# BUILDING RESEARCH IN GREAT BRITAIN*

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SO much is being said nowadays about the need for additional research in connexion with the housing programme that there is a tendency to forget what has already been done in Great Britain. In fact, during the period between the two world wars, the foundations of a real science of building were solidly laid. This work has been centralized in the Building Research Station of the Department of Scientific and Industrial Research, though sister establishments, notably the Forest Products Research Laboratory, the Fuel Research Station and the National Physical Laboratory have also made their contribution.

It is of interest to recollect that the foundation of the Building Research Station was a direct result of the housing problems that remained with us after the First World War. The Department of Scientific and Industrial Research undertook its first researches on building materials and construction at the instance of a committee of the Local Government Board, which was considering, during the War of 1914–18, the problems of post-war housing. The Department appointed a Building Materials Research Committee to advise on this work; but later, in 1920, the committee was superseded by a Building (Materials and Construction) Research Board which was given the task of co-ordinating and supervising the wider range of building research which the Department was then being called upon to undertake, particularly by the Ministry of Health, which had absorbed the Local Government Board. Later still, the expressed need of the Ministry of Health for an acceleration and expansion of the work in relation to housing was a factor which, in 1925, led to the decision to move the Building Research Station from temporary premises at East Acton to its present site near Watford, where better provision could be made for its increased activities.

The first Director of Building Research, appointed in 1921, was Mr. H. O. Weller; he was succeeded in 1924 by Dr. R. E. Stradling (now Sir Reginald Stradling), under whose guidance the organisation was developed until, in 1939, he was seconded for duty with the Ministry of Home Security.

Initially, the Station concentrated on the study of building materials. There was much to be learned. The building industry was traditional in character, but success on this basis was possible only so long as workmen continued to use their local materials; things went wrong when labour and materials became more mobile. Organised scientific study of the materials and of the methods of using them became essential. But building is not merely a matter of the materials. Good building must take account of the conditions required for comfort and convenience in use. For example, the houses must not be expensive to heat; they must provide adequate natural lighting; they must be reasonably quiet; and the Station was soon drawn into the examination of these problems. It was also necessary to seek the advice of the physiologist on the various environmental conditions needed for human well-being. Thus, the Building Research Board has, for many years, had a joint committee with the Medical Research Council on problems of heating and ventilation.

As the work developed, the emphasis on housing became less pronounced. There is, of course, no sharp dividing line between research on building materials and methods of construction for housing and similar research for building generally; and, indeed, research on building problems is common, over a considerable field, with research on civil engineering problems. Inevitably, therefore, the scope of the Station's work came to embrace constructional problems on a wide basis. A notable example was in the study of soil mechanics, in which the Station has come to be concerned with the stability of earth dams, embankments and cuttings and retaining walls, and has acquired knowledge which has found useful application in connexion with reservoir construction, railway, dock and harbour work, flood protection schemes and so on.

The development of the Station during the inter-war period may be judged from the fact that in 1924 the total staff was 34. The scientific and technical staff included five graduate engineers, five graduate chemists, one graduate physicist, and three architects and builders; whereas in early 1939 the staff totalled 213, including 68 officers of graduate or other equivalent standard.

The services of the Station to the public throughout this period were steadily developed. Inquiries from the building industry were encouraged and were dealt with as a free service when they could be answered from existing knowledge. Where a particular inquiry called for further experimental work, this might also be done without charge if the matter was of sufficient general interest; otherwise the inquirer was expected to bear the cost of the work. It was also possible for firms to have their products examined at the Station on a repayment basis, and to receive either detailed reports on their performance or brief 'records of test' if only routine tests on particular samples were involved. On a wider scale, arrangements for co-operative researches of some magnitude on problems of general interest to particular sections of the industry were made with professional institutions and groups of building materials producers. In such instances the outside body concerned contributed to the cost of the work on an agreed basis.

Despite these activities, the amount of money received in repayment charges remained relatively small, and has at no time exceeded 17 per cent of the Station's total annual income. The bulk of the work is undertaken as a charge on public funds and in the general interest: and in all arrangements with individual firms or other outside bodies, the right is reserved, subject to prior consultation with the contributing firm or body, to publish the results of the work should it seem necessary in the public interest to do so.

