THIRD REPORT OF THE COMMITTEE
FOR THE YEAR ENDING 31 MARCH 1979

Standing Committee on Structural Safety

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REPORT OF THE STANDING COMMITTEE FOR THE YEAR ENDING 31 MARCH 1979

1. CONSPECTUS

Our Committee was formed in 1976 with the intention that we should function for a trial period of three years, after which our work would be reviewed and the future reconsidered.

Having now completed the initial three years, we have reported to the Presidents of the three sponsoring Institutions who have decided to extend the life of the Committee for a further three years. The necessary funding has also been agreed, and the terms of reference and method of working will be revised as appropriate to ensure effectiveness and economy in the work of the Committee.

The list of main topics which we have considered during the first three years and the results of our activities are briefly summarised in Appendix A of this report.

When we began, we thought that a number of important and unexpected structural safety matters of general application would be brought to our attention by professional people and the public at large. There have been few. We have worked hard on certain matters suggested by members of the Committee and others, and we have looked at a few matters suggested by our sponsors.

We have also invited a substantial number of individuals to speak to us either from their personal experience or on behalf of the organisation for which they work, and tell us about any structural safety matters of current concern. The fact that the Committee has discussed with these individuals or representatives whatever structural safety problems they wished to mention has probably been helpful to them. But, in these discussions, the Committee has not detected a weakness that was not already appreciated, even though there might sometimes have been some difference in the degree of importance attached to a risk.

The Committee has on several occasions met the problem of the structural safety of old structures still in use. There are many old structures in the United Kingdom where there is no reliable knowledge of what the remaining useful working life might be, such as bridges, sewers, local gas pipes - the list could be greatly extended.

The nearest the Committee came to finding a general case of loss of structural safety in old structures was cladding. Here it should be noted that there was already an understanding of the potential risks in the structural and architectural professions, individually and corporately, and there was also some recognition of the potential risks by technical Civil Servants and Local Authority staff.

The Committee can take credit for identifying and taking actions in a number of cases of potential risk where structural safety was involved. Perhaps the most important examples are liquefied petroleum gas (LPG) in those high-rise flats where connection to the gas mains is banned;

risks of a high road vehicle load damaging a bridge, followed almost immediately by a second accident on the damaged bridge; and cladding failures. The Committee has made a useful contribution to structural safety in these and a few other cases, but the contributions have been modest rather than outstanding.

In 16 of the 24 topics considered in the first three years, there was a clear need for better communication, education, care or management. It would seem that more serious and more systematic attention to such matters could greatly benefit the industry and community at large in terms of improved economy with safety. Such observations, even though they are almost certainly accurate, are prone to inaction because of their generality. In view of this, the Committee will be considering, amongst other problems, what specific actions could be taken in these areas, and will welcome suggestions to improve the situation, especially as regards avoidance of error, a better understanding of overall structural behaviour, and better husbandry in the design and construction processes.

During the last year, 11 topics have been considered, of which eight were new and three followed from previous discussion and action by the Committee. Reports on these topics are included in Section 2.

The Committee has continued to press for a restriction on the height of loaded vehicles and for warning devices on low bridges to reduce the risk of damage. The Committee has also recommended that the effect of other measures already taken should be monitored.

One of the new subjects, corrosion of tendons in post-tensioned concrete bridges, illustrates the two major complementary aspects of structural safety which are (1) structural integrity and (2) the forces and other environmental effects to which the structures may be subjected. The former is largely under the control of the designers and builders while the latter may not be. Control of the man-made environment may be possible for example, to take a few possibilities among many, by controlling the use of sodium chloride for de-icing, or by controlling the height of vehicles or the loading on floors, or by banning LPG in certain buildings. Such examples confirm the need for reliable, adequate and relevant data on environmental effects. There is also a need for data on structural performance and failures. These are matters which will continue to receive the attention of the Committee.

The Committee notes with some concern the present and possible future cutbacks on research in the Department of the Environment and the Department of Transport and recommends that a review of short- and long-term research needs in structural safety should be made. It is the Committee's view that research, related to structural safety, should be given very high priority.

