38
8 in dense concrete, cavity, 1½ in aluminium faced plasterboard dry lining	0.18	1.02
Spar dash on ¾ in rendering +		
10 in no-fines concrete, ½ in plaster	0.30	1.70
12 in no-fines concrete, ⅝ in plaster	0.27	1.53
12 in no-fines concrete, cavity, 1½ in plasterboard dry lining	0.16	0.91
¾ in rendering +		
12 in no-fines concrete, vermiculite plaster	0.24	1.36
10 in no-fines concrete, ½ in cellular polystyrene, ⅜ in plaster	0.19	1.08
4½ in brick, 2 in cavity, 8 in no fines concrete +		
½ in plaster	0.23	1.31
vermiculite plaster	0.21	1.19
cavity, 1½ in plasterboard dry lining	0.17	0.97
4½ in brick, 10 in no-fines concrete, ½ in plaster	0.27	1.53
½ in rendering, 6 in aerated concrete (Thermalite) blocks, ½ in plaster	0.17	0.97
½ in rendering, 8 in aerated concrete (Thermalite) blocks, ½ in plaster	0.13	0.74

Muroglas, cavity, 3 in clinker block, ½ in plaster	0.29	1.65
Asbestos-cement sheet +		
2 in woodwool, ½ in plaster	0.24	1.36
studwork, 1½ in Celotex panel	0.16	0.91
¼ in plywood, 1 in cellular polystyrene, 3 in studwork, ½ in plasterboard	0.15	0.85
½ in plywood, 1 in glasswool between studwork, 4 in clinker block, ½ in plaster	0.12	0.68
Pitched Roofs		
Tiling on felt +		
⅜ in plasterboard skimmed ceiling	0.43	2.44
⅜ in aluminium faced plasterboard skimmed ceiling	0.31	1.76
½ in fibreboard skimmed ceiling	0.26	1.48
⅜ in aluminium faced plasterboard skimmed ceiling with building paper draped over joists and plasterboard	0.22	1.25
⅜ in plasterboard skimmed ceiling with 1 in vermiculite filling between joists	0.22	1.25
⅜ in plasterboard skimmed ceiling with ¾ in glasswool over joists and plasterboard	0.19	1.08
⅜ in plasterboard skimmed ceiling with 2 in vermiculite filling between joists	0.17	0.97
⅜ in plasterboard skimmed ceiling with 1 in glasswool over joists and plasterboard	0.16	0.91
Flat Roofs		
Asphalt, 1 in cellular polystyrene +		
6 in concrete, plaster	0.18	1.02
6 in concrete, plasterboard on battens	0.16	0.91
5 in concrete, ¾ in polystyrene, plaster	0.11	0.62
Asphalt +		
2 in vermiculite screed, 6 in concrete, plaster	0.23	1.31
⅞ in softwood, ½ in insulation board, joists, ⅜ in plasterboard skimmed, insulating screed, 6 in concrete, aluminium faced plasterboard on battens	0.21	1.19
2 in insulating screed, 8½ in pre-cast concrete hollow beams, plaster	0.20	1.14
3½ in vermiculite screed, 5 in concrete, 1 in Celotex on battens	0.13	0.74
5/16 in asbestos cement tiles, ¾ in asphalt on felt, ½ in cane-fibre board, 6 in concrete, ¾ in to 1 in cavity, ½ in aluminium faced plasterboard	0.20	1.14

Concrete tiles, asphalt, cement screed, 1 in cellular polystyrene, 5 in concrete, cork	0.16	0.91
Roofing felt +		
$\frac{7}{8}$ in softwood, aluminium faced plasterboard	0.17	0.97
2 in woodwool, joists, $\frac{3}{8}$ in plasterboard skimmed	0.16	0.91
$1\frac{1}{2}$ in cement screed, 2 in woodwool, joists, $\frac{3}{8}$ in plasterboard skimmed	0.15	0.85
2 in mineral wool between two $\frac{1}{4}$ in plywood sheets on wood lattice	0.13	0.74
1 in cellular polystyrene, $\frac{3}{4}$ in chipboard, joists, plasterboard	0.11	0.62

Suggested Use of Surface/Floor Ratios for Obtaining Approximate Shell U Value and Floor Index of Thermal Insulation

For approximate calculation of insulation standards or for showing the effect of different materials and constructions of elements on the insulation of a dwelling as a whole, surface/floor ratios suitably rounded off may be used.