The results of the Station's work are made available through annual reports, technical papers, special reports and bulletins published by H.M. Stationery Office, by the submission of papers by members of the staff to technical and scientific journals and, before 1939, by the issue every month to some thirty trade and technical journals of "Notes from the Information Bureau". On occasion unpriced leaflets are prepared and issued. For example, a series of some twenty leaflets are now in process of publication on different aspects of the general problem of the repair and restoration of war-damaged and neglected property.

With the outbreak of war in 1939, new problems soon arose and the normal programme was very largely suspended. Much advisory work was done in connexion with protective measures, such as the design of air-raid shelters and blast walls, anti-scatter treatments for windows and roof glazing, and fire prevention. Special attention was also given to the design of war-time factories which had to be erected speedily with minimum quantities of scarce materials.

The Station also undertook research on various other problems for which it happened to have the right kind of experience and facilities. Thus, to quote a few examples, a process for the manufacture of phosphate fertilizer was developed; the design of reinforced concrete railway sleepers was investigated; and the Station co-operated with the Ministry of Aircraft Production and the aircraft industry in developing reinforced concrete jigs for use in the manufacture of the De Havilland 'Hornet' and other aircraft of plywood construction.

At the same time, it was kept constantly in mind that the end of the War would have to be followed by a period of intensive reconstruction and, from 1942 onwards, the Station was marshalling its information, so far as other calls on its staff allowed, to ensure that the fullest possible use should be made of the new science of building when the time came. Later the pace was quickened.

Undoubtedly the most significant contribution made by the Station in connexion with reconstruction has been the work done for the Interdepartmental Committee on House Construction (the Burt Committee). This committee was appointed in 1942 by the Minister of Works, the Minister of Health, and the Secretary of State for Scotland, to advise on forms of house construction suitable for the post-war programme. The resources of the Building Research Station have been put freely at the disposal of the Committee. A critical point in this general connexion has been to provide quantitative standards of performance both for the guidance of the designer and for use in assessing the merits of novel forms of construction. The necessity for this is clear. The performance of the traditional brick-and-timber house is well established and it might almost be said to be scarcely necessary to consider what, in fact, are the scientific standards that such a house satisfies. We know that it will stand up; we know that it provides an amount of thermal insulation which has been accepted as reasonable in the past; we know that it is reasonably quiet and that it does not present any undue fire risk. But in making radical departures from this traditional form of construction, it is very necessary that measurable scientific standards should be laid down. The Interdepartmental Committee has found it possible, on the basis of the scientific work carried out in the inter-war period, for the first time to advance suggestions as to what these standards should be. In considering this matter, the Committee has not been content merely to reproduce as nearly as possible the conditions of the brick and timber house, but has examined afresh what the desirable standards are, irrespective of whether they happen to be higher or lower than those provided by the brick and timber house. The accompanying table, taken substantially from the Committee's report, which has been published as "Post-War Building Studies No. 1", sets out the recommended standards and also shows how the brick and timber house stands in relation to them.