Another new topic which was tentatively discussed was the role of the Health and Safety Executive in building control. The Health and Safety Executive is developing an interest and a capability of control in many matters touching on structural safety not covered by the Building Regulations, including codes of practice, temporary works, methods of construction, materials of construction, subsequent effect of design decisions, special structures and professional responsibility. Most of the experts in these fields are members of the Institutions, and many of them might be willing to give their help in a safety matter.

Looking to the future, the Committee thought that it was worthwhile exploring the idea that in due course a joint committee on structural safety should be established, representing several professional institutions and to which representatives from the Health and Safety Executive could be appointed. The committee could act as an early warning system and provide a corps of people with experience of safety problems, available for serving in the examination of any important accident involving structural safety or engineering safety problems. The Standing Committee on Structural Safety could be modified and subsumed into such a scheme. There are pros and cons for such an arrangement which the Committee thinks are worthy of general discussion.

The Committee recognises that, with the resources at its disposal, monitoring of trends and identification of research needs as required in its terms of reference must necessarily be limited. Voluntary assistance will continue to be the means by which the Committee gathers information and the ready and helpful response of individuals and organisations to enquiries by the Committee since its inception is gratefully acknowledged.

The Standing Committee recognises the need to make the Committee's work and that of the Institutions better known. It will encourage the Institutions and others to suggest new topics for consideration. It will also build on the links already established with statutory bodies and will work towards an integrated approach to problems of common interest.

2. TOPICS DISCUSSED DURING THE 12 MONTHS ENDING 31 MARCH 1979

The Committee discussed the following topics during the third year 1978 to 1979:

2.1 Welded structures: discussion with welding specialists from a research association and a university

2.2 Visit to the Building Research Establishment
July 1978

2.3 The use of chemical admixtures in concrete
October 1978

2.4 The influence of various factors on the structural safety of buildings: discussion with a building contractor member of the Institute of Building
December 1978

2.5 Safety of post-tensioned concrete bridges: corrosion of tendons
January 1979

2.6 The role of the Health and Safety Executive in building control: discussion with senior officers of the Health and Safety Executive
February 1979

2.7 The influence of safety factors on overall structural safety with special reference to bridges
March 1979

2.8 Cladding failures

2.9 Liquefied petroleum gas containers in dwellings

2.10 The stability and durability of timber roof trusses

2.11 Cavity wall ties and metallic components

2.1 WELDED STRUCTURES: DISCUSSION WITH WELDING SPECIALISTS FROM A RESEARCH ASSOCIATION AND A UNIVERSITY

The discussions and correspondence on this subject touched on many aspects including workmanship, management, motivation, education, training, skill, care, research, contractual problems, fabrication and design errors, imperfections, residual stresses, material properties, structural behaviour and failures.

The following conclusions were reached by the Committee:

1. There appears to be no great problem with regard to the safety of existing welded structures constructed in the UK in accordance with the appropriate current British Standards (BS449 and BS153), both of which incidentally are being re-written. However, it seems inevitable that isolated cases of failure will occur as a result of unfavourable combinations of circumstances.

2. A less satisfactory situation could develop in the future as a result of possible changes and of errors and imperfections occurring at the various stages of design fabrication and construction. Surveys of existing structures show that errors and imperfections are fairly common. However, surprisingly few failures have been reported. This may be because the structures have not been subjected to their full design loads, because of hidden reserves of strength, or because failures which have occurred have simply not been made public.

3. Avoidance of errors and imperfections is best achieved by adequate training and education, and by good management, using systematic procedures in design, construction and control.

4. There is considerable doubt whether sufficient attention is being paid to these matters to meet ever-changing circumstances. In particular, welding technology, including design of welded connections and an understanding of their structural behaviour, appears to receive scant attention in undergraduate courses in the UK. The few post-graduate courses which are provided are not particularly well attended. A review of the content of engineering courses in the UK is required to establish the needs for improved training in welding technology.

Satisfactory arrangements seem to be available in the UK for the training and certification of welders, but these facilities are not necessarily used to the full by the construction industry. As so much depends on the quality of workmanship in welding, more attention should be paid by employers to ensuring that welders and supervisors are properly skilled and motivated to produce good work. Particular attention should be paid to training requirements, terms and conditions of employment, and method of payment.

