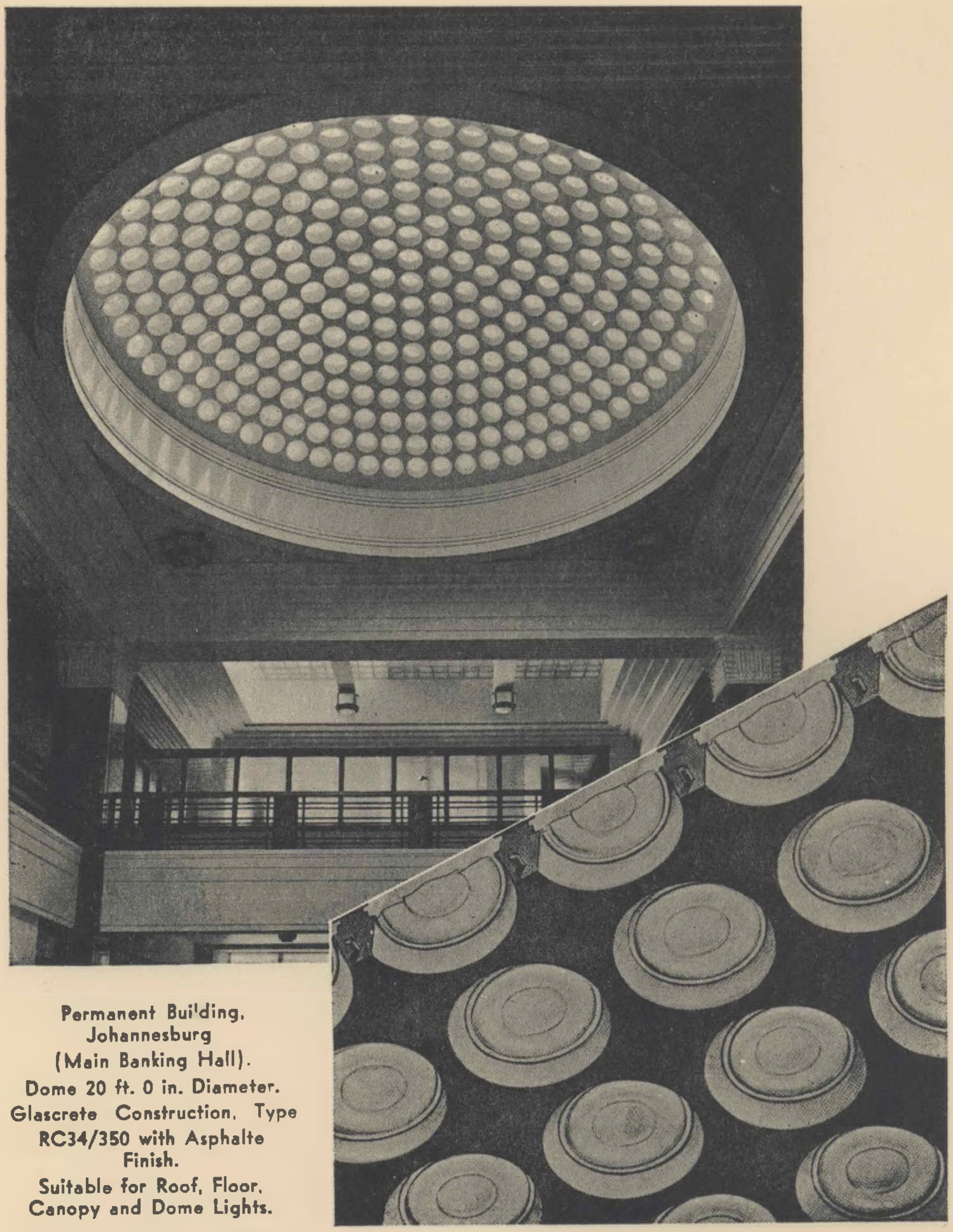
SOUTH AFRICAN ARCHITECTURAL RECORD

MARCH, 1941



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THE SOUTH AFRICAN ARCHITECTURAL RECORD

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HON. EDITORS: G. E. PEARSE, REX MARTIENSSEN.

Detail of the Wine Cellar Pediment   Groot Constantia

A MODERN APPROACH TO BUILDING TECHNIQUE

by A. MILLER, B Sc. (Arch.)*

WITH ACKNOWLEDGMENTS TO THE TRANSACTIONS OF THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND [APRIL, 1940]

The Editors are grateful to Mr. James Drysdale, M.I.E.S., of the Department of Mechanical Engineering in the University of the Witwatersrand for drawing their attention to the paper reprinted below. Mr. Drysdale has given permission to do so, on behalf of his Society.

The term "building technique" is so wide in its implications that, although the subject of this paper is essentially the approach, and not the technique itself, a preliminary word of explanation is desirable on the interpretation put on it for the present purpose.

If we accept the loose definition that technique is the manner in which a desired result is obtained, it is evident that the production of a large modern building involves numerous techniques which vary according to what is regarded as the finished result. The following five distinct sections or degrees may, however, be recognised, and they are perhaps best described by reference to a typical simple unit of a building such as a brick wall.

1. The technique of the brick manufacturer, whose aim generally is the production of bricks better than, or different from, those of his competitors.

2. The technique of the bricklayer, whose aim should be to produce a wall exactly in conformity with the architect's specification and according to the best traditions of his craft.

3. The technique of the architect, who as master builder designs the wall to satisfy measurable requirements, such as strength, durability, waterproofness, heat insulation and sound insulation.

4. The technique of the architect, when, as planner, he places the wall in such a position, and balances its other properties in such a way, as to satisfy the less clearly defined requirements of the occupants of the finished building.

*Of the Scottish Building Centre.

5. The technique of the architect, when, in his capacity as artist, he exercises good taste and creative thought in meeting material requirements.

The subject of this paper is confined mainly to section 3, that is, to the technique of the master builder, whether he be architect, engineer, clerk of works, or builder. This obviously includes sections 1 and 2, and it will be found at times to overlap somewhat the sphere of section 4.

The developments that have taken place since the beginning of this century in the design and equipment of buildings are well known, and it is probable that the general public is conscious also of changes in constructional methods as exemplified by the use of steel and concrete frames, concrete roof slabs, tubular scaffolding, etc. It might be thought, therefore, that building technique, in the sense already defined, has undergone a fundamental and thorough-going transformation during the last thirty or forty years, and this is, in fact, partly true. There can be no doubt, for example, that the development of reinforced concrete and structural steel has produced fundamental changes, and that innovations such as electric lighting or central heating have been far reaching in their effects.

It is not correct, however, to assume that parallel evolution has taken place uniformly throughout the whole industry. The building industry has always paid great respect to tradition, particularly to local tradition, and has been shaped slowly by the attrition of trial and error. Precision in building is the result of either strict financial control or the use of some mass-production method, and in more leisurely days neither of these factors was significant. The tendency therefore was to meet the measurable requirements with a generous factor of safety and to accept the result as a standard to which other less definite requirements must conform. The traditional building industry was thus in no way prepared for impact with nineteenth century industrialism and the rise to importance of engineering and science. The advent of the Industrial Revolution, moreover, found architects with their minds fixed on the past, arguing among themselves on the relative merits of the Classic and Gothic styles, and it is not surprising therefore to find that initiative in the task of modernising building technique was taken by engineers rather than by architects or building craftsmen.

The result has been the development of a variety of types of engineering, each having an important field of operation in the building industry, though not belonging essentially to it—structural engineering, heating and ventilating engineering, lift engineering and so on.

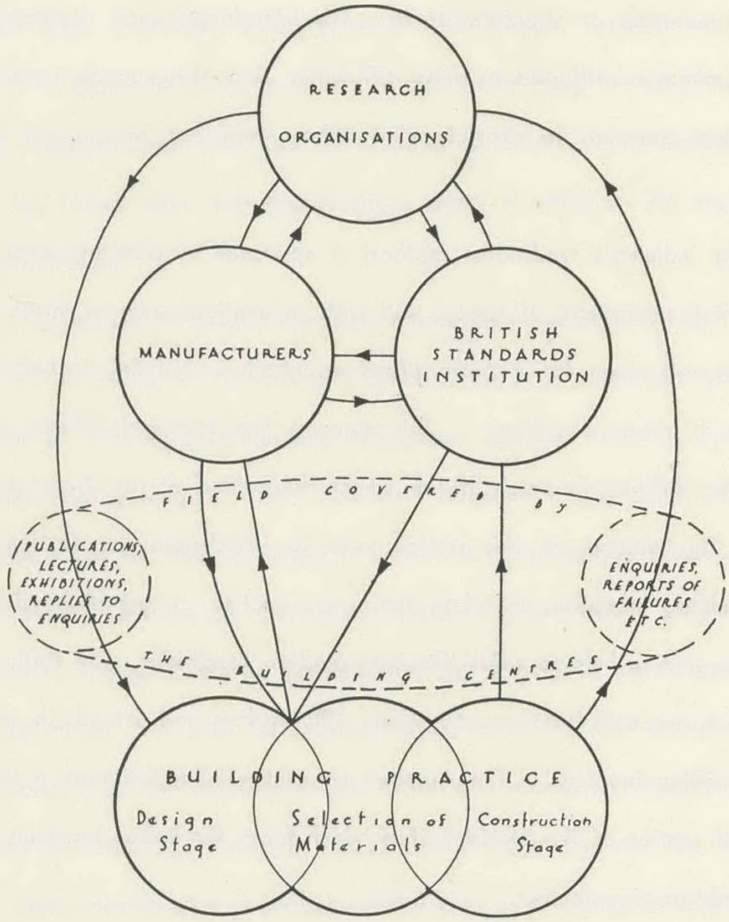

Fig. 1 — Diagrammatic representation of the main channels for the dissemination of data on modern building technique

Meantime, however, the traditional element has found these innovations difficult to assimilate. The engineers provided, for instance, a sound structural frame, but did not, and indeed could not, solve the problem of devising an appropriate covering. So there appeared the anomaly of massive stone masonry, which previously had been able to support itself and the floors and roof as well, now being hung with great ingenuity on steel joists. Modern cement began to be used for jointing traditional bricks, modern heating systems were installed in buildings with traditionally-seasoned joinery, and the modern demand for speed was imposed on the traditional craft of plastering. Many of these combinations of the old and new were only wasteful, in that they did not employ either element in its most logical and economical form. Certain of them, however, could also be sources of disastrous failure, and many instances are recorded in which costly repairs or reconstruction have been necessitated through some misapprehension of the essential properties of materials or structural forms. The introduction and development of mechanised transport has to some extent contributed to these difficulties, since it has made it possible and economical to carry certain building materials to districts where they were not known and their properties not fully understood.