PERFORMANCE OF BRICK AND TIMBER HOUSE IN RELATION TO PROPOSED STANDARD

| Element of house | Requirement | Value | Desirable standard | Value compared with standard |
|---|---|---|---|---|
| Outside wall: 11 in. cavity wall (two leaves of 4½ in. brick separated by a 2 in. air space, unventilated), plastered internally. | Thermal insulation | 0·30[1] | 0·15–0·20 | Low |
| Outside wall (Scottish practice): 9 in. solid brickwork, roughcast outside and with lath and plaster fixed on battens of 1¼ in. by 1 in. on the inside, giving 1 in. air space between plaster and wall. | Thermal insulation | 0·28[1] | 0·15–0·20 | Low |
| Party wall (wall separating two houses): 9 in. solid brickwork, plastered on both sides. | Sound insulation[2]<br>Fire resistance[3] | 50 db.<br>6 hr. | 55 db.<br>2 hr. | Low<br>Ample |
| Partitions (walls between rooms which give no support to the structure): 2½ in. clinker blocks, plastered on both sides. | Sound insulation between living room and other main rooms<br>Between other main rooms | About 35 db.<br>About 35 db. | 45 db.<br>35 db. | Low<br>Adequate |
| Ground floor: ⅞ in. (1 in. nominal) tongued and grooved floor boards on timber joists, ventilated underneath, covered with lino.<br>Wood block floor on concrete laid direct on ground. | Thermal insulation<br>Thermal insulation | 0·25<br>0·15 | 0·15<br>0·15 | Low<br>Satisfactory |
| First floor: 1¼ in. floor boards on timber joists: lath and plaster ceiling under joists. | Sound insulation air-borne<br>Sound insulation impact | 35–45 db.<br>Standard | For flatted dwellings only, 55 db.<br>+20 phons | For flatted dwellings only, low<br>Low |
| First floor (Scottish practice): ⅞ in. (1 in. nominal) tongued and grooved floor boards on joists. Trays of ⅝ in. board fixed between the joists carrying 3 in. of ashes. Lath and plaster ceiling under joists. | Sound insulation air-borne<br>Sound insulation impact | 50 db.<br>+10 phons | 55 db.<br>+20 phons | Low<br>Low |
| Roof: Tiles fixed on battens with continuous layer of felt between this and the rafters. Lath and plaster ceiling under ceiling joists. | Thermal insulation | 0·43 | 0·20–0·30 | Low |
| Roof (Scottish practice): Slating direct on felt underlay on ⅝ in. sarking (boarding). Lath and plaster ceiling under ceiling joists. | Thermal insulation | 0·35–0·30 | 0·20–0·30 | Low |

[1] Thermal insulation figures are expressed throughout in terms of $U$, the transmittance coefficient. A high value of this coefficient means low insulation.

[2] The values given for sound insulation refer throughout to the reduction of air-borne noise, except where impact noise is specifically mentioned. The decibel (db.) is a unit of measurement of sound energy and is usually used for measuring air-borne sound. The phon is a unit of loudness (not necessarily equivalent to the energy) and is usually used for the measurement of impact noises.

[3] As tested under the standard conditions laid down in British Standard Definitions (No. 476, 1932).

It would not be right to quote these standards, without at the same time adding that the Committee recognized that "For one reason or another, it may be difficult, particularly in the immediate post-war years, to realize all the suggested standards; nevertheless, they should represent the aim until sufficient further experience has been gained to warrant a review of them".

The Building Research Station has, moreover, been responsible, on behalf of the Interdepartmental Committee, for the scientific checking of all designs for which licences have been sought from the Ministry of Works. Usually helpful comment can be made after inspection of the drawings only. Confirmatory tests may, however, be needed to check, say, the thermal insulating value of a particular method of wall construction; and later, when a prototype building is erected, full-scale tests may be made in final confirmation of any doubtful points. For example, test loads are applied to ascertain the behaviour of the structure under specified wind and snow loads; party walls are tested for soundproofness; and so on.

It is of interest to contrast this state of affairs with that existing after the War of 1914–18. Then, as now, there were big arrears of house building and replacement to be made good. But scientific knowledge about buildings was, in the earlier period, almost completely lacking, and this was responsible for some of the difficulties encountered with new constructions. Now there is a clear scientific basis of design so that alternative types can be proposed with much greater confidence that they will prove satisfactory, and it seems that some at least will come into extensive use.

Within the framework of the post-war study committees established under the ægis of the Ministry of Works, the Building Research Station has also been active in connexion with five special inquiries made by committees of the Building Research Board on heating and ventilation, lighting, acoustics, fire grading and plumbing. All these committees have presented reports, four of which, on the heating and ventilation of dwellings, lighting, acoustics and plumbing, have been published in the post-war building study series. The fifth should appear shortly. In the course of this work the need for some sociological inquiries became apparent, and arrangements were made with the Wartime Social Survey of the Ministry of Information to conduct surveys on the heating and ventilation, lighting and sound insulation in low-cost housing. These have provided a valuable basis for further inquiry and research.