5. It should preferably be the combined contractual responsibility of the fabricator and designer to use satisfactory control and checking procedures in the performance of the work, and to provide the client with evidence that such is the case.

6. Registration of 'welding engineers' has been suggested as a means of achieving satisfactory standards in welded construction, but it is not clear how this would operate in relation to qualification and contract procedures. The Committee feels strongly that due recognition of the importance of a job leads to a greater sense of responsibility on the part of the workman and so to better workmanship. Any changes which tend to promote such appreciation (e.g. certification of welders, registration of welding engineers, or better pay for greater skill and better work) deserve serious consideration.

7. There is a need for systematically collected data on material properties, imperfections and errors in welded structures to enable appropriate checking procedures to be identified, to enable safety and serviceability factors to be determined for future design purposes, and for assessing the reliability of existing structures. This work would need to be centralised and carefully formulated if it is to be of general use and economically carried out.

2.2 VISIT TO THE BUILDING RESEARCH ESTABLISHMENT July 1978

At the Director's invitation, the Committee visited the Building Research Establishment (BRE) on 3 July 1978 to discuss matters of structural safety and meet the staff concerned. Among the topics discussed were:

Gas explosions in buildings: The Committee was informed of progress in the work initiated following the Ronan Point collapse in 1968, with the objective of providing optimum designs for domestic premises.

High alumina cement: The BRE's work in connection with recent high alumina cement (HAC) investigations were summarised, and it was pointed out that more long-term studies are required to appraise the extent of durability problems.

Calcium chloride study: Progress was reported on the BRE's investigation of deterioration of some pre-tensioned prestressed concrete elements in a system of building which had been used widely in schools since about 1960. The cause of deterioration was found to be corrosion of tendons because of the presence of calcium chloride, although this admixture had been prohibited for use in prestressed concrete.

Survey of recent structural failures: A summary was given of nine structural collapses investigated by BRE since 1973, and the lessons from these investigations were discussed. All had been failures of roofs spanning 9 to 18 m, incorporating prefabricated components of steel, timber or concrete built between 1954 and 1974. The causes included inadequate joints and connections, inadequate bearing or deterioration of concrete.

Improving building integrity and identification of hazards: The work of the Building Integrity Division was discussed (see First Annual Report for earlier discussion).

A number of potential weaknesses in building components and assemblies had been identified and were being examined.

This visit and discussion provided the Committee with very useful views and experience on structural safety problems. The BRE contributions, both in investigating failures and in providing essential information on material properties and structural behaviour to assist others, had been invaluable.

The Committee noted with concern that cuts in research within the Department had adversely affected progress in some important aspects of the BRE's programme bearing on safety. The Committee suggests that the three Presidents should consider making representations to the appropriate Minister that recent cuts were having an adverse effect, and that adequate funds for future safety work should be provided as soon as possible.

2.3 THE USE OF CHEMICAL ADMIXTURES IN CONCRETE
October 1978

It has been estimated that 10 to 20% of concrete produced in the UK contains an admixture, compared with 60 to 80% of concrete in Australia, Japan, USA and West Germany. The lower usage of admixtures in the UK may, it is argued, be to some extent as a result of the wider availability of good quality aggregates, more conservative specifications, better control over concrete production, and differences in climate. Nevertheless, it seems likely that the use of admixtures will increase in the UK.

Water-reducing and other workability agents are generally based on lignosulphonate, which has been used in concrete for more than 40 years, and most air-entraining agents are based on wood resin derivatives with a similar long-term usage. Other ingredients include calcium formate, sodium nitrite, naphthalene sulphonate, melamine formaldehyde, stearates, hydroxycarboxylic acid, and (sometimes) calcium chloride.

Super-plasticisers, which are the most recently introduced admixture, are based on napthalene sulphonate or melamine sulphonate, both of which have been used with concrete for between 10 and 20 years.

There seems to be no reason for concern about an increased use of the admixtures currently available in the UK or of new formulations based on these admixtures, provided they are properly used and that calcium chloride is excluded from concrete containing steel in any form. Sufficient information is available through the Concrete Admixtures Association, Cement and Concrete Association, BRE, and others on acceptable formulations and dosages of admixtures. With appropriate control, the harmful effects of over-dosage can be avoided. The record shows that the main risks are of misuse or misapplication.