For example:

Speculative semi-detached house, wholly two-storey

Element	U Value	Surface/floor	Element U Value
Walling (net)	0.15	0.8	0.12
Openings	0.80	0.3	0.24
Lowest floor	0.10	0.5	0.05
Topmost ceiling	0.12	0.5	0.06
Total		2.1	0.47

Shell U Value $= \frac{0.47}{2.1} = 0.22$

Ventilation heat loss	0.16
Floor index of thermal insulation	0.63

TABLE AI.3

Classification of defects[a]

SLIGHT DEFECTS	BAD DEFECTS
External Brickwork	
<u>Chips in facing bricks, showing different colour</u>	
Area $\frac{1}{4}$ - $\frac{1}{2}$ in^2 (150 - 300 mm^2)	Area exceeding $\frac{1}{2}$ in^2
<u>Chips neatly filled with mortar, or not showing different colour</u>	
Area $^2/5$ - $^4/5$ in^2 (250 - 500 mm^2)	Area exceeding $^4/5$ in^2
<u>Droppings or splashes of mortar</u>	
Area $\frac{1}{4}$ - 1 in^2 (150 - 600 mm^2)	Area exceeding 1 in^2
or	or
Greatest dimension $1\frac{1}{4}$ - $2\frac{1}{2}$ in (30 - 60 mm^2)	Greatest dimension exceeding $2\frac{1}{2}$ in
<u>Variation in colour of mortar, or bricks, in patches</u>	
Just noticeable	Distinct
<u>Pointing</u>	
Showing distinct trowel marks Distinct irregularity of cut line	Mortar not filling joint
Mortar spreading from joints on to face of bricks for distance of $^3/16$ - $\frac{3}{8}$ in (4 - 8 mm) over length of 1 - 2 in (25 - 50 mm)	Worse spread of mortar
<u>Deviation from straight or level (as seen when facing surface) of bed joints</u>	
Just noticeable	Distinct

Continued/

Deviation from plumb of perpends

1 - 1½ in (25 - 40 mm)	Exceeding 1½ in
Irregular bond	

Tiled Roofs

Seating of tiles

Not lying quite flat	Distinctly misplaced

Flatness

	Sag in roof

Deviation from straight of courses or alignment of tiles

Just noticeable	Distinct

Flashings

Not trimmed off neatly	Not dressed down tightly
Not neatly pointed	Pointing of distinctly worse quality than surrounding brickwork

Eaves fascias, barge boards, soffits and verges - deviation from straight (as seen from ground level)

Just noticeable	Distinct

Ditto - gaps at heading joints

$^3/32$ - $^3/16$ in (2 - 4 mm)	Exceeding $^3/16$ in

Ditto - gaps between boards or members

$^3/16$ - ⅜ in (4 - 8 mm) over lengths of 30 - 50 in (750 - 1250 mm)	Exceeding ⅜ in over any length or exceeding $^3/16$ in over length exceeding 50 in.

Tile Hanging

Seating, flatness, flashings, as for roofs, chips as for brickwork)

Cutting or fitting to abutments - gaps

⅜ - ⅝ in (9 - 15 mm)	Exceeding ⅝ in

Continued/

Ditto - deviation from straight

¼ - ⅜ in (6 - 9 mm)	Exceeding ⅜ in

Angles and edges - deviation from straight (as seen when facing surface)

Just noticeable	Distinct

External Boarding and Sheeting

Gap at laps and between boards or sheets

³/32 - ³/16 in (2 - 4 mm) over lengths 10 - 20 in (250 - 500 mm)	Exceeding ³/16 in or length exceeding 20 in

Gap at heading joints

³/64 - ³/32 in (1 - 2 mm)	Exceeding ³/32 in

Deviation from straight or level (as seen when facing surface)

Just noticeable	Distinct

Abutting surfaces intended to be flush - difference in levels

³/64 - ³/32 (1 - 2 mm) over length exceeding 2 in (50 mm)	Exceeding ³/32 in over length exceeding 2 in (50 mm)

Distinct raised grain, or roughness (woolliness) or torn grain just showing through surface

Area ½ - 2 ft^2 (50,000 - 200,000 mm^2)	Area exceeding 2 ft^2

Roughness (woolliness) standing out clearly from surface or torn grain showing flats below general surface

Area ¼ - 1 ft^2 (25,000 - 100,000 mm^2)	Area exceeding 1 ft^2

Damaged edges, scores

Width ³/64 - ³/32 in(1- 2 mm) over length 1 - 3 in (25 - 75 mm)	Width exceeding ³/32 in or length exceeding 3 in

Splits and shakes

Width ¹/32 - ³/64 in (0.75 - 1 mm) over lengths 10 - 20 in (250 - 500 mm)	Width exceeding ³/64 in or length exceeding 20 in

Continued/

External Rendering	
Wave or ripple in surface	
Just noticeable over length 20 - 40 in (500 - 1000 mm)	Exceeding 40 in in length or distinct
Depressions or prominences	
Area ½ - 1 in^2 (300 - 600 mm^2) not exceeding $^3/_{64}$ in (1 mm) in depth or height	Area exceeding 1 in^2 or height or depth exceeding $^3/_{64}$ in
Angles and edges - deviation from straight	
Just noticeable	Distinct
Ridges and Trowel marks	
Not exceeding $^3/_{64}$ in (1 mm) in depth or height over length 2 - 4 in (50 - 100 mm)	Height or depth exceeding $^3/_{64}$ in or length exceeding 4 in