The work for these study committees, however, is but one example of the efforts now being made to produce satisfactory standards for construction. On a much wider front, arrangements are in train for the production of a comprehensive series of codes of practice covering all aspects of building work as well as civil engineering and public works. It had been a frequent complaint in the building industry that complications are introduced by the differing requirements of different local authorities, of which there are fourteen hundred in England and Wales, and that great advantage would accrue from greater unification of practice. The model by-laws prepared by the Ministry of Health in 1937 represented a great step forward in this direction, for they have been adopted by the great majority of local authorities, so that, outside London, by-laws are, to all intents and purposes, uniform throughout Great Britain. But by-laws are necessarily concerned only with certain specialized requirements—requirements of a type such that failure to comply can be discouraged by legal penalties. A whole range of problems of everyday practice are in no way touched upon in the by-laws, and the codes of practice will fill this gap. Even before the War, the Building Research Station took part in the production of codes of practice, for example, those for reinforced concrete structures and for steel structures; but the Station has always taken the view that the preparation of codes could not be regarded as one of its normal functions, and that it was more the function of the industry itself, and particularly of the professional institutions associated with the industry. During the War, an important step forward has been taken. With the encouragement of the Ministry of Works, acting in consultation with the Ministry of Health and other interested departments, the different professional institutions have combined together to form a Codes of Practice Committee which sits under a chairman appointed by the Minister of Works. This Committee has the duty of arranging for the production of codes of practice concerning all matters relating to building as well as civil engineering and public works. The codes will not be mandatory, except in so far as they may be made so by being made part of a contract; but, nevertheless, they should exercise a very wide influence on building work in Britain, because of the authority that lies behind them. When the series is completed, there will be available an authoritative statement of what is considered, to-day, to be good building practice. Much of this work is bound up with research activity and indeed is founded on research activity. Officers of the Building Research Station, and of other establishments of the Department of Scientific and Industrial Research, are attached to all the committees operating in their respective fields, and it is, in fact, scarcely an exaggeration to say that the venture could not have been undertaken were it not for the work which the Station has carried out in the past twenty years. Corresponding work, but of longer standing, is being undertaken in the field of standardization.

The Building Research Station serves as an advisory body to the various Government departments interested in building, and in this connexion the creation by the Ministry of Works of a scientific department, under Sir Reginald Stradling as chief scientific adviser, is to be welcomed as a stimulus both to research and the more effective application of its results.

Among the most recent developments, special mention may be made of a new series of large-scale experiments in house-building. The Station, with the help of the Ministry of Works, now has facilities for carrying out full-scale trials, under its own control, of ideas that have emerged from the laboratory. For example, eight experimental houses have already been erected in which different degrees of thermal insulation have been incorporated in the walls, floors and roof to obtain further information on the effect on heating costs of thermal insulation; and during the erection observations were made on building technique.

A feature of the organisation, which makes the Building Research Station unique, is the fact that it provides for the working together on the problems of the industry of teams of chemists, engineers, physicists and architects; so that it becomes a relatively easy matter to assess the practical implications of the results of investigations undertaken from a number of different points of view. It is part of the normal day-to-day routine for chemists, physicists, engineers and architectural members of the staff to meet together to discuss the practical implications of information obtained. The effective teamwork thus made possible is commonly the subject of comment by visitors, particularly visitors from abroad. It now seems likely that other similar organisations will be established in the Dominions and other countries—an uninvited testimonial to the form of organisation which has been developed for the application of science to an industry so practical and traditional as building, and an acknowledgment of the value of the twenty-five years research work of the Building Research Station.

Finally, it is of interest to note how the basis of building research has been broadened as the work has proceeded. Starting in the relatively restricted field of materials and structures, the Station at once found it necessary to join hands with sister establishments of the Department of Scientific and Industrial Research having special facilities for certain classes of work. Then it became desirable to establish a link with the physiologist, through the Medical Research Council; and more recently the help of the War-time Social Survey of the Ministry of Information was enlisted for certain inquiries. Again, the Station is extending its work on materials to cover their assembly on the site, and the properties of the finished building. The main question now is one of scale, and this is under consideration by the Department of Scientific and Industrial Research.