No doubt the building industry's traditional method of approach by trial and error would in time have restored the balance, but in an age of speed, and with innovations such as those described, it is not surprising that the demand arose for a more direct approach to building technique, more in line with scientific achievement in other directions. This demand first received official recognition with the formation in 1921 of the Building Research Station under the control of the Department of Scientific and Industrial Research. The objects of this station were to investigate the fundamental properties of traditional and new building materials, to relate these to practice, to establish scientific bases for the traditional working rules, and to help to adjust these to modern conditions. The station has steadily grown in size and widened it's scope, until it now employs over 200 workers and extends its interests in practically every branch of the building industry. The Author's connection with this work is that he was for some years a member of that section of the Station's staff which forms the liaison between the more specialised scientific work and conditions in practice.

Fig. I gives a pictorial representation of the functions of the Station in relation to the practising and manufacturing parts of the industry and to other bodies which will be referred to later. The lines and arrows in this diagram are intended to represent the circulation of information. Five distinct functions of the Building Research Station may be noted:

1. Research into the fundamental properties of building materials.

2. Interpretation of the results of research on behalf of the users of the materials, and recommendations on structural forms.

3. Interpretation of the results of research on behalf of manufacturers of building materials.

4. An advisory service for architects, and other users, on failures and difficulties in the use of building materials.

5. A testing service for manufacturers, now carried out in conjunction with a panel of practising consultants.

A review will be given later of the known data relating to some of the essential elements of building, namely, external walls, roofs, partitions, floors, external wall finishes, internal wall and ceiling finishes. Meantime, however, it is desirable to refer briefly to two other types of organisation illustrated in Fig. 1, namely, the British Standards Institution and the Building Centres. The Building Division of the British Standards Institution has issued some 130 specifications, many of which are the result of lengthy research at the Building Research Station.

The Building Centres in London and Glasgow are each separate, self-contained organisations, but they have the common purpose of providing for the use of architects, builders, engineers and the general public, a continuous exhibition of building materials and equipment, together with an information service on all matters relating to building technique. Their advice is impartial and is based on the most authoritative data obtainable. The scope of their usefulness is suggested graphically in Fig. 1.

Turning now to a more detailed study of building technique, it is convenient to discuss this in relation to specific building elements, though it will be realised that any attempt at rigid classification of work of this kind is bound to break down. It must be emphasised, however, that the work described here represents only a very small proportion of the Building Research Station's interests and activities. In each case two lists are given, by way of introduction, one of "traditional components," and the other of "non-traditional components." Here again classification is perhaps misleading, as no sharp dividing line existed historically, nor is there any such distinction drawn in the conduct of the research described. If, however, the lists are accepted with this limitation in mind they may assist in explaining the information which follows and in linking it to the subject of this paper.

EXTERNAL WALLS.

Traditional Components	Non traditional Components
Clay bricks	Structural steelwork
Natural stone	Reinforced concrete
Dry-stone walling*	Mass concrete (solid and cellular)
Timber framing	Precast concrete blocks (solid, cavity and cellular)
Limes, hydraulic and non-hydraulic	Concrete bricks
Sand	Sand-lime bricks.
Half-timbering*	Faience and terra-cotta
Pise-de-terre*	Wood fibre slabs
Chalk-walling*	

*Not now in general use.

The following desiderata apply to external walls:

1. Resistance to penetration of rain.

2. Resistance to disintegrating influences.

3. Resistance to loading from floors and roofs, and other vertical and horizontal forces.

4. Resistance to excessive loss of heat when the interior of the building is heated.

Rain may enter a wall by the pores or cells of the constituent materials, or through cracks or interstices between inadequately joined units. Investigations have shown that the latter form of penetration is the more common at present. The majority of walls are built of small units with a binding mortar, and it is frequently found that, in solid construction, penetration occurs at the interfaces between units and mortar. Adhesion between units and mortar may therefore be as important as the properties of these components themselves, and in choosing a mortar for use with particular building units, whether stone, clay brick, sand lime brick or terra-cotta block, a general principle is that the mortar should be compounded so that its strength is similar to, but somewhat less than, that of the unit it binds. A good mortar, however, should also be easily workable, in order to ensure thorough spreading and filling of vertical joints, With these principles as guides the Building Research Station has suggested[1] appropriate mortars for use

TABLE I.

	Composition of Mortar by Volume		
Crushing strength of brick lb. per sq. in.	Portland Cement	Non-Hydraulic Lime	Sand
1,500—3,000	1	3	12
	(or 1 hydraulic lime: $2\frac{1}{2}$ sand)		
3,000—5,000	1	1	6
Over 5,000 (e.g., all engineering bricks)	1	0	3

with various classes of building unit, and Table I gives the mortars for three wide classifications of brick. In each instance, this recommendation involves some consideration of the weather conditions likely to be experienced. Units of lowest strength are, in general, those having the highest degree of absorp-

[1]See Bibliography, p. 126.

tion, and solid walls constructed in this way will be most suited to situations where the rainfall is likely to be least continuous. It is interesting, therefore, to find that this method was traditional in the South of England, where the rainfall is light.

The satisfactory use of units and mortar of maximum density requires a particularly high standard of workmanship, and where more severe weather conditions demand good protection, it may not always be possible to ensure such workmanship. In such cases, and indeed wherever reliable protection against damp penetration is sought, it is recommended by the Building Research Station that cavity construction should be employed. It is emphasised, however, that for the best results the cavity must be continuous, and Figs. 2 and 3 illustrate possible faults in cavity brick walls and methods of avoiding them. The need for good protection of this kind is as great in Scotland as anywhere in the British Isles, and it seems probable that our traditional practice of "strapping" walls internally developed in recognition of this fact.

The question of the disintegration of external walling materials introduces so many factors that adequate treatment is not possible in the scope of this paper. Mention must be made, however, of two very fruitful cases of decay, namely, frost and soluble-salt action. The disruptive effect of frost on porous materials is analogous to the bursting of water pipes from the same cause, that is, water filling the pores expands on freezing and exerts an outward thrust. The important point to be noted is that the pores must be filled, that is, the material must be saturated before such damage can occur. The mechanism of frost action on all materials is not yet fully understood, but it is known that certain materials may be apparently saturated without complete filling of their pores, and in general these are more resistant under frost action. The danger points for frost attack are parapets, cornices, string-courses, plinths, etc., and it is obvious that careful selection should be made of the materials for such positions. A parallel precaution, and one which is valuable in other directions, is to protect these features as far as possible against saturation, both by suitable design and by the use of flashings and damp-proof courses.

Soluble-salt action consists of crystallization at or near the surface of a porous material, resulting in spalling or flaking. Visible deposits of crystals on a surface are termed "efflorescence," which is not necessarily harmful and in many cases may merely be brushed off periodically without leaving permanent damage. In either case the soluble salts concerned may originate in any of the constituents of a wall, or in some source in contact with it (for example, the soil), and the salts are carried to the surface by means of moisture. The logical solutions to this problem are, therefore, to choose walling materials of low soluble-salt content, to isolate the wall from possible sources of salts, and again to protect the wall as far as possible from saturation by rain or ground moisture. The use of relatively porous mortars for jointing is also considered advantageous since in this way salts tend to be deposited at the joints, which can be repaired if damaged, rather than on the units, which are more permanent features of the structure.

Other agents of disintegration, notably acid attack in polluted atmospheres, are discussed in publications of the Building Research Station.[1 2 3]

The compressive strength or load-bearing capacity of walls is of considerable importance in large buildings or engineering structures, but it is not always realised that in the majority of buildings it is rarely a critical factor. For example, the walls of a normal two-storey building are estimated to carry a load of from $1\frac{1}{2}$ to 2 tons per square foot at foundation level, yet the construction used can generally be stressed safely (with a factor of safety of 5) to about 11 tons per square foot. There figures are applicable to walls built of bricks having a crushing stress of 3,000 lbs. per square inch and bonded in 1 : 3 cement mortar, and they lead us to consider how far the use of lime-cement mortar instead of cement mortar would affect the strength of a wall. This point has been investigated for brickwork, and the results[4] of a series of tests are illustrated in Fig. 4, which shows that the loss of strength due to the use of the more plastic mortar need not be great. If the mortar recommended in Table I for bricks with a crushing strength of from 1,500 to 3,000 lb. per square inch be used instead of 1 : 3 cement mortar, the resultant loss in strength of the brickwork would be less than 20 per cent.