Internal Plastering	
Wave or ripple in surface	
Just noticeable over length of 10 - 20 in (250 - 500 mm)	Exceeding 20 in in length
Roughened surface	
Area 1 - 3 in^2 (600 - 2,000 mm^2)	Area exceeding 3 in^2
Depressions or prominences	
Area ¼ - ½ in^2 (150 - 300 mm^2) not exceeding $^3/_{128}$ in (0.5 mm) in depth or height	Area exceeding ½ in^2 or height or depth exceeding $^3/_{128}$ in
Ridges and trowel marks	
Not exceeding $^3/_{128}$ in (0.5 mm) in depth or height over length 1½ - 3 in (40 - 75 mm)	Depth exceeding $^3/_{128}$ in or length exceeding 3 in
Angles and edges - deviation from straight	
Just noticeable	Distinct

Continued/

Joinery

Knots showing through paint (discoloured or not flush with surface)

Not exceeding $\frac{5}{8}$ in (15 mm) diameter	Exceeding $\frac{5}{8}$ in diameter

Raised grain, roughness or wolliness, and torn grain showing through paint

Area 5 - 20 in^2 (3,000 - 12,000 mm^2)	Area exceeding 20 in^2

Raised grain and roughness or woolliness standing out clearly from surface, and torn grain showing flats below general surface

Area 2 - 10 in^2 (1200 - 6000 mm^2)	Area exceeding 10 in^2

Cupping or warping of surface (as seen when facing surface)

Just noticeable	Distinct

Damage (pieces knocked out, or torn out by planer, damaged edges)

Area $\frac{1}{4}$ - $\frac{1}{2}$ in^2 (150 - 300 mm^2)	Area exceeding $\frac{1}{2}$ in^2

Hammer marks

Just showing and not exceeding half hammer face in area	Deeper depression or exceeding half hammer face in area

Planer cutter markings

6 or less to 1 in	

Saw markings on end grain

Area $\frac{1}{4}$ - 1 in^2 (150 - 600 mm)	Area exceeding 1 in

Splits and shakes

Not exceeding $^3/128$ in (0.5 mm) in width over length $\frac{3}{4}$ - $1\frac{1}{2}$ in (20 - 40 mm)	Width exceeding $^3/128$ in or length exceeding 20 in

Gap at joint of members

$^1/32$ - $^3/64$ in (0.75 - 1 mm) over lengths $\frac{1}{2}$ - $1\frac{1}{2}$ in (12 - 40 mm)	Exceeding $^3/64$ in or length exceeding $1\frac{1}{2}$ in.

Continued/

Abutting surfaces intended to be flush - difference in levels

$^{1}/32$ - $^{3}/64$ in (0.75 - 1 mm) over lengths $\frac{1}{2}$ - $1\frac{1}{2}$ in (12 - 40 mm)	Exceeding $^{3}/64$ in or length exceeding $1\frac{1}{2}$ in

Mottled surface of hardboard

Showing up clearly (see Plate 18.11)	

Uneven paintwork

Distinct brushmarks in thick paint covering: runs 1 - 2 in (25 - 50 mm) wide	Ridges formed in paint: runs over 2 in wide

Fit of room doors - between edge of door and surrounding framework

$^{3}/16$ - $\frac{1}{4}$ in (4 - 6 mm) over length exceeding 10 in (250 mm)	Exceeding $\frac{1}{4}$ in

Ditto - between inside face of door and bottom of rebate when door is fastened

Exceeding $^{1}/16$ in up to $^{3}/32$ in (1.5 - 3 mm) over length exceeding 10 in (250 mm)	Exceeding $^{3}/32$ in

Fit of cabinet doors and drawers - between edge of door or drawer and surrounding framework

$^{3}/32$ - $\frac{1}{8}$ in (2 - 4 mm) over length exceeding 6 in (150 mm)	Exceeding $\frac{1}{8}$ in

Fit of sashes - between lip of sash and face of frame, and between inside face of sash and bottom of rebate

Exceeding $^{1}/16$ in up to $^{3}/32$ in (1.5 - 3 mm) over length exceeding 6 in (150 mm)	Exceeding $^{3}/32$ in.

(a) Dimensions in millimetres are alternatives not equivalents.

APPENDIX II

Typical sketch of house made during the fieldwork (Fig. AII.1)

Check list used in examination of dwellings and questions put to occupiers.

Letter and form sent to builders

Letter to householders.