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# SOME USES OF D.D.T. IN AGRICULTURE

THE discovery in recent years of a new class of insecticides has given man an advantage over his insect enemies such as he has never before enjoyed. Although these materials kill insects by contact, they possess a stability and persistence which confer a protective effect far exceeding that of any previously known contact insecticide. Best known among them is D.D.T., a substance the properties of which are so remarkable that it has been accorded the doubtful honour of becoming 'news'. Very little of the vast amount of experimental work done has yet been published, and the door has thus been opened wide to the wildest speculation and exaggeration. A meeting of the Association of Applied Biologists on October 5 sought to adjust the outlook at least upon some of the agricultural uses of D.D.T. by bringing together workers qualified to speak on original investigations.

Mr. C. T. Gimingham, of the Ministry of Agriculture and Fisheries Plant Pathology Laboratory, introduced the proceedings with a plea for a restrained and balanced approach. The peculiar circumstances in which D.D.T. was introduced had led to intensive investigations on an unprecedented scale. The substance had proved to be of inestimable value and, by controlling disease-carrying insects, had probably been a major factor in the success of several Allied campaigns. Unfortunately, much of the resulting publicity had not been in the highest tradition of scientific accuracy. Contrary to the popular view of D.D.T. as a cure-all, it had recently been reported in the United States[1] that while it excelled the commonly used insecticide against some thirty insect species, it was only about equal against nineteen and was inferior against fourteen. Most of the work so far had been exploratory, and increased knowledge of dosage, timing and compounding would doubtless lead to improved performance in many cases. At present little was known as to which of the variety of possible forms of application was most effective and safest for particular purposes. A special problem in agriculture was the risk of harmful effects upon beneficial insects. Injury to birds and fishes also might follow widespread use over large areas. There appeared to be little danger to warm-blooded animals, but more information was required about cumulative effects. D.D.T., said Mr. Gimingham, was of such outstanding interest and promise that it would be peculiarly unfortunate if its future were prejudiced by misuse in the early days.

Dr. G. H. L. Dicker described experiments at East Malling Research Station on the control of apple blossom weevil. Emergence from hibernation begins in late February or early March and may extend over five weeks. Egg-laying starts at bud burst and continues for about three weeks, so effective treatment demands continuous protection over this period, with the first application timed for bud burst. In laboratory tests a 5 per cent D.D.T. dust consistently gave more than 90 per cent kill in five days, and this concentration was chosen for field trial. In comparison a 5 per cent benzene hexachloride dust killed about 60 per cent, reaching the maximum in sixteen hours. In 1944, 60–70 lb. of 5 per cent D.D.T. dust per acre, applied as soon as practicable after egg-laying began and twice following at weekly intervals, reduced an infestation of 5–6 per cent to 0·02 per cent, whereas a 1 per cent rotenone dust gave only about 50 per cent reduction. In 1945 two applications of 5 per cent D.D.T. at 40–45 lb. per acre gave more than 90 per cent control, but at 3 per cent only about 60 per cent control resulted. In another trial, however, 3 per cent D.D.T. apparently gave no kill, whereas 3 per cent benzene hexachloride gave 50 per cent. It remained to be seen whether a single dusting with 5 per cent D.D.T. at bud burst would suffice, whether 5 per cent benzene hexachloride was as good, and whether control could be attained by wet spraying. A spray containing 0·05 per cent D.D.T. gave complete kill in laboratory tests. As the optimum time of application was a month before flowering, there seemed to be little risk to beneficial insects. Dr. Dicker thought that D.D.T. would be compatible with lime-sulphur or a winter petroleum wash, but he preferred the dust because of the speed of application and because the best time for the weevil treatment was after petroleum oil and before the first lime-sulphur. Dr. W. Heeley said that other trials[2] showed a wet spray to be far superior to a dust, but Dr. Dicker pointed out the surprisingly poor results given by the dust in these trials.

Dr. M. Cohen reported exploratory work on the production of D.D.T. 'smokes' by burning impregnated filter papers. The heavy smoke produced settled quickly and gave a firmly adhering deposit. By drawing this smoke through benzene, unchanged D.D.T. could be recovered. Houseflies, stable flies (*Stomoxys calcitrans*), Drosophilid flies, mosquitoes (*Culex* spp.), thrips, clothes moths, and pollen beetles were knocked down within five seconds of being exposed to the smoke. Aphides, though less obviously affected, appeared not to recover. The deposit produced when the smoke settled consisted of minute droplets that remained liquid until mechanically disturbed, as by brushing lightly or by the movement