Where walls are to be stressed more nearly to their safe limit it is important to be able to assess these limiting values without full size tests. The more nearly homogeneous the structure is, the more accurately can this be done from small samples (except for the effects of high slenderness ratio), but with brickwork or similar composite walling the strength of the wall depends, as has already been pointed out, on the nature of the mortar as well as on the strength of the units. As a result of numerous tests it is now possible to relate these three values empirically. Tables included in the Model Bye-Laws recently published by the Ministry of Health[5] give these relationships, and the following are applicable to walls built in cement mortar and having a slenderness ratio not exceeding 6 :

Minimum Crushing Strength of the Individual Brick or Block	Maximum Permissible Pressure	
lb. per sq. in.	tons per sq. ft.	lb. per sq. in.
1,500	8	124
3,000	11	170
4,000	13.5	210
5,000	16	247
7,500	23	358
10,000	30	466

The final function of external walls to which reference must be made is heat insulation. This is very largely the heating engineer's concern, but there is a number of general points which are of vital importance to those who design the buildings to be heated. Two distinct stages, for example, must be recognised in the process of warming a building. First comes the heating up process, and in this the thermal capacity of the structure is the important factor. The second stage is reached when the supply and loss of heat balance one another and a steady temperature is maintained ; during this process the thermal resistance of the whole outer shell of the building determines, for given temperature conditions, the rate of heat input required. In the long run, therefore, the heat insulation of roofs and outer walls is a matter of economy ; initial costs of heat insulating materials are balanced against initial savings in heating apparatus and subsequent economies in fuel consumption. But if a building or a room is to be heated intermittently, the steady heating state may never be reached. It is in such conditions that a knowledge of the behaviour of various materials in relation to heat transmission will benefit the architect. He will find, for instance, that in general a building will heat up and cool down most quickly if massiveness is avoided, and if the necessary insulation is applied as a small quantity of a material of high thermal resistance rather than as a large quantity of a material of low resistance. The heat-insulating properties of enclosed air-spaces merit attention in this connection, and research has shown that for intermittent heating the best place for heat insulation is on the inner surfaces of walls and ceilings. In the case of existing massive structures also, the addition of heat-insulating linings can greatly facilitate quick raising of the

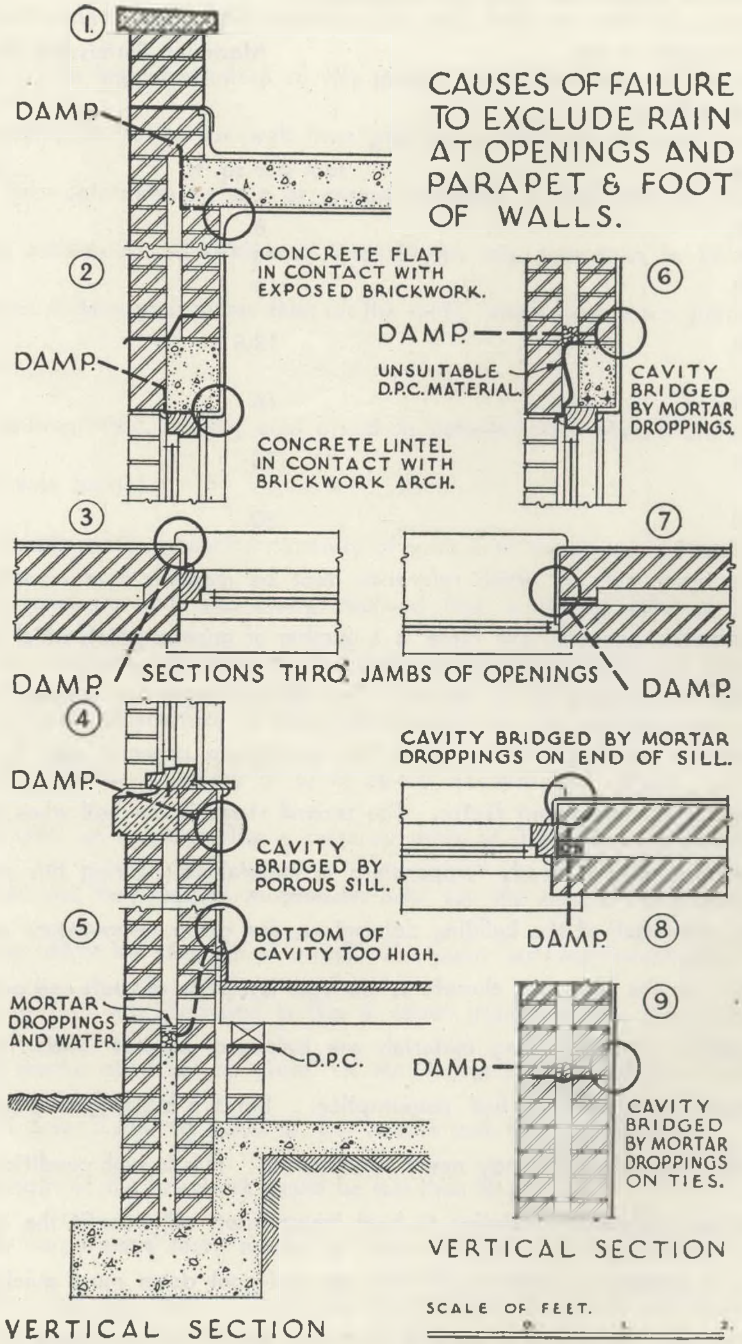
CAUSES OF FAILURE TO EXCLUDE RAIN AT OPENINGS AND PARAPET & FOOT OF WALLS.
1.
DAMP.
CONCRETE FLAT IN CONTACT WITH EXPOSED BRICKWORK.
2
DAMP.
CONCRETE LINTEL IN CONTACT WITH BRICKWORK ARCH.
6
DAMP.
UNSUITABLE D.P.C. MATERIAL.
CAVITY BRIDGED BY MORTAR DROPPINGS.
3
7
DAMP.
SECTIONS THRO. JAMBS OF OPENINGS
DAMP.
4
DAMP.
CAVITY BRIDGED BY POROUS SILL.
5
BOTTOM OF CAVITY TOO HIGH.
MORTAR DROPPINGS AND WATER.
D.P.C.
CAVITY BRIDGED BY MORTAR DROPPINGS ON END OF SILL.
DAMP.
8
9
DAMP.
CAVITY BRIDGED BY MORTAR DROPPINGS ON TIES.
VERTICAL SECTION
VERTICAL SECTION
SCALE OF FEET.
0
1
2

Fig. 2

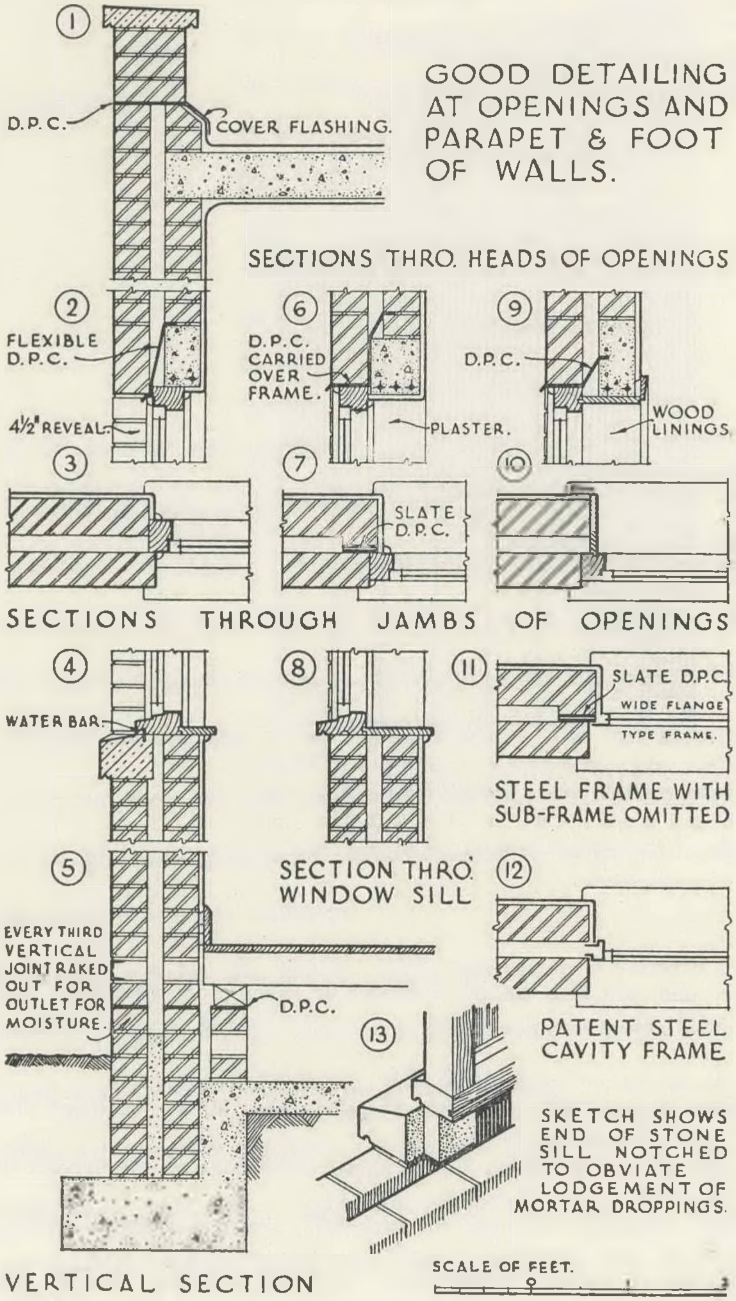
GOOD DETAILING AT OPENINGS AND PARAPET & FOOT OF WALLS.
1
D.P.C.
COVER FLASHING.
SECTIONS THRO. HEADS OF OPENINGS
2
FLEXIBLE D.P.C.
4½" REVEAL.
6
D.P.C. CARRIED OVER FRAME.
PLASTER.
9
D.P.C.
WOOD LININGS.
3
7
SLATE D.P.C.
10
SECTIONS THROUGH JAMBS OF OPENINGS
4
WATER BAR.
8
SECTION THRO. WINDOW SILL
11
SLATE D.P.C.
WIDE FLANGE
TYPE FRAME.
STEEL FRAME WITH SUB-FRAME OMITTED
5
EVERY THIRD VERTICAL JOINT RAKED OUT FOR OUTLET FOR MOISTURE.
D.P.C.
12
PATENT STEEL CAVITY FRAME
13
SKETCH SHOWS END OF STONE SILL NOTCHED TO OBVIATE LODGEMENT OF MORTAR DROPPINGS.
VERTICAL SECTION
SCALE OF FEET.
0
1
2

Fig. 3

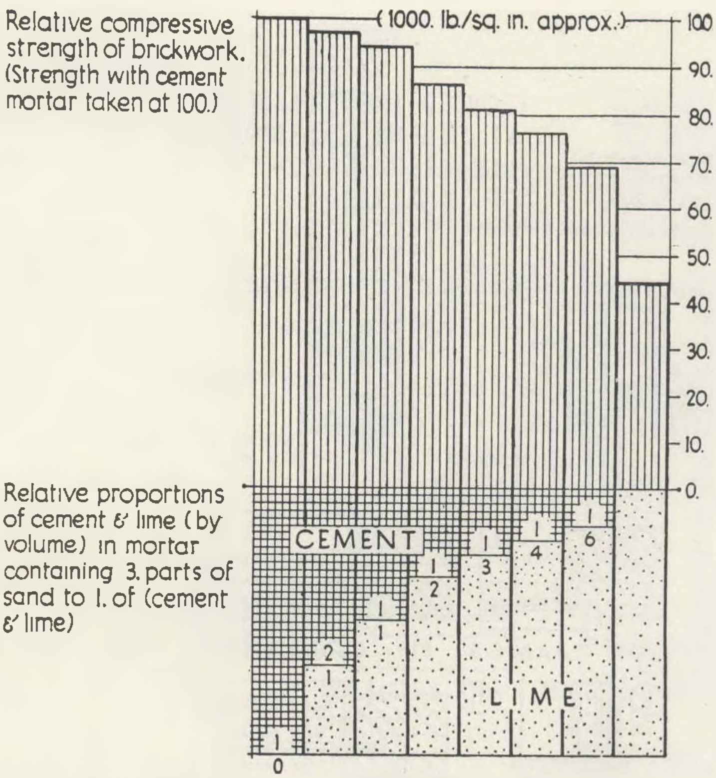

Fig. 4 — Effect of mortar composition upon the strength of fletton brickwork. (Compressive strength of bricks 2,685 lb. per sq. in.)