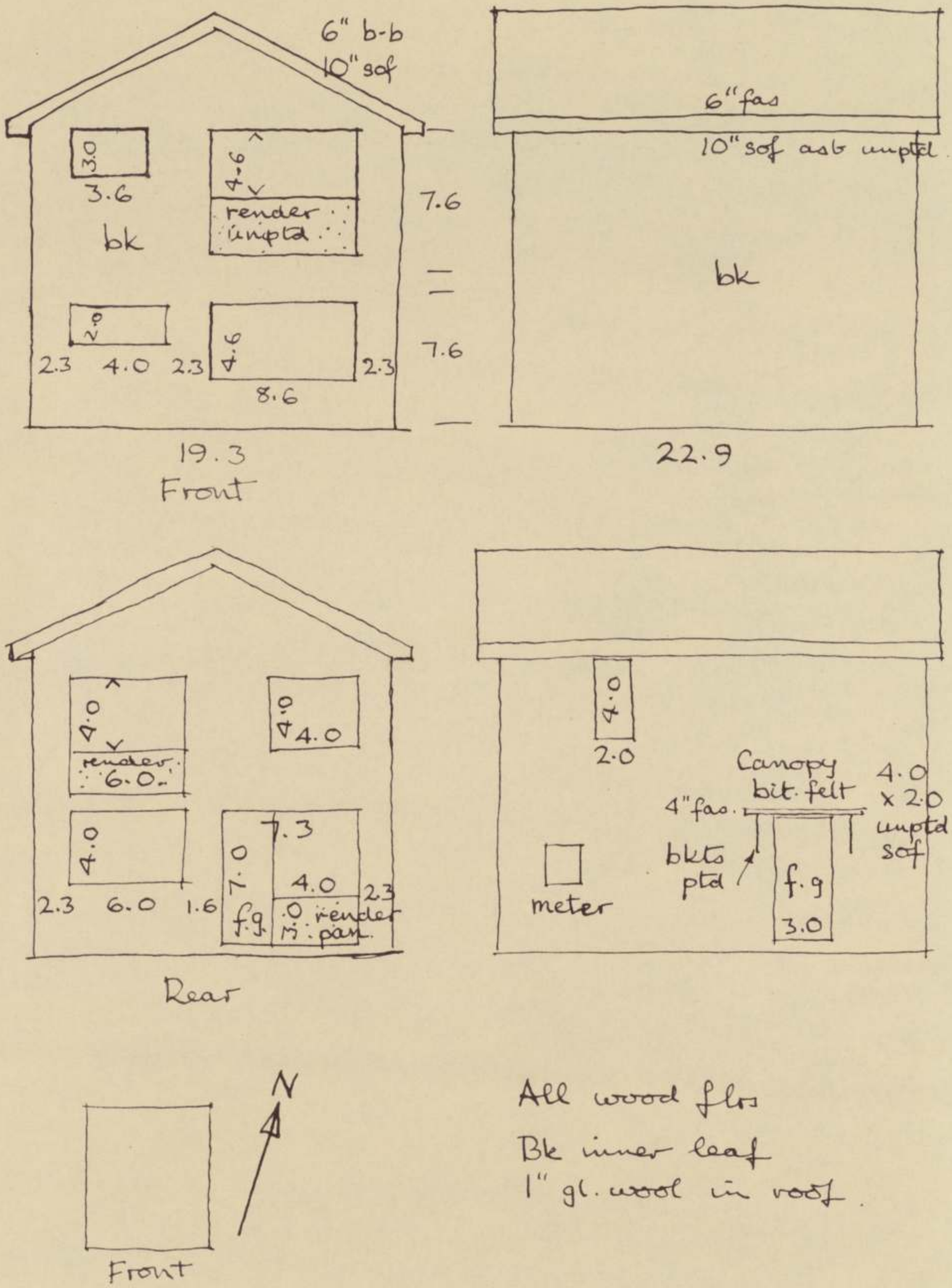

6" b-b
10" sof
3.0
3.6
4.6
render unptd
bk
7.6
2.3 4.0 2.3 4.6 2.3
8.6
7.6
19.3
Front
6" fas
10" sof asb unptd.
bk
22.9
4.0
4.0
render 6.0
4.0
7.0
7.3
4.0
2.3 6.0 1.6 f.g. render
Rear
4.0
2.0
Canopy bit. felt
4.0 x 2.0 unptd sof
4" fas.
bkts ptd
f.g
3.0
meter
N
Front
All wood flrs
Bk inner leaf
1" gl. wool in roof.

Fig AII-1

STANDARDS IN HOUSING

CHECK LIST

Except where otherwise indicated (1) denotes Yes, (2) No, (0) Not known, (11) Special case.

Grading of surface finish and fit (Grades may be used in combination)

(1) Good throughout
(2) Small areas (length) with slight defects
(3) Large area with slight defects
(4) Slight defects throughout
(5) Small area with bad defects
(6) Large area with bad defects
(7) Bad defects throughout

Card No. 1 -- 1 ______

Dwelling No. -- Hunds. 2 ______

Tens 3 ______

Units 4 ______

Age of dwelling (months) -----------------------------------) 5 ______) 6 ______

Exposure - Heat loss (1) Sheltered (2) Normal (3) Severe 7 ______

Outside sources of noise

Noise climate (greatest) (1) A/B (2) C (3) D (4) E (5) F/G 8 ______

Near vicinity hilly or otherwise needing gear changing ----- 9 ______

Other sources nearby (1) Aircraft (2) Railways (3) Factories (4) Play areas (5) Other 10 ______

Mitigating planning. Is it appropriate (1) Definitely (2) Probably desirable -------------- 11 ______

Type of mit. planning (1) Screens (2) Grassed areas (3) Discouragement of speeding (4) Siting of rooms most sensitive to noise on quieter side of building (5) Other 12 ______