The reduction in cement content which can accompany the use of a water-reducing agent is, in normal circumstances, unlikely to have a significant adverse effect on the durability of concrete provided the accepted minimum cement contents, associated with different environments, are respected.

Long-term durability of concrete is difficult to establish, except through experience in use, although accelerated testing can be a useful guide to long-term effects.

It is recommended that any new type of admixture introduced in the future should be assessed by an independent body prior to its adoption for general use in the UK. However, the Committee feels that education of those responsible for using concrete is required to ensure that the benefits and disadvantages of admixtures are better understood and taken advantage of or avoided.

The use of pulverised fuel ash (PFA) in concrete has not yet been considered by the Committee, and nothing in this report should be taken as necessarily applying to this material.

2.4 THE INFLUENCE OF VARIOUS FACTORS ON THE STRUCTURAL SAFETY OF BUILDINGS: DISCUSSION WITH A BUILDING CONTRACTOR MEMBER OF THE INSTITUTE OF BUILDING December 1978

Although the general standard of design and construction in the UK is high and the incidence of failure is low compared with the volume of construction, it is a matter for concern that many defects in buildings result from both builders and designers failing to apply well established information and practices, or to communicate their requirements adequately within and between their organisations.

In cases of failure or difficulty, there has long been a tendency in the construction industry for the contractor to see the mote in the designer's eye and for the designer to see the mote in the contractor's eye.

There is also a problem of getting the client to understand the implications of cost limits and other restraints he places on the design/construction team. The following points were put forward as requiring attention for better assurance of safe and satisfactory construction:

1. Builders and designers should be constantly on the alert to ensure that their procedures, their systems of communication and the competence of their employees are adequate to meet continually changing circumstances. A periodic review of these matters would be helpful.

2. Designers should have site experience in construction so that they may better understand the need for realistic specification for tolerance and design to take account of imperfections and construction difficulties.

3. Contractors should be provided with sufficient information about a design to enable them to devise and apply adequate supervision and control procedures in the performance of the contract. In collaboration with the contractor, designers should consider the strength and stability of the structure at all stages of construction and handling or demolition.

4. More precise specification of workmanship and quality in contract documents could, in some cases, help the contractor to achieve the required standard.

5. In view of difficulties which have arisen in the use of new materials and with new uses for tried materials, care should be taken to ensure that sufficient research and testing has been done to establish performance characteristics. Traditional and well-tried practices should not be lightly abandoned to satisfy a desire for novelty.

6. More effective dissemination of guidance documents is needed so that existing information is put to use and unnecessary mistakes avoided.

7. Data on imperfections are required to establish satisfactory safety and serviceability factors for use in future design. For effectiveness and efficiency, the collection of such data should be systematic and fully co-ordinated.

The Committee recognises the validity of the various points made, and it will seek to identify specific actions which could be taken to eliminate deficiencies.

2.5 SAFETY OF POST-TENSIONED CONCRETE BRIDGES: CORROSION OF TENDONS
January 1979

It is estimated that about 600 post-tensioned concrete bridges have been built in the UK during the past 20 years, but there is no known case of bridge failure in the UK as a result of corrosion of tendons. However, engineers have expressed doubt about the effectiveness of cement grout injected into tendon ducts to provide bond between the tendons and the rest of the structure, and to inhibit corrosion of the tendons. In post-tensioned construction, structural integrity does not normally rely on bond.

The Committee has considered information provided by the Transport and Road Research Laboratory (TRRL) and the Department of Transport based on a survey of the condition of grouted tendons in 14 post-tensioned highway bridges. On some of the bridges, the grout was of poor quality, soft or crumbly, but generally it appeared to be satisfactory. The size and extent of voids varied considerably, some ducts being virtually empty of grout and others filled fairly solidly with grout. One 2-year-old bridge examined had some grouting faults, so it cannot be assumed that recent workmanship is necessarily better than that provided in the past.