internal temperature, and can also be of considerable benefit in reducing condensation and pattern staining.[6]

An interesting experiment was made a number of years ago in an occupied house, with the object of illustrating the benefit of heat-insulating linings under conditions of intermittent heating. A small room, which was unpannelled originally, was used for breakfast, and it was found necessary to turn on the gas fire 1½ hours beforehand to warm it sufficiently. The walls were subsequently panelled in wood, and the period required for heating up was then reduced to half an hour. The curves in Fig. 5 show the rises in temperature actually recorded before and after panelling. This result was achieved because the new lining was of lower thermal capacity and better heat insulation than the bare wall. Figs. 6 and 7 illustrate the relative thermal insulation values of a number of materials and the relative heat losses through common types of construction.

EXTERNAL WALL FINISHES.

Traditional Materials.	Non-traditional Materials.
Limes (hydraulic and non-hydraulic)	Portland cements (grey, white and coloured)
Marble sheathing	Asbestos cement-sheeting
Gypsum plasters*	Fibre boards
Sands and aggregates	Glass
Paints and distempers	Special alkali-resistant paints
Weather boarding	Bituminous emulsions

*Not now generally used for external work in this country on account of slight solubility in water.

Wall finishes differ somewhat in their characteristics from the structural parts of walls, and it is therefore convenient to discuss them separately. It should be mentioned also that certain roofing materials sometimes used for finishing walls externally have been omitted from the traditional list above, and that in the case of timber framed walls with plastic finishes on lathing both the strength of the wall and the value of the finish may be affected by the type of lathing employed. The traditional method consisted of riven wood laths, or reeds, but there are now available expanded metal lathings and continuous dovetail-section sheetings of steel or bitumen-impregnated fabric, capable of providing good protection against damp penetration and an efficient base for rendering.

Mortar renderings (which term includes the finishes usually referred to in Scotland as "harling," "rough-cast" and "cement-finish") are probably the commonest of the modern group, listed above, and whether applied to solid or framed backings they illustrate an important stage in the development of a modern building technique. They are generally employed for some or all of the following reasons:

1. Appearance—as a means of obtaining a light-coloured surface free from joints.

2. Economy—where the cost of common bricks plus finish is less than that of suitable facing bricks or other facing material.

3. Protection against damp penetration.

Whichever of these functions may be the most important in a particular instance, two overriding considerations exist, namely, that the rendering when applied must remain firmly bonded to its backing, and that it must not develop unsightly cracks in the course of time. Actually it is now coming to be recognised

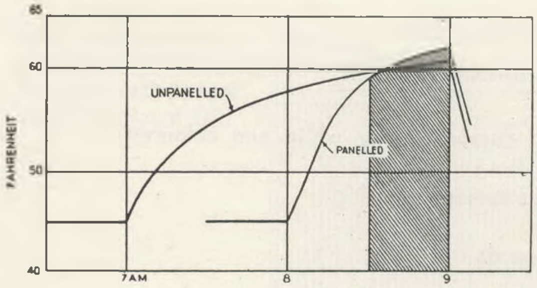
65
60
50
40
FAHRENHEIT
UNPANELLED
PANELLED
7 AM
8
9

Fig. 5

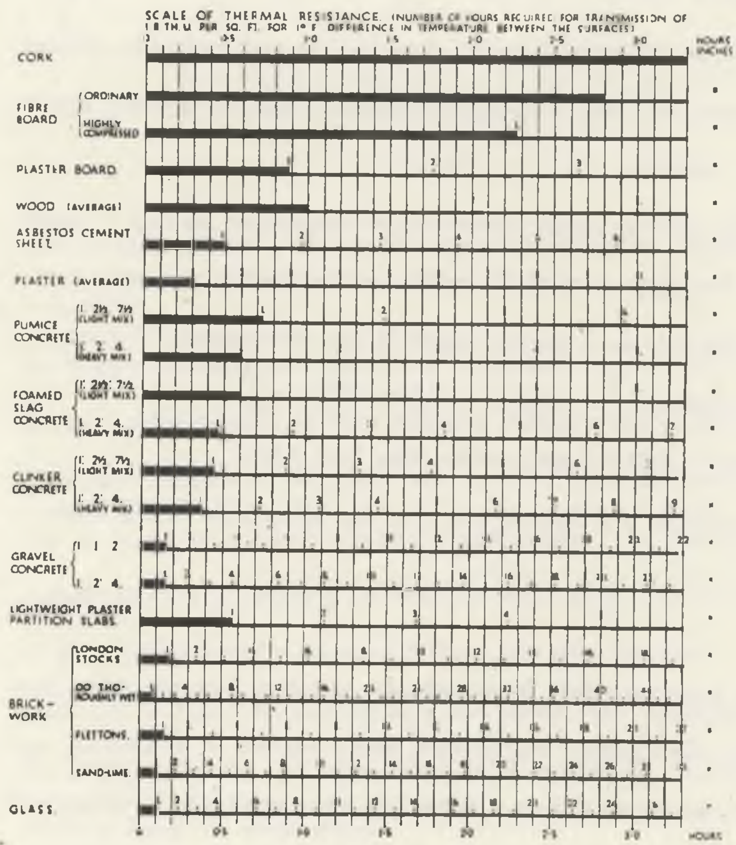
SCALE OF THERMAL RESISTANCE.
HOURS
INCHES
CORK
FIBRE BOARD
ORDINARY
HIGHLY COMPRESSED
PLASTER BOARD
WOOD (AVERAGE)
ASBESTOS CEMENT SHEET
PLASTER (AVERAGE)
PUMICE CONCRETE
FOAMED SLAG CONCRETE
CLINKER CONCRETE
GRAVEL CONCRETE
LIGHTWEIGHT PLASTER PARTITION SLABS
BRICK-WORK
LONDON STOCKS
FLETTONS.
SAND-LIME.
GLASS
HOURS

Fig. 6

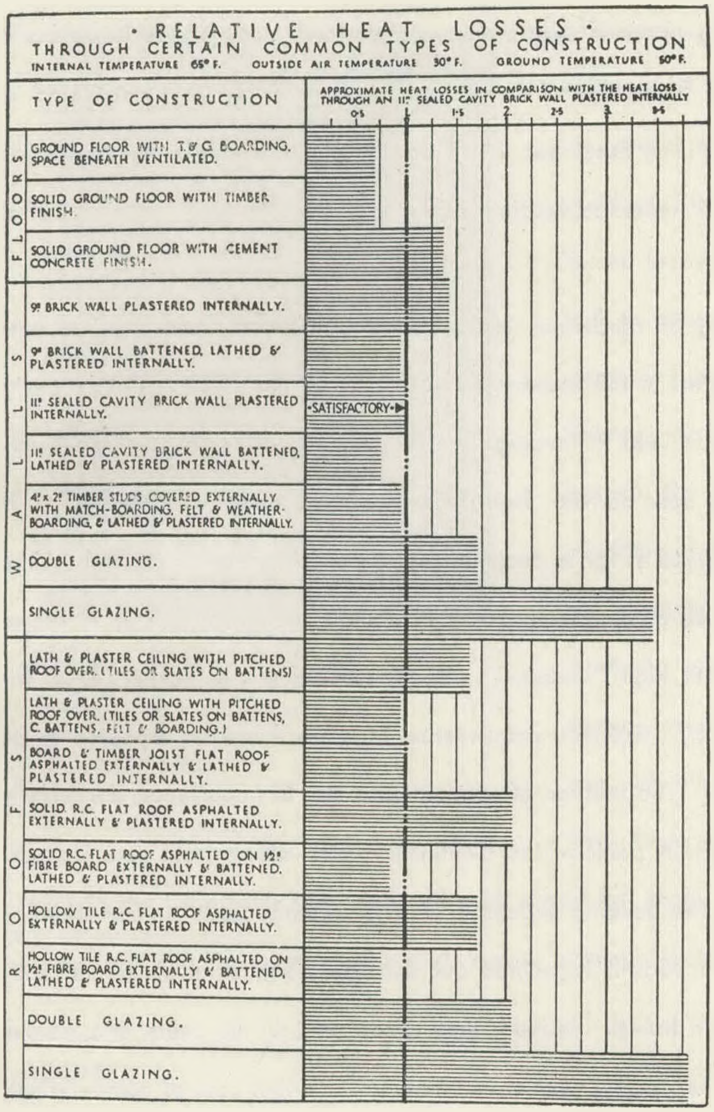

Fig. 7

that attention to these two points will go a long way towards ensuring satisfactory performance. It is fairly obvious how in extreme cases they apply in respect of appearance and economy (see Fig. 8), but it is perhaps not so commonly appreciated that even fine hair-cracking of a dense rendering produces a condition very favourable to the penetration of rain. In fact, the view is sometimes held that a wall covered with a dense but cracked finish may be less waterproof than the same wall without any applied finish, because rain is quickly drawn into the cracks by capillary action and absorbed by the brickwork.

Here it is trapped, for the dense rendering prevents evaporation, and moisture accumulates in the body of the wall. Where a rendering is used for facing a well constructed cavity wall, water accumulated in the outer leaf of brickwork will not reach the inner face, but it will reduce the heat-insulating properties of the wall slightly, and may cause a lack of adhesion, leading in turn to further cracking, and a repeated cycle of failure.