LOCATION card 1

Undesirable planning (1) Narrow hard paved courts (2) Other 13 ______

Mitigating construction Windows
(1) Sealed light (2) Sealed heavy (3) Double 14 ______

EXTERIOR

Window frames (1) Wood (2) Steel (3) Aluminium
(4) Wood and metal (5) Other ---------------------- 15 ______

Short-lived materials (1) Bit. felt (2) Mastics (3) Other 16 ______

Finish (underline where defective)

Roof: No sag, tiles lying flat, courses and joints straight, neat flashings and fillets, eaves, fascia and gutter straight, fascia and soffit neatly jointed 17 ______

-- 18 ______

Walls: Bricks and stone - undamaged and clean, colour uniform, straight and level beds, plumb perpendiculars, regular bond. Boarding or sheeted surfaces - flat, neatly jointed, good finish. Tile hanging - flat, courses and joints straight, regular bonding. Rendering - flat good finish, good angles, good joints with other surfaces. 19 ______
R.W. and other pipes - straight, properly jointed, good finish. 20 ______

Windows: Finish ---------------------------------- 21 ______

-- 22 ______

Fit -- 23 ______

-- 24 ______

Defective detailing e.g. in joints, parapets -------------

-- 25 ______

Overhanging eaves ---------------------------------- 26 ______

Cracking (1) Slight (2) Moderate (3) Severe (4) No 27 ______

Position --

Cause --

Effect on
performance
of building --

Other signs
of movement -- 28 ______

Cause and
effect ---

Movement (a) complete (b) incomplete (c) intermittent

HALL AND LANDING

Art. light at front door (2) not necessary (3) not applicable
(4) none 29 ______

Front doors (1) Weather stripped by builder (2) Other
precautions by builder (3) lobby (4) draught exc.
by tenants (5) none ---------------------------------- 30 ______

Locks (1) to BS 3621 (2) Mortice (3) Cylinder rim
night latch (4) Other -------------------------------- 31 ______

Bolts -- number 32 ______

Type (1) Rack (2) 10 in (3) less than 10 in (4) Other 33 ______

Glazing below lock rail with (1) sheet glass or similar
(2) plate (3) toughened (4) wired (5) none 34 ______

Stairs

Rise --in. 35 ______

$\frac{1}{8}$ths 36 ______

Going ---in. 37 ______

$\frac{1}{8}$ths 38 ______

Adequate headroom (6 ft 6 in) (Indicate inches below) 39 ______

Adequate clearance (5 ft) (Indicate inches below)----- 40 ______

Balustrade, spacing of bars --------------------------in. 41 ______

$\frac{1}{8}$ths 42 ______

Handrail both sides ---------------------------------- 43 ______

Single steps --- 44 ______

Winders (1) top (2) bottom (3) middle of flight (4) none — 45

Opening between treads ---------------------------------in. — 46

$\frac{1}{8}$ths — 47

Obstruction from doors ------------------------------------ — 48

Encroachment on circ. space -------------------------- — 49

Inadequately lighted by (1) daylight (2) art. light — 50

Finish of stairs and balustrade ---------------------- — 51

52

Fit of stairs and balustrade -------------------------- — 53

54

Construction not equal to normal timber construction — 55

Windows cannot be cleaned safely on inside --------------- — 56

can be cleaned safely on outside ----------------- — 57

Socket outlets -- — 58

LIVING AND DINING ROOMS

Fire

	Living	Dining
Fireguard fixing for open fire ------------	59	70
Hearth inadequate -------------------------	60	71
Open fire flue with (1) unrestricted throated (2) restricted throat ---------------	61	72
Gas fire flue (1) ordinary (2) balanced (3) se-duct --------------------------	62	73

Lighting

	Living	Dining
Lighted from more than one wall by (1) windows on adjacent walls (2) windows on opposite walls	63	74
Sunlight (1)-(7) hours, (10) None	64	75
(1) $\frac{1}{4}$ (2) $\frac{1}{2}$ (3) $\frac{3}{4}$ hours	65	76

(1) Morning (2) Midday (3) Afternoon	66	77
Artificial lighting points ----------------	67	78
Glazing below lock rail with (1) sheet glass or similar (2) plate (3) toughened (4) wired	68	79
Socket outlets ---------------------------	69	80

Card No. 2 --		1
Dwelling No. ---	Hunds	2
	Tens	3
	Units	4

Communications

Provision made for installation of telephone ------------	5
Provision for t.v. reception ----------------------------	6
Sockets for aerial --------------------------------------	7

Flats (Living rooms above 1st floor)

Windows. Sill height (min.) ---------------------------	ft.	8
	in.	9
Floor referred to above --------------------------------		10
Limitation on opening windows --------------------------		11
Can be cleaned outside safely --------------------------		12

KITCHEN

Preparation area

Cooker, unused space at sides --------------------------	13
Cooker under window ------------------------------------	14

Working surfaces at different heights or not continuous | 15 ________

Work sequence - surface - cooker - surface - sink - surface
(1) Yes (2) Partially (3) No ---------------------- | 16 ________

Housewife in own light at (1) sink (2) cooker (3) prep. table (4) sink and cooker (5) sink and prep. table (6) cooker and prep. table (7) all | 17 ________