Although severe and rapid corrosion was found in some ducts containing no grout, the presence of at least some grout appeared to be sufficient to inhibit corrosion in both water and air filled voids in structures up to 20 years old. In all cases where water was found in a grouted or partially grouted duct, the pH value of the water exceeded 11.5. It could not necessarily be inferred from this that partial filling of a duct would inhibit corrosion indefinitely or in circumstances in which chloride ions could enter the duct through cracks or porous areas.

Voids may form as a result of entrapped air or water or may be due to segregation or leakage of the grout. Segregation, contamination or freezing of the grout can result in its being of poor quality. Longitudinal cracks corresponding with the tendon positions have been observed on one bridge in the UK and one in Japan, resulting, it was thought, from freezing of water in voids in the ducts. Difficulties can arise because of local blockages or pockets of water in the ducts, or because of breakdown of the grouting equipment.

From the evidence available, it seems that complete filling of the ducts with grout, although desirable, is not essential, providing the ducts are sealed against ingress of air, water and chloride ions. The effectiveness of the water-proofing system on the bridge deck is of considerable importance in providing this seal, especially where cracking is likely to occur (e.g. at joints). It is thought that voids are most likely to occur at high points in deflected cables and where ducts are damaged during concreting. The most vulnerable points are those where cracking, voids and failure of the waterproofing coincide. There appears to be sufficient guidance available through the FIP and other recommendations to ensure satisfactory grouting, but the process relies on careful workmanship and supervision. More rapid and effective dissemination of this information and TRRL's findings on the performance of grouted bridges would help to reduce the risk of unsatisfactory work in the future.

Most post-tensioned bridges considered contained about 100 longitudinal tendons, and so the risk of sufficient tendons failing by corrosion at any time to cause sudden collapse is considered to be small. However, for particular cases where the structural integrity is sensitive to the failure of a relatively small number of tendons and where the environment is likely to be aggressive, it will be necessary to pay special attention to design and construction to ensure fully effective grouting.

In view of the significant number of cases in which unsatisfactory grouting has been discovered, work should be continued to develop more reliable grouting techniques and materials for both new and remedial work, and to develop non-destructive and other forms of test for monitoring purposes. It is also considered important to maintain routine surveillance of post-tensioned concrete bridges, as is the practice for all bridges by the Department of Transport (DTp). DTp's proposals in these respects appear to be satisfactory. Currently, some work is being done at the Cement and Concrete Association on improving grouting materials and techniques.

It has been reported* that nearly one-third of reinforced concrete bridge decks in the USA are seriously deteriorated because of reinforcement corrosion by de-icing salts. Although in the UK bridge decks are provided with waterproofing membranes and surfacings, which is not standard practice in the USA, and, generally, lesser quantities of de-icing salts are applied than in the USA, the use of salt for de-icing purposes introduces a hazard which could lead to serious consequences. It seems prudent that, where adequate waterproofing cannot be ensured, alternatives to the use of salt for de-icing should be considered.

2.6 THE ROLE OF THE HEALTH AND SAFETY EXECUTIVE IN BUILDING CONTROL: DISCUSSION WITH SENIOR OFFICERS OF THE HEALTH AND SAFETY EXECUTIVE February 1979

The Health and Safety Executive (HSE) is the executive arm of the Health and Safety Commission which derives its authority from the Health and Safety at Work, etc. Act 1974.

**Engineering News Record* 1 February 1979

Anxiety had been expressed over the effects of possible overlap between the HSE and the Building Regulations Division of the Department of the Environment in building control matters. It was thought that any such overlap or uncertainty might add unnecessarily to the cost of buildings, and to the difficulties of designers and builders in achieving structural adequacy.

The purpose of this discussion was to clarify the situation and to understand the intended future role of the HSE and any consequent implications with regard to professional responsibility and structural safety.

Included (for legislative convenience) in the 1974 Act is Part III Building Regulations, and Amendment of Building (Scotland) Act 1959. The Building Regulations Division of the DoE has responsibility for operating and enforcing Part III of the Act, and is directly concerned with structural adequacy and performance in use.