The primary cause of cracking and crazing of renderings is that cement mixtures, such as are now practically always employed for external plasters in this country, shrink on setting and drying. This property is, of course, common to all cement products, and in investigating the problem of renderings, the Building Research Station has been able to apply data derived from work done in other directions. It is important that this shrinkage should be restrained as far as possible by uniform adhesion to a stable backing. Little exact information is at present available on the factors which promote adhesion, but it is known that bricks, for example, of medium to rather high "suction" will generally form an easier base for working than the denser and smoother types. Grooves and undercut keys are, however, expected to be an asset to any material used as a backing. The method of application is also of importance, particularly since the practice in rendering walls in certain parts of the Continent, which differs from ours, appears also to be more successful in its results. The Building Research Station recently made an investigation of these methods, and in the reports[7] of this work, it is pointed out that the Continental plasterers rarely lay on their materials for external work with a trowel. Instead they throw on all the coats, in a manner similar to our rough-casting technique. The employment of this method for a first coat of comparatively liquid consistency is suggested as an important factor in obtaining good adhesion.

It is apparently not always possible or practicable to restrain the shrinkage of a cement rendering so completely that no cracking or crazing will occur, and other means are suggested for minimising the harmful results of such shrinkage. Briefly stated, these are that open-textured mixes and rough finishes may be preferred to dense mixes and smooth trowelled finishes, excepting, of course, in special conditions, such as might be found in a plinth at street level, where a smooth hard finish is desirable for other reasons. Suitable mixes to produce the effects suggested may be obtained by reducing the proportion of cement and substituting lime to maintain workability. Numerous methods are available for producing rough textured finishes —roughcasting, pebble-dashing, scraping and tearing—and full descriptions of these are given in the

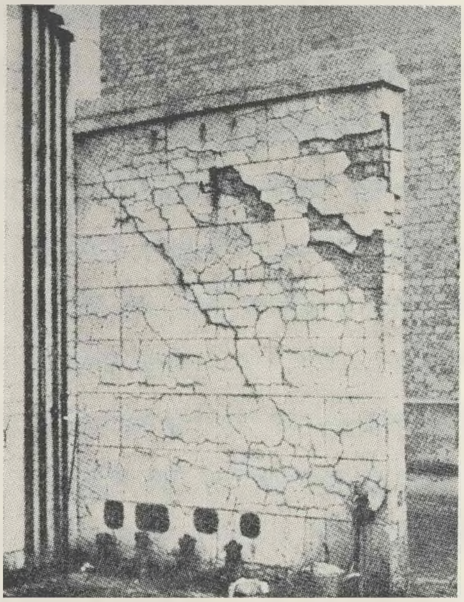

Fig. 8 — Failure of an external cement rendering associated with bricks containing sulphates

publications referred to. There appears to be ample evidence of the effectiveness of these methods as observed on current and completed jobs on the Continent and in practical trials at the Building Research Station.

Before leaving the subject of external finishes it would be well to refer again to a matter which has already been mentioned in connection with frost action and efflorescence. Finishes which would otherwise be safe may be dislodged because the backing is damp, and it may happen that this condition of dampness arises independently of the rendering. For example the wall may have been saturated when the rendering was applied, or dampness may be gaining access through some faulty piece of construction. It is, therefore, an important point, and one which is reported to have been observed in all the successful rendering work seen on the Continent, that rendered walls should be given a generous measure of protection against falling rain by means of overhanging eaves, copings, damp-proof courses, flashings and string courses.

ROOFS.

Traditional Components.

Timber trusses, purlins and rafters

covered with:

- Slates
- Clay tiles
- Thatch
- Wood shingles
- Lead
- Copper
- Zinc

Non-Traditional Components

Steel trusses and beams

Reinforced concrete trusses and beams

Reinforced concrete slabs, with or without clay or other filler blocks

Precast concrete roofing systems

Asphalt

Bituminous felt

Asbestos-cement sheets and slabs

Concrete tiles

One of the most striking developments in modern architecture is the use of the flat roof, and technically this constitutes an innovation comparable with any of the non-traditional components listed above. Flat roofs may be constructed in timber, but it happens that they are frequently associated with concrete construction and it seems probable that their coming into fashion in this country was due more to the structural facilities offered by reinforced concrete than to any aesthetic considerations. Flat roofs may thus be non-traditional in both design and construction, and it is not altogether surprising that they have called for a certain amount of fundamental study during the past few years. This is in contrast with pitched roofs, which continue to be constructed substantially on the traditional pattern and frequently employing traditional materials. In this instance research has tended towards investigating the properties of individual products, and this work has resulted in the production of British Standard specifications for Welsh roofing slates,[8] clay[9] and concrete,[10] [11] roofing tiles and a Code of Practice for Roof Tiling.[12] An investigation of clay roof tiling is still continuing, in co-operation with the National Association of Roofing Tile Manufacturers.

The functions of a roof are very similar to those of an external wall: strength, weatherproofness, durability and heat insulation are generally the determining factors. There is, however, a difference of emphasis. Strength is of paramount importance, and is usually estimated according to well known principles. Weatherproofness is achieved in a more positive fashion than in walls, particularly in flat roofs, where use is made of perfectly impervious outer coverings such as asphalt, bituminous felt or metal sheetings. In such cases weatherproofness depends, apart from the quality of the covering, on the design of flashings, parapets, etc.

The durability of roofs is naturally a matter of some complexity since so many diverse materials are involved. Clay and concrete tiles in this respect share some of the characteristics of bricks and stones previously discussed in that they may be subject to attack by frost and soluble salt action. Asphalt, bituminous products and metal sheetings are affected in different ways by atmospheric and climatic influences, and each of these materials has been subjected to examination and experiment by the appropriate research body. For instance, research has been proceeding for some years in co-operation with the Natural Asphalte Mine Owners and Manufacturers Council, and an interesting piece of apparatus has been devised for this work. This submits specimens of asphalt mastic to cycles of heating, ultra violet radiation, spraying and freezing, and the results of this accelerated weathering test are co-ordinated periodically with results obtained by natural weathering. [13] [14]

Pitched roofs with ceilings at gutter level generally provide adequate heat insulation for rooms below, but experience has shown that flat roofs of simple joist-and-board or concrete slab construction are somewhat lacking in this respect. Such a deficiency may, of course, be easily remedied by incorporating in the construction an additional layer of material of good heat insulating properties, such as cork, fibre board, lightweight concrete, etc. So far as the problem of reducing heat loss in cold weather is concerned, it is immaterial whether the insulating layer is placed above or below the structural element in the roof. It has already been pointed out, however, how an insulating lining is effective in reducing the time lag in a room heated intermittently, and in certain instances this principle may advantageously be applied to flat roofs, particularly where they are of relatively heavy construction.

There is, however, a further thermal problem in connection with roofs which has been found to be of considerable importance in the south of England at least, namely, the effect of hot sunshine on thin roof slabs. A roof surface, particularly if it is dark in colour, can in hot sunny weather become considerably hotter than the structure supporting it, resulting in discomfort to the occupants of the topmost storey, and possibly structural damage to the building due to unequal thermal expansion. This effect is illustrated in Fig. 9. Three main lines of approach to this problem are possible:—

(a) To accept temperature rise and movement of the roof structure, and to make provision for the latter by means of expansion joints.

(b) To accept temperature rise but prevent movement by means of suitable restraint.

(c) To prevent temperature rise by heat insulation or heat reflection.

It is debatable whether (a) or (b) is practicable to the extent necessary on many buildings for complete protection, and they are more likely to prove useful as adjuncts of method (c). Heat insulation and heat reflection differ fundamentally, although in practice they can produce equivalent results in heat exclusion. In the one instance a medium of high heat-insulating value is interposed between the structural slab and the waterproof covering, while in the other the upper surface of the roof is so treated as to reduce its absorption of radiant heat. Dark-coloured surfaces have the property of absorbing a high proportion of such heat, while white surfaces are at the other end of the scale and reflect a maximum proportion. To

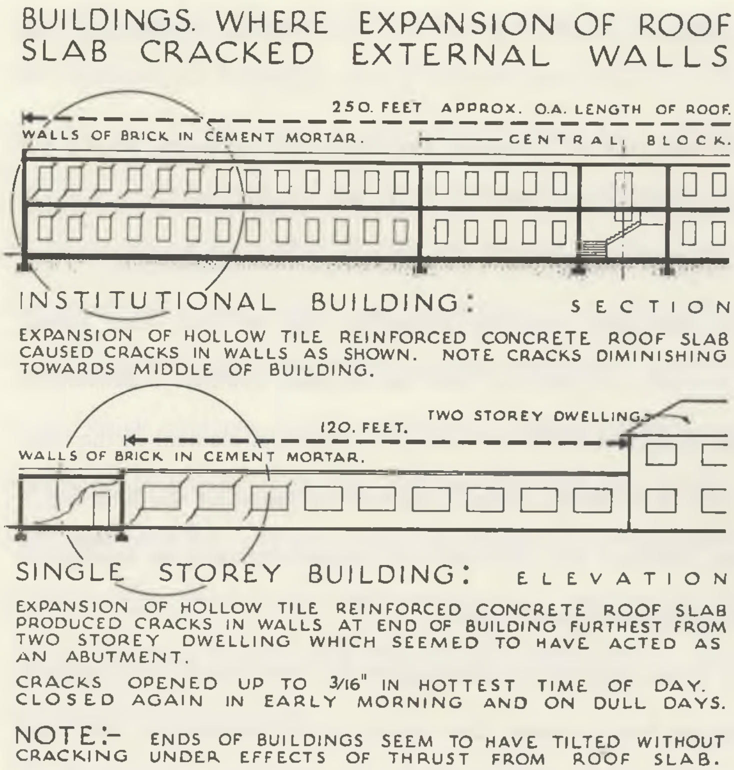

Fig. 9

employ this principle for the protection of a roof, therefore, the upper surface must be kept whitened. Various methods of doing this are available, some of which combine other functions such as the provision of a good wearing surface. In the simplest form of this treatment, namely, whitewashing, while benefit will accrue in summer, there will be no corresponding advantage in respect of heat loss outwards in cold weather.