Sill more than 6" above working surface ins. above 6" | 18 ________

Power for cooking (1) Electricity (2) Gas | 19 ________

Hood over cooker -- | 20 ________

Mechanical extract (1) In conjunction with hood
(2) separate -- | 21 ________

Cross Ventilation -- | 22 ________

Ceiling airer over cooker ---------------------------------- | 23 ________

Layout

Door swings and position causing obstruction ------------- | 24 ________

Non-slip floor -- | 25 ________

Socket outlets badly positioned -------------------------- | 26 ________

Lockable cup'd for cleaning liquids etc. ----------------- | 27 ________

Provision for clothes washing equipment ------------------ | 28 ________

Clothes drying equipment (or provision) ------------------ | 29 ________

Sunlight (1)-(7) hours (10) none ------------------------- | 30 ________

(1) $\frac{1}{4}$ (2) $\frac{1}{2}$ (3) $\frac{3}{4}$ hours ------------------- | 31 ________

(1) Morning (2) Midday (3) Afternoon ------------ | 32 ________

Artificial lighting points -------------------------- No. | 33 ________

Separately controlled ------------------------------ | 34 ________

Cupboards including work surfaces

Finish -- | 35 ________

36 ________

Fit -- 37 ______

38 ______

Back Door (1) Weather stripped by builder (2) Other precautions by builder (3) lobby (4) draught exclusion by tenants (5) none ---------------------- 39 ______

Lock (1) to BS 3621 (2) Mortice (3) Cylinder rim night latch (4) Other ------------------------------- 40 ______

Bolts -- No. 41 ______

(1) Rack (2) 10 in (3) less than 10 in (4) Other 42 ______

Artificial lighting over back door ------------------------ 43 ______

Locks on ground floor or other easily accessible windows 44 ______

Socket outlets in working area -------------------------- 45 ______

Socket outlets in dining area (if this definitely separate) 46 ______

Socket outlets in utility room ------------------------- 47 ______

BATHROOM

Appliances

W.C. separate from bath with wash basin ---------------- No. 48 ______

W.C. separate from bath without wash basin ------------- No. 49 ______

Bathroom contains: Bath -------------------------------- 50 ______

Shower ------------------------------ 51 ______

Washbasin --------------------------- 52 ______

Vanitory Unit ----------------------- 53 ______

W.C. -------------------------------- 54 ______

Bidet ------------------------------- 55 ______

W.C. over living room (1) Yes (2) Not applicable (3) No. 56 ______

Syphonic trap -- 57 ______

Close coupled cistern ------------------------------------ 58 ______

Hot Water

Means of warming airing cupboard provided ------------------ 59 ________

Heated towel airing pipe or heated towel rail -------------- 60 ________

Fuel for heating water (1) Elect. (2) Gas (3) Solid 61 ________

Head of water above hot water bath tap ft. 62 ________

in. 63 ________

Safety Points

Non-slip floor -- 64 ________

Grab rail by bath --- 65 ________

Lockable medicine cupboard ---------------------------------- 66 ________

Safe lamp holder -- 67 ________

Door openable from both sides ------------------------------- 68 ________

Safe heating or wiring provision ---------------------------- 69 ________

Planning

W.C. adjacent to living room or bedroom --------------------- 70 ________

Wall between W.C. and bedroom at least equal to 3" clinker block plastered both sides (41 dB slope B) 71 ________

W.C. door facing other door --------------------------------- 72 ________

Heavy door (solid core) on W.C. ----------------------------- 73 ________

Card No. 3 -- 1 ________

Dwelling No. --------------------------------------- Hunds. 2 ________

Tens 3 ________

Units 4 ________

BEDROOMS	Bed 1	Bed 2	Bed 3	Bed 4
Bed or other furniture can be placed at least 3 ft from fixed fire	5	13	21	29

Lighting

Light switch near each bed	6	14	22	30
Socket outlet near bed	7	15	23	31
Number of socket outlets	8	16	24	32
Artificial lighting points No.	9	17	25	33
Sunlight (1)-(7) hours	10	18	26	34
(1) $\frac{1}{4}$ (2) $\frac{1}{2}$ (3) $\frac{3}{4}$	11	19	27	35
(1) Morning (2) Midday (3) Afternoon	12	20	28	36