In general terms, the HSE is concerned with health and safety matters during periods when buildings are either being built or demolished. It is also concerned with the health and safety of people at work in or about the building in use (e.g. in the provision of safe and satisfactory window cleaning facilities and freedom from pollution - such as from blue asbestos). Many such matters are influenced by decisions made at the design and construction stages, and it will therefore be necessary for the HSE to be involved with the work of the architects and engineers during these stages. The HSE is not generally concerned with the control of structural materials, except where they represent a hazard to health as pollutants.

The HSE will act in areas which lie outside the purview of the Building Regulations, but will consult with DoE when there is some overlap. The HSE will also collaborate with other bodies which have overlapping responsibilities such as the Railways

Inspectorate which acts as agent for the HSE in matters concerned with health and safety (e.g. of railway structures).

The Health and Safety Commission has a constitution of nine members. The Confederation of British Industry and the Trade Unions are strongly represented in it, but not the professional engineering Institutions. There is at present one vacancy on the Commission.

There is a possibility that an engineering advisory committee will be set up, and the HSE considers this would provide the necessary link with and support of the Institutions. The engineering and architectural institutions nominate members to serve on HSE working parties. The intention is apparently to broaden this dialogue. HSE staff, including 26 civil and structural engineers, already provide some links with the institutions on various BSI committees and occasionally co-operate with them in organising safety seminars and conferences.

The Committee concluded that:

1. HSE will not normally be involved in matters covered by the Building Regulations, which will continue to be administered by the Building Regulations Division of DoE.

2. In matters not covered by the Building Regulations, HSE considers it will necessarily be involved at the design and construction stages to ensure that adequate provision is made for health and safety during construction and use. The extent of this involvement and methods by which HSE will exert influence on designers and builders are not yet clear, nor has there been any substantial dialogue with the professions on many matters which will arise relating to professional responsibility and expertise.

3. There is a clear need to broaden this dialogue and for co-operation at all levels with the Executive to avoid the possible introduction of inappropriate measures.

2.7 THE INFLUENCE OF SAFETY FACTORS ON OVERALL STRUCTURAL SAFETY WITH SPECIAL REFERENCE TO BRIDGES

In the second report of the Committee, a suggestion was made that lower safety factors might be justifiable when independent checking is done.

DTp engineers have since expressed the view that there is no room for such reductions for bridges designed and built in accordance with the current system of technical approval and certification of bridges operated by the Department. The view has also been expressed that safety factors cannot be used to cover gross human error.

It is the Committee's opinion that currently used safety factors must, to some extent, reflect the minor defects resulting from human error. Errors, omissions and accidents having a major effect are not normally covered by safety factors, and it would be wasteful of resources for them to be so. However, there will be cases where margins of safety will need to be greater than normal to avoid undue sensitivity to errors, omissions, accidents and imperfections, or where the economic consequences of failure are severe.

In general, where improvements are made to a tried and tested checking and control system so that the risk of failure is effectively reduced, there must be scope for a corresponding reduction in safety factors. Where independent checking is already part of the system and no specific improvements are made, there is clearly no scope for further reduction of safety factors on this account.

Under the DTp system, the type of checking required is related to the importance of the structure (i.e. to the probable consequences of failure) as follows:

Category I

Certificate required stating that the design has conformed to the Department list and instructions, that it has been accurately translated into contract drawings, and that all these have been checked.

Category II

Two certificates are required: one stating that the design has conformed to the Department list and instructions, the other stating that the design has been checked by an independent team in the design office.

Category III

As for Category II, but the independent team must be from a different design organisation.

It is understood that the system has been operated and tuned over a significant period of time, and that the reliability of bridges built under the system is acceptable. It is claimed that the system is practicable and flexible in that Department experts are able to use good engineering judgement in deciding which category of checking is appropriate to a particular case.

Determination of the degree of importance and of what is an acceptable level of reliability is invested in the Department and its officials. DTp has been very helpful in explaining to the Committee how the system works, but without further information on these two matters and without a very thorough and wide ranging study (for which the Committee does not have the necessary resources), it would not be possible for it to assess fully the safety of bridges built in accordance with the Department system. However, the Committee is aware of an impressive record of research into structural safety by the Department and sees no reason to doubt the effectiveness of the method of technical approval and certification operated by DTp.