Of the two methods of excluding solar heat, therefore, the insulation method might appear to be preferable were it not for the problem of deciding where the insulation should be placed. To insulate the roof from solar heat obviously the insulation must be on top of the slab, and generally it must be protected from the weather by being placed under the waterproof covering. A layer of insulation in this position, however, has the effect of making that waterproof covering even more responsive to temperature variations, and in certain conditions this may produce harmful results. Further, it has already been shown that a room will heat up from cold more readily and remain more uniformly warm if its inner surfaces are lined with heat-insulating materials. This is of particular importance in buildings which are to be heated intermittently and it is probable that in such buildings the best arrangement will be an internal heat-insulating lining and, if necessary, a white heat-reflecting finish externally. Circumstances, will, of course, determine whether this arrangement or a layer of insulation above the roof slab will be the more advantageous.

PARTITIONS AND FLOORS

Traditional Components	Non-Traditional Components
(a) Partitions	(a) Partitions
Clay bricks	Sand-lime bricks
Natural stone	Concrete bricks
Timber framing	Hollow clay slabs
	Precast-concrete slabs (solid and hollow)
	Plaster slabs
	Steel framing
	Concrete cast in situ
(b) Floors	(b) Floors
Timber-joists and beams.	Steel beams
Stone slabs	Reinforced concrete beams
Finishes in: timber (boards and blocks), tiles, stone, bricks, mosaic, marble, etc.	Reinforced concrete slabs (with or without filler blocks)
	Precast concrete flooring systems
	Finishes in: plywood, fibre-board, cork, linoleum, rubber, concrete, concrete tiles, glass, asphalt, magnesite, etc.

It is convenient to discuss partitions and floors together here, since, whatever diverse characteristic they may have, they share the common purpose of subdividing the internal space of a building. The most important aspects of their dividing function are sound insulation and fire resistance, and it is proposed to discuss these two subjects briefly as they affect partitions and floors.

Sound Insulation. It is difficult to point to a single factor which has caused the problem of noise in buildings to be one of the most clamant in recent years. It appears, however, that some of the causes may lie outside the sphere of building technique, such as an increase in the actual amount of noise made in domestic buildings, owing to the popularity of gramophones and radio, a trend towards flat-dwelling in certain parts of the country, and possibly an increased sensitivity on the part of the public. There are

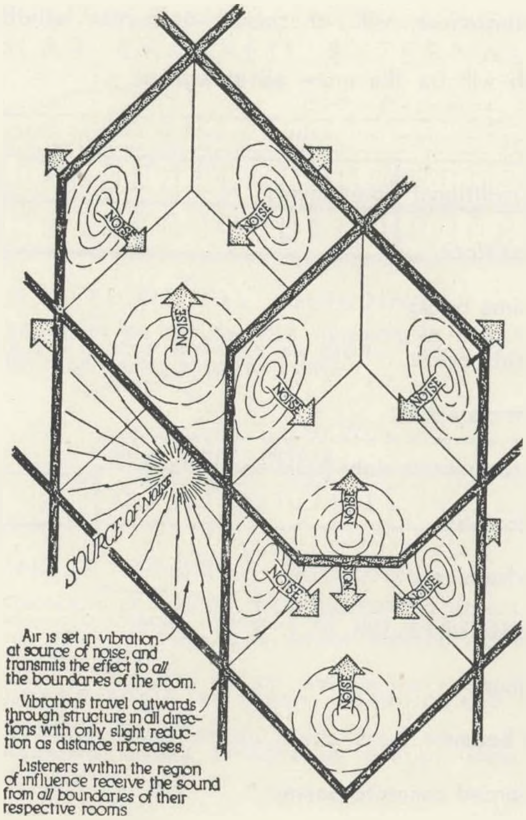

Fig. 10 — Diagrammatic indication of how air-borne sound travels in a continuous building structure

also structural considerations, as will be shown later, such as the use of lighter and more rigid continuous construction.

Sound is, of course, a form of energy, and the sound emitted in a building may reach the ear of a hearer by transmission through the air or through the structure of the building. The path of a sound may also be complex, that is, it may originate in the air, pass to the structure, and finish in the air. Hard and fast classification is thus not possible, but it is customary to draw a distinction between air-borne sound, or sound which starts in the air, and impact sound which originates as a vibration in the structure itself. The former may be due to speech, radio, etc., while the latter is typically caused by footfall on a floor. This distinction is important because the methods of insulation appropriate to the two differ considerably. It is also essential, in an existing building in which sound reduction is required, to determine at the outset exactly which path is responsible for the greatest proportion of the transmission. For instance, it is not always realised how much sound will pass through small openings such as gaps round doors, and it is futile to attempt other more elaborate treatment if such direct paths are allowed to remain.

Air-borne noise is not, however, transmitted solely by continuous air-paths but may pass through walls, floors, etc. Sound waves striking any such part of a building set up vibrations in the structure, which in turn passes them on to the air in parts of the building not previously affected. One of the first major points to be established by research work in acoustics during the past few years has related to the characteristics of solid membranes in transmitting air-borne noise. Numerous tests made by the Department of Scientific and Industrial Research at the National Physical Laboratory, and by authorities abroad, have shown that the weight per unit area of a solid homogeneous transmitting membrane is the only factor that need be considered (assuming, of course, that there are no direct air-paths to cause leakage). Homogeniety is obviously a matter of degree, but a brick wall with mortar joints and plaster finishes or even a reinforced-concrete floor with hollow filler blocks, has been found to conform to this rule. Discontinuity begins to take effect with structures such as timber framing, and when suitably applied this principle can be used to obtain a degree of sound insulation considerably higher than is possible with solid construction of equal weight.

The fact that heavy construction reduces sound transmission better than light construction is, of course, well known, and at times influences prospective house-owners in choosing old property with massive party-walls and partitions in preference to newer and more lightly-constructed buildings. It must not be thought, however, that adequate sound reduction between, say, two adjoining rooms, can necessarily be obtained merely by increaseing the weight of the partition between them. In the first place, the intervening structure includes not only the partition but also the walls and floors which flank it, and the sound-transmission characteristics will be determined by the weight of the lightest part of this system. This is illustrated in Fig. 10. In the second place, the relationship between the unit mass of a solid membrane and its sound-insulating characteristics, as appreciated by the human ear, is a logarithmic one. Consequently equal increments in sound insulation are obtained not by adding equal increments to the mass but by multiplying by the same factor. Further the least improvement which can be perceived by the ear is that obtained by doubling the weight of the construction.

These facts show fairly clearly that there is a limit to the degree of insulation against air-borne noise obtainable with continuous construction. In a recent report,[15] the Building Research Station places this limit at the insulation which might be expected from $4\frac{1}{2}$ to 9 in. of brickwork or its equivalent. Where greater insulation or air-borne noise is required, or where impact noises are concerned, the principle of discontinuity must be applied.

The relationship between unit mass of solid partitions and their sound transmission for air-borne sound, is expressed by the curve shown in Fig. 11, where weights are set out on a logarithmic scale, resulting in approximately a straight-line relationship. The unit of sound reduction, the decibel, is logarithmically related to energy ratios, and corresponds to the behaviour of the human ear. This unit is best explained, however, by a brief reference to the methods of test employed for problems of sound transmission. In the laboratory the transmission of air-borne sound through partitions or floors is studied by emitting a test note of known frequency and physical intensity on one side of a test panel. (At the National Physical Laboratory the test panels measure 10 by 8 feet, or 5 by 4 feet.) The panel is built in an aperture with suitable precautions to avoid sound leakage. The intensity of the transmitted sound is measured, and the reduction factor for the construction, and for the particular frequency tested, calculated as 10 times the logarithm, to the base 10, of the ratio (intensity of incident sound/intensity of transmitted sound). This expresses the reduction factor in decibels. The decibel is thus used only to compare sounds of the same frequency. Most forms of construction have different reduction factors at different frequencies, but for the purposes of comparison it is common to take an average of representative reduction factors at frequencies ranging from 200 to 2,000 cycles per second, and to term this the " average sound reduction factor " for the particular form of construction concerned. This is only an approximation and its limitation must be borne in mind in use.

In the case of impact noises on, say, a floor, the ratio of incident sound to transmitted sound is not of so much interest as the loudness of a normal impact as heard below the floor. The decibel scale, as already pointed out, is used to express the ratio of intensities at one frequency, but does not establish an absolute scale of loudness, since the human ear is not uniformly sensitive at all frequencies. The loudness of a noise of any frequency is therefore related to a standard frequency, and expressed in phons. The equivalent loudness of a sound is said to be *n* phons if it is judged by a normal observer to be as loud as a 1,000-cycle pure tone, of which the sound intensity is *n* decibels above a fixed zero almost identical with the threshold of audibility.

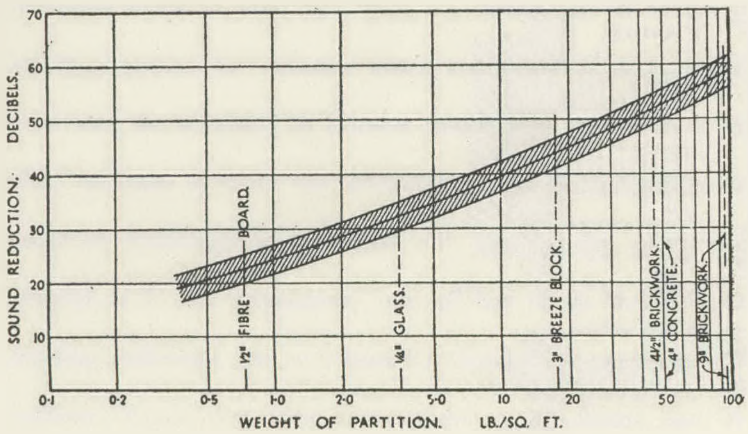

Fig. 11 — Transmission of air-borne sound through single homogeneous partitions

The method of test employed for impact noises on floors, therefore, is to apply a series of standard impacts (about $\frac{1}{4}$ ft. lb.) by means of a rapping machine to each floor and to measure the equivalent loudness of the impacts as heard below. A standard figure is first obtained for a bare structural floor, and then corresponding figures for the various treatments as they are applied. The amount by which each differs from the standard is taken as the insulation gain obtainable with that particular treatment. Mention has already been made of the necessity for discontinuous construction in dealing with the transmission of impact noise, or in obtaining higher degrees of insulation against air-borne noise. From what has been said it will be appreciated that discontinuity affects the whole of a structure and not merely individual partitions or floors. The details of the numerous ad hoc tests[16] that have been made on structures, and the application of theory to practice, are thus somewhat specialised and outside the scope of this paper. It may be sufficient, therefore, to refer briefly to two forms of construction which contain the elements of discontinuous construction, namely, the double partition and the floating floor. In laboratory tests a double partition consisting of two 2-in thicknesses of clinker concrete, 2 in. apart and connected only at the edges, has been found to have a reduction factor, for air-borne noise, about 5 decibels above that of a solid partition of equal total weight; and when all the edges of such a partition were isolated from the surrounding structure by cork or felt an improvement of about 10 decibels over the corresponding solid partition was obtained, that is, the edge-isolated partition was in this respect equal to a solid partition of about 4 times its own weight. This partition is illustrated in Fig. 12.