Windows

Opening light min. size 2' 9" x 1' 5" ---------------------- 37

Limitation on opening windows above 1st floor -------------- 38

Can be cleaned outside safely ---------------------------- 39

Sill height (min.) --------------------------------------- 40

41

Wash basin or vanitory unit in bedroom ------------------- 42

INTERIOR FINISH

Ceilings Flat, smooth or regular surface (as intended) 43

good decoration --- 44

Walls Flat, smooth, plumb, good decoration, good angles, 45

good joints with other surfaces 46

Trim skirtings, architraves, fillets, window boards -------- 47

Finish -- 48

Fit --- 49

50

Doors

Finish -- 51

52

Fit -- 53 ____

54 ____

Windows

Finish --- 55 ____

56 ____

Fit -- 57 ____

58 ____

Draught exclusion by occupiers -------------------------- 59 ____

Rain penetration (1) None (2) Roof (3) Walls ------------- 60 ____

Rising Damp (1) None (2) Floor (3) Walls ---------------- 61 ____

GARAGE/METERS

Socket outlets in garage or workshop --------------------- 62 ____

Gas and Electricity Meters

In separate cupboards or well apart ---------------------- 63 ____

Fuses within reach --------------------------------------- 64 ____

Provision for fire extinguisher -------------------------- 65 ____

HEATING

Type of fuel (1) Solid (2) Oil (3) Gas (4) Elect. 66 ____

Extent (1) Whole house heating (2) Part house heating
(3) Single fires ---------------------------------- 67 ____

Type (1) Small pipe with boiler (2) Small pipe with master
radiator (3) Ducted warm air (4) Underfloor (5) Other 68 ____

Control (1) Outside 'stat (2) Inside 'stat (3) time clock
(4) Manual (5) Other ------------------------------ 69 ____

Thermostat setting ------------------------------ °F Tens 70 ____

Units 71 ____

Appliance rating ------------------------------ Btu 10,000's   72 ______

1,000's   73 ______

Hot water heated from same appliance --------------------   74 ______

SOUND INSULATION (Semi detached houses and flats)

Mitigating planning (1) Rooms adjoining party walls or party floors of similar use (2) Ditto, partially (3) No (4) Not possible ------------------------------------   75 ______

Staircase, hall and kitchen adjoining on each side of party wall, (1) Yes (2) Partially (3) No (4) Not possible   76 ______

Mitigating Construction Standard of insulation of separating walls (1) Better than house party wall grade (2) House party wall grade (3) Worse than house party wall grade (4) Better than Grade I (5) Grade I (6) Grade II (7) Worse than Grade II by   dB 77 ______

Card No. 4 --   1 ______

Dwelling No. ------------------------------------- Hunds.   2 ______

Tens   3 ______

Units   4 ______

SOUND INSULATION (Flats only)

Floor Construction

Insulation of separating floors (1) Better than Grade I (2) Grade I (3) Grade II (4) Worse than II by   dB   5 ______

Undesirable planning (1) Soil pipe passing through kitchen without adequate protection (2) Ditto with adequate Protection ------------------------------------   6 ______

(1) Ditto living room without adequate protection

(2) Ditto living room with adequate protection   7 ______

W.C. of another dwelling over living room or bedroom   8 ______

Refuse chutes next to living room or bedroom ------------ 9

Mitigating Planning Internal passages and bathroom between corridor and living rooms or bedrooms (1) Yes (2) Partially (3) No ------------------------------ 10

Mitigating Construction Insulation of walls (1) Better than I (2) I (3) II (4) Worse than II by -- dB 11

BALCONIES

Guarding, height -- ft. 12

Details of construction in. 13

Spacing -- in. 14

⅛ths 15

Horizontal bars or encouragement to climb 16

REFUSE DISPOSAL

(1) Dustbin (2) Chute ---------------------------------- 17

GENERAL INFORMATION

Unit (1) House (2) Bungalow (3) Flat (4) Maisonette 18

Position (1) Detached (2) Semi (3) Terrace (4) Top floor (5) Inter floor (6) Bottom floor 19

(1) End (2) Inter position 20

Construction (1) Trad. (2) Non-trad. 21

Type (1) Municipal (2) Spec. without NHBRC cert. (3) Spec. with NHBRC cert. (4) Housing Assn. (5) Showhouse (6) Other 22

Floor area ft^2 (3) 300 or under (4) 400 - - (0) 1000

(1) 1100 (2) 1200 (11) 1300 or over 23

Cost inc. land £ ------------------------------------ Thous. 24

Hunds. 25

SOUND INSULATION/BALCONIES/REFUSE DISPOSAL/GENERAL INFORMATION card 4

Cost exc. land £ --	Thous.	26
	Hunds.	27
Cost/floor area (inc. land) -------------------------	Hunds.	28
	Tens	29
	Units	30
Cost/floor area (exc. land) -------------------------	Hunds.	31
	Tens	32
	Units	33

Sub contractors employed

(0) Not known	(1) Bricklayer	34
(0) None	(1) Carpenter	35
	(1) Plasterer	36
	(1) Plumber	37
	(1) Roofer	38
	(1) Painter	39
	(1) Glazier	40
	(1) Floor Layer	41
	(1) Gas Fitter	42
	(1) Electrician	43