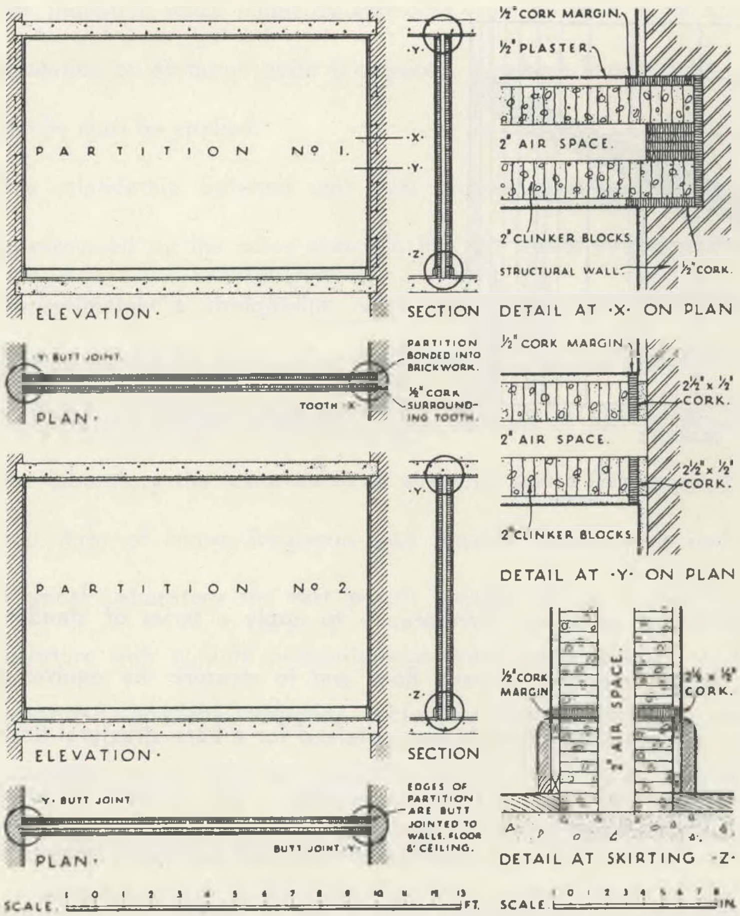

Fig. 12

Four different types of floating floor construction are shown in Fig. 13, Type No. 2, having been developed at the Building Research Station. It will be noted that the principle involved in all these floors is to exclude the energy of impacts from the structure as early and as near the source as possible. It might be thought that the application of resilient finishes would be most useful for this purpose, but tests have shown that they are not so efficient as the forms illustrated. Linoleum, cork and rubber fixed direct to a structural floor may give up to 5 phons insulation gain, and coverings embodying sponge rubber or underfelts 10 phons. The insulation values for the floating floors are : Types 1, 3 and 4 between 15 and 20 phons: Type 2 between 20 and 25 phons.

For the purpose of applying these results in practice, the Building Research Station has recently devised nomograms linking conditions with structural forms, and one of these is illustrated in Fig. 14.

From this it will be seen that there are certain sets of conditions which cannot be dealt with by any known structural means, for instance where equipment noise is the chief disturbance, though in this case some relief may be obtained by suitable selection of treatment of the equipment. There are, however, many other instances in which the structural and other measures necessary to be even appreciably effective, would be uneconomical compared with planning for sound insulation.[16 17] This is one of those instances, referred to in the introductory part of this paper, in which building technique cannot be separated from planning technique, and it is essential that in the construction of a modern building the question of sound insulation should rank with accommodation, circulation, cost, etc., as a factor affecting the general layout, as well as a constructional matter to be considered in detail at later stages.

Fire resistance. The question of the fire resistance of buildings is at present controlled largely by building regulations which are based on general usage. For some years, however, research has been proceeding both in this country and abroad, in an endeavour to put this matter ultimately on a more rational basis. In 1932 the British Standards Institution defined[18] in terms of tests:

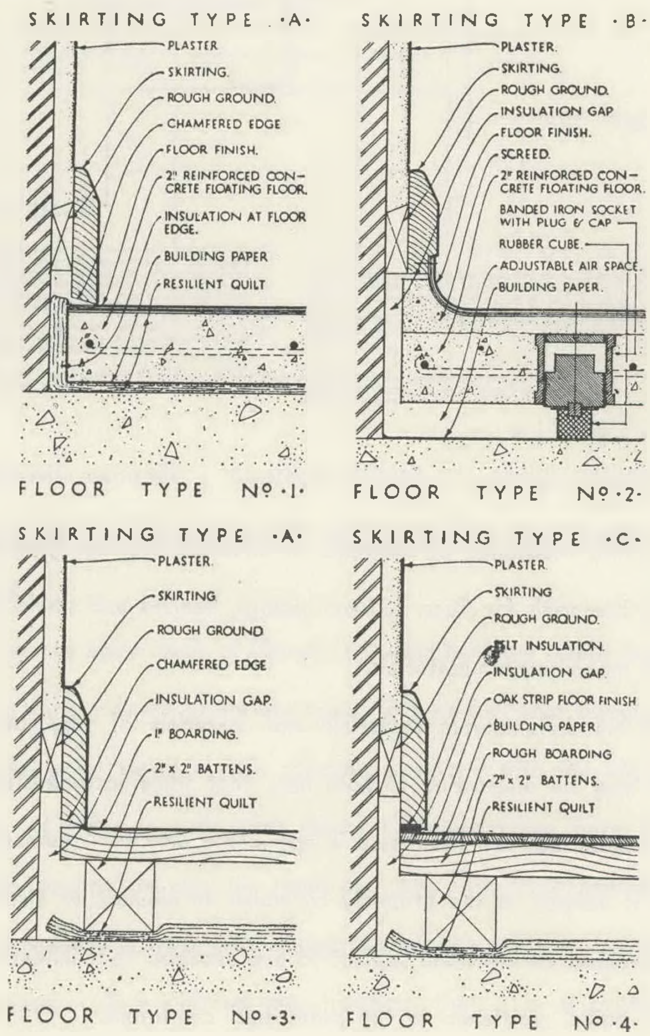

Fig. 13

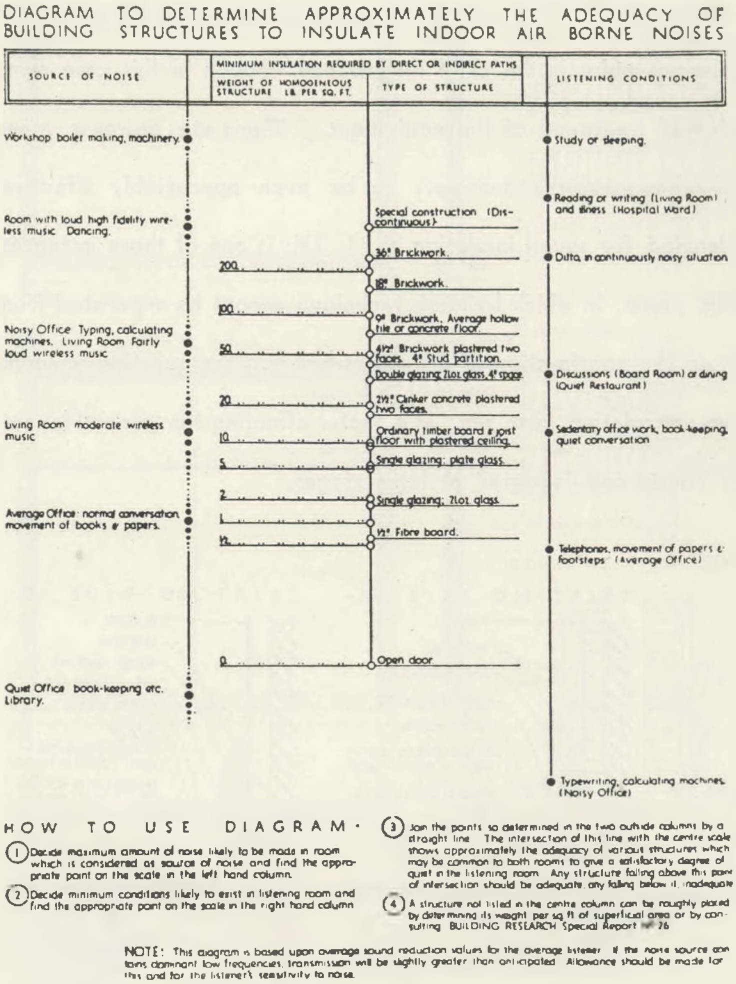

Fig. 14

(a) Fire resistance of elements of structure (various grades).

(b) Materials for flues, furnace casings, hearths and similar purposes.

(c) Incombustible materials.

(d) Non-inflammable materials and materials of very low and low inflammability.

It may be interesting to note here that while incombustibility and non-inflammability are terms applicable to materials, fire resistance is applicable only to " elements of structure " such as walls, floors and columns. It is defined as the property by which an element of structure as a whole functions satisfactorily for a specified period while subject to a prescribed heat influence and load. Results are expressed as a number of hours' resistance to the prescribed conditions.

The property of fire resistance of an element cannot be deduced from the incombustibility or non-inflammability of the component parts of the structure, and full size tests are necessary to assess its value. It is only within the last few years that the equipment has become available in this country for the tests laid down in the Standard Definitions. This work is carried out at the fire-testing station at Elstree, which is controlled jointly by the Fire Office Committee and the Building Research Station. From the results of tests made at Elstree and at similar testing stations abroad Table II has been drawn up showing the probable fire resistance of solid walls. Class I aggregates comprise clean, crushed, unused clay brick, burnt clay, blast furnace slag, pumice, or other approved materials. Class II aggregates

Table II

Wall Construction	Minimum Thickness in Inches expected to give Various Grades of Fire Resistance laid down in British Standard Definitions No. 476				
	Grade A 6 hrs.	Grade B 4 hrs.	Grade C 2 hrs.	Grade D 1 hr.	Grade E ½ hr.
Solid walls of clay, sand-lime or concrete brick -	9	9	6	4	3
Solid walls of precast concrete units or unreinforced concrete cast in situ					
Class I aggregates - -	8	8	6	4	3
Class II ,, - -	12	10	8	6	4

comprise flint gravel, broken stone, or other approved materials. Aggregates must not contain material injurious to cement. Half an inch of Portland cement or gypsum plaster may replace an equal thickness of wall provided it is properly keyed to the wall.

A considerable number of fire tests on floors also has been made at Elstree, and details of the results have been published.[19] Summarised, these show that timber floors of various types, with and without pugging, endured from 24 minutes to 1 hour 42 minutes, the latter being a floor specially designed with the object of giving a high fire-resistance value under test. Of the incombustible floors, filler-joist types gave the best results at 4 hours for freely-supported floors, and hollow clay tile types and solid reinforced concrete slabs, similarly supported, endured from 2 to 3 hours, and from ½ to 2 hours respectively. Tests on floor slabs restrained at the edges have also been made. It is pointed out, however, that it is at present premature to discuss these results in their application to practice, and the figures quoted do not necessarily indicate that the floors concerned attained a British Standard Definition grade of fire resistance equivalent to the times shown.

WALL AND CEILING FINISHES.

Traditional Materials	Non-traditional Materials
Lime plasters	Magnesite
Gypsum plasters	Concrete tiles
Clay tiles	Plaster board
Wood panelling	Asbestos-cement sheeting
Oil paints	Plywood
Lime wash	Fibre board
	Compressed cork
	Plastic sheeting

There are two very general requirements for internal wall finishes as for external renderings, namely, that they must remain bonded firmly to their backing and avoid any tendency to cracking or, in the case of those applied as units, to opening at joints.

The problem of obtaining perfect bonding of plaster ceilings is one which has received much attention at the Building Research Station, and while it is not intended to discuss the matter now in any detail, it is thought that some reference to the fact will be interesting as having a bearing on the main subject of this paper. Plaster for joisted ceilings consisted traditionally of lime and sand, and this was applied to wood lathing. Generally the application was leisurely, and the lime was given adequate time to harden by drying. In any event, there would not be much vibration of the ceiling after the plaster was applied. Under modern conditions, however, a plaster ceiling in two or three coats might be applied in a few days, and then subjected to hammering and sawing of other tradesmen installing services or completing the floor above. This naturally calls for greater early strength in the undercoats of plaster ceilings. It has been found, however, that a great many architects and tradesmen have continued to use traditional materials under modern conditions, with the result that fallen ceilings are one of the commonest of building failures. In view of this the Building Research Station has recommended that for plaster work on lathing lime undercoats should be suitably gauged with cement, or that one of the proprietary gypsum plasters should be used in accordance with the manufacturers' instructions.

CONCLUSION.

One point which may be noted in the descriptions of building research given in this paper is that scientific investigation frequently points to the conclusion that traditional methods were correct. Where this is so, it may be justified or explained by saying that the research confirms that traditional method, but the Author prefers the view that it is the traditional method which confirms the research. In other words, if both point to the same conclusion, it is a sign that the research methods are proceeding on the right lines. Research has, in a sense, been forced on the building industry by the march of events—in some instances by the introduction of new structural methods or the popularity of new materials and in others by influences lying outside the sphere of building altogether. It has been the Author's endeavour to describe here a few of the points at which this march has assailed building technique and the approach that has been made to reconstruction at these points. The ultimate aim of this work, however, should be the construction of a new technique as satisfying and harmonious as the old, and if it can be claimed that scientific method is making progress towards this end then it is surely more than justified.

The Author desires to thank the Controller of H.M. Stationery Office for permission to reproduce Figs. 2 to 14, in which the Crown copyright is reserved. Figs. 2, 3 and 9 are taken from "The Principles of Modern Building."[1] and Figs. 11 and 12 from Building Research Special Report No. 26.[16]

Overleaf: Bibliography

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THE CAPE PROVINCIAL INSTITUTE OF ARCHITECTS

REPORT OF THE COMMITTEE FOR 1940

MEMBERSHIP

The membership at the close of the year consisted of 113 practising, 37 salaried, 14 retired, 2 absentee members and 1 Life Member, a total of 167 members.

The death is recorded with deep regret of H. L. Attridge.

THE LATE MAJOR P. MILNE DUNCAN

On May 29th, 1940, the death occurred of Major P. Milne Duncan, O.B.E., F.S.A.A., who had been Secretary of the Institute for almost fifteen years. The Institute has suffered a great loss in one who had given of his best for so many years in the interests of the profession.

MEETINGS

One Annual General Meeting, Thirteen Provincial Committee Meetings, besides numerous Sub-Committee meetings were held during the year.

The following is a record of members' attendances at Provincial Committee meetings showing actual attendances and possible attendances :—

	Attended.	Possible.
R. F. R. Day	8	9
L. A. Elsworth	12	13
Fred M. Glennie	3	13
Douglas Hoets	13	13
B. St. C. Lightfoot	5	8
Brian Mansergh	3	7
R. F. Ohlsson	5	7

J. K. Parker	10	13
A. J. C. Retief	7	8
Hubert L. Roberts	12	13

Note.—Messrs. Lightfoot, Brian Mansergh, R. F. R. Day and R. F. Ohlsson proceeded on Active Service during the year and Mr. A. J. C. Retief was co-opted to fill one of the vacancies.

FINANCIAL

The audited Statement of Accounts for the year under review is attached to this report. It will be seen that the Revenue and Expenditure account shows a surplus of £43 15s. 6d., as compared with a deficit of £22 14s. 6d. in the previous year. The total Expenditure has fallen by £99 8s. 4d. being made up, principally, by decrease in Secretarial Fees, £30 5s. 0d., and absence of Congress Expenses which accounted for £55 of the expenditure in 1939. In view of the prevailing unsettled conditions and having regard to the waiving of subscriptions of those members on full-time Active Service only essential expenditure has been incurred during the year and economies effected wherever possible. On the credit side of the account Subscriptions Account has increased by £17 15s. 2d., the profit on the Kalendar has fallen by £5 6s. 11d., and R.I.B.A. Moieties, amounting to £37 10s. 9d., which appear in the 1939 account were waived in 1940.

After transferring the above surplus of £43 15s. 6d. the Capital Account stands at £663 10s. 5d.

CENTRAL COUNCIL

The Annual Meeting of the Central Council was held in Johannesburg on the 24th, 25th and 26th April, 1940. The Cape Provincial Institute's representatives were Messrs. B. St. C. Lightfoot, Hubert L. Roberts and F. Owen Eaton to whom the Committee's thanks are due for their efficient services at the meeting.

THE PORT ELIZABETH LOCAL COMMITTEE

The interests of members in the Eastern Province are being looked after by the Port

Elizabeth Local Committee under the Chairmanship of Mr. E. H. Stevenson, L.R.I.B.A. Mr. F. Owen Eaton, F.R.I.B.A. continues to act as a most capable Honorary Secretary.

THE SCHOOL OF ARCHITECTURE

The number of students attending the Architectural and Quantity Surveying classes at the University during 1940 was 85. Of the Architectural students, 24 were first year, 16 were second year, 13 were third year, 4 were fourth year, 12 were fifth and sixth year and 11 were part-time students. Of the Quantity Surveying students, 3 were first year and 2 were second year students. The following number of students qualified during the year :—6 for degree course, 1 for diploma course, and 1 for the Special Qualifying Examination.

C.P.I. BRONZE MEDAL AND OTHER PRIZES

The 1940 Bronze Medal for the best example of architecture executed within the Province of the Cape of Good Hope has been awarded to Messrs. Walgate & Elsworth for the design of the Stellenbosch Town Hall.

The John Perry Students' prize of five guineas for the best work done during the third year's course at the University has been awarded to Mr. C. S. Brink.

The C.P.I. Students' prize of five guineas for the best work done during the final year of the University course has been awarded to Messrs. K. E. Gow and E. Greenblo.

EMPLOYMENT REGISTER

Members are reminded that the Institute maintains a Register of assistants seeking positions and of members who require assistants for their offices.

MEMBERS ON ACTIVE SERVICE

Members who have proceeded on Active Service and have not notified the Institute are kindly requested to do so to enable the register to be kept up-to-date. The Committee desire to take this opportunity of wishing all those members serving with the Forces every success in their military undertakings and a safe return.

GENERAL

Although the work of the Committee was handicapped during the year owing to four of the members joining the Forces, the various Sub-Committes continued to function efficiently. Particular reference must be made to the Practice and Vigilance Sub-Committee which was instrumental in settling amicably a number of disputes between architects and clients and also spent considerable time in preparing a statement for submission to the Town Clerk regarding delays and methods of passing plans at the City Hall. The Practice Sub-Committee was successful, as a result of complaints from members, in obtaining proof that a draughtsman employed in the City Engineer's department was carrying out architectural work privately without the prior consent of the City Council. The Council took action against the official concerned and a warning was issued to all employees that transgression of the relevant Municipal Ordinance would not be tolerated.

HUBERT L. ROBERTS,

President.

Union of South Africa,

Office of the National Research Council

and National Research Board,

Johannesburg.

5th March, 1941.

Sir,

I have to inform you that applications for Grants in Aid of Research, to be conducted during the financial year commencing 1st April, 1941, are now invited.

Applications must be made on the form prescribed for the purpose and should be submitted as soon as possible, but must be in my possession by Saturday the 19th April, 1941.

I shall be glad if you will be good enough to bring this to the notice of members of your Society who may be interested.

Enclosed is a supply of forms of application. Should additional copies be required, they will be furnished on request being received.

Yours faithfully,

(Signed) BEATRICE C. EVA.

Secretary:

National Research Council and Board.

The Secretary,

Associated Scientific and Technical Societies of South Africa,

75, Marshall Street,

Johannesburg.