Architect (1) No (2) Designed (3) Designed and supervised 44

Is advice given to tenants on fire precaution 45

GENERAL CONSTRUCTION

U Values	Wall --	46
		47
	Panel ---	48
		49

Overall external wall ---------------------------	50
	51
Topmost ceiling ------------------------------	52
	53
Lowest floor ---------------------------------	54
	55
Shell U -------------------------------------	56
	57
<u>Sound Insulation</u> Partitions downstairs ------------- dB	58
	59
upstairs ---------------	60
	61
Robustness of partitions (1) Inadequate	62
<u>Preservative used on timber</u> Ground floor	63
Wall Framing	64
Partitions	65
Roof	66
Boarding, external	67
Other	68
<u>Surface material</u> with good thermal insulation or light weight lining on walls, floor and ceiling	69
<u>Flat roof</u> of dense concrete (1) Yes with insulating material on underside (2) Yes without ditto.	70
<u>Harmful interstitial condensation</u> likely	71
<u>Cold bridges</u> likely to cause condensation	72
<u>Mechanical ventilation</u> (except in kitchen)	73

Card No. 5 --		1
Dwelling No. ---	Hunds.	2
	Tens	3
	Units	4

SUMMARISED INFORMATION

Insulation index (floor area) -------------------------------		5
		6
(volume) ------------------------------------		7
		8
Windows/floor area --------------------------------------	%	9
		10
Garage or corridor. Estimated temperature ^{o}F ---------------		11
		12
General assessment of ventilation (1) Excessive (2) Satisfactory (3) Inadequate		13
Cost of external redecoration	£	14
		15
Socket outlets		16
		17
Garage/Total area	%	18
		19

QUESTIONS TO OCCUPIERS

Except where otherwise indicated (1) Yes (2) No (3) Don't know

Is condensation troublesome in the kitchen	20
bathroom	21
other rooms?	22

Do you take precautions to prevent it? 23 ________

What is the temperature like in the winter time in

living rooms 24 ________

kitchen 25 ________

bedrooms? 26 ________

Answer (1) Cold (2) Allright (3) Too hot

Is the cost of heating the house (1) cheap (2) reasonable or (3) expensive? 27 ________

Are you satisfied, on the whole, with the finish of the outside of the house? 28 ________

Ditto - inside 29 ________

Are any of the rooms draughty? 30 ________

Which rooms? (1) living room (2) bedrooms (3) kitchen, (4) Other rooms 31 ________

Do you have enough hot water? 32 ________

Are you disturbed by noise from outside 33 ________

other houses (flats) 34 ________

within your own house? 35 ________

Answer, if yes, (3) slight disturbance
(4) more than slight

Type of noise ---

Have you received advice on fire precautions, or what to do if there should be a fire? 36 ________

Owner occupiers. Do you think you have received value for money in the house (flat)? 37 ________

Tenants. Do you think this house (flat) is worth the rent you pay? 38 ________

What is there in connection with the house that you would have liked provided and which you would have been prepared to pay more for?

QUESTIONS TO OCCUPIERS card 5

The University of Aston in Birmingham
Gosta Green, Birmingham 4
Telephone: 021-359 3611

The Department of Building.
Telephone Ext.
Head of Department: Professor A. W. Pratt, D.Sc., F. Inst.P., F.I.O.B.

BU/WRS/JW

Dear Sir,

As part of a research project into standards in housing I recently visited a house which I believe was erected by your Company.

If you would be good enough to assist my study of this house by giving as much as possible of the information requested on the enclosed form I should be grateful.

The information is required only for the purpose of research and will not be attributed to any particular building or builder.

I shall appreciate your help.

Yours faithfully,

W.R. Sinnott
(Postgraduate Student)

Enc.

SURVEY OF STANDARDS IN HOUSING

Address of Dwelling ______________________

____

Details of Construction (Thickness and material)

External Walls ______________________

Panel ______________________

Partitions: Downstairs ______________________

Upstairs ______________________

Insulation of Topmost Ceiling ______________________

Cost (Local Authority dwellings only) ______________________

Architect ______________________

____

Builder ______________________

____

Sub-Contractors Employed (Including labour only) (Please tick as appropriate)

Bricklayer	________	Carpenter	________
Plasterer	________	Plumber	________
Roofer	________	Painter	________
Glazier	________	Floor layer	________
Gas Fitter	________	Electrician	________

Whether Preservative Used on Timber

In Ground Floor	________	Wall Framing	________
Partitions	________	Roof	________
Boarding (external)	________	Other position	________

Kindly complete and return to: The Department of Building
The University of Aston in Birmingham,
Gosta Green, Birmingham 4.

The University of Aston in Birmingham

Gosta Green, Birmingham 4

Telephone: 021-359 3611

The Department of Building. Telephone Ext.

Head of Department: Professor A. W. Pratt, D.Sc., F. Inst.P., F.I.O.B.

BU/WRS/JW

Dear Sir,

As part of a research project in the Department of Building at this University a survey is to be made of a sample of recently constructed housing in the West Midlands. The aim is to determine the standard of construction of new housing in the region.

We should like to include your house in the survey and would be grateful for any comments you may care to make on the performance of the building.

Mr. W.R. Sinnott, the postgraduate student undertaking this research, will be calling on you in a few days time. If you or your wife are at home and are willing to assist, he would like to ask you some questions and if it is convenient, to make a visual examination of your house and take a few measurements.

The information obtained will be used only for the purpose of research and will not be identified with any specific person or address.

I shall be most grateful if you are able to co-operate in this research.

Yours faithfully,

A. W. Pratt.

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