Recent cutbacks at DTp and TRRL are noted with some concern. It would be unfortunate if they were to herald less attention to structural safety in the future. The Committee considers that this work should be given high priority.

2.8 CLADDING FAILURES

The second report of the Committee drew attention to the need for careful consideration to be given to various aspects in the design, manufacture, and construction of claddings and their fixings to avoid risk of failure and consequential hazards to the public. Attention was also drawn to the need for inspection of existing claddings at risk, especially those where failure was attended by high potential consequences. The need for better dissemination of information on the subject was pointed out.

A suggestion by the Committee that some specific reference to cladding might profitably be made in the Building Regulations was rejected by DoE on the grounds that, in general, structural safety was covered in the regulations, and that there was pressure (not least from the professional institutions) to simplify the regulations.

It was, however, agreed to be important to get information on the problem across at a technical level and to the owners of buildings (perhaps via the British Property Federation), the Institution of Structural Engineers perhaps taking a lead in the matter.

The Institution of Structural Engineers Report on Structural Appraisal of Construction referred to in the second Report is not expected to be available before autumn 1979.

A Digest* on the design of claddings which had been in the course of preparation for some time was issued by BRE in March 1979. An earlier Digest+ on diagnosis of cladding defects was issued in September 1978.

2.9 LIQUEFIED PETROLEUM GAS CONTAINERS IN DWELLINGS

The Committee's concern that many local authorities were unaware of the risk of LPG in high rise flats was noted in its second report.

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*Wall cladding: designing to minimise defects due to inaccuracies and movement. BRE Digest 223, March 1979

+Wall cladding defects and their diagnosis. BRE Digest 217, September 1978

As a result of further discussion with DoE the co-operation of the local authority associations was obtained in drawing the attention of local authorities to the possibility of an accidental escape of LPG causing an explosion which, in certain high-rise flats, could result in serious structural damage. The local authority associations agreed that all authorities should be advised to consider whether any safeguarding action was necessary in their particular situations and, if so, to put it in hand as quickly as possible.

In November 1978, the local authorities were advised by the Association of District Councils that, as a first step, they should distribute individual warning leaflets to each tenant in buildings identified as being multi-storey flats of large panel construction which had not been strengthened after the Ronan Point incident in 1968, either because they had no mains gas supply or because the supply was disconnected. Further, it was suggested that these leaflets should be supplemented by notices in similar terms displayed in entrance halls and other prominent places within the blocks. It was noted that individual warnings would need to be repeated from time to time and that care should be taken to ensure that warnings were issued to new tenants. It was agreed that enforcement of safety measures would be difficult.

For the longer term, it was suggested that authorities might wish to consider:

1. the possibility of prohibiting the introduction of refillable LPG cylinders to buildings particularly at risk (e.g. by appropriate clauses in tenancy agreements)

2. the possible need to warn social service departments of the dangers involved in supplying LPG appliances as an emergency measure to tenants of such buildings.

The Standing Committee is satisfied that the action taken by DoE and the advice given to the local authorities is appropriate, and that it should substantially reduce the risk of explosions in high-rise dwellings.

2.10 THE STABILITY AND DURABILITY OF TIMBER ROOF TRUSSES

During the second year of work, the Committee considered some potential problems arising from the extensive use of proprietary prefabricated timber roof trusses incorporating galvanised metal jointing plates. In particular, the Committee sought further evidence on the durability of the galvanised plates and the effect of moisture changes and ageing of the timber on the long-term performance of the joints.

The Committee welcomed BRE Current Paper CP83/78 (December 1978) on the subject, which concluded that, during the 15 years in which trussed rafters had been in use, less than 0.1% had been found to require remedial treatment. Trussed rafters now form the roof in about 80% of all new houses. The most common defect is inadequate bracing of the assembled roof, rather than failure of individual trusses. Rarer problems include under-design, unauthorised alteration and connector plate corrosion.

The Committee endorses the BRE recommendation for further work, especially on the durability of jointing plates in insulated roof spaces and the preparation of design rules for lateral bracing. The Committee feels strongly that roof trusses should not be treated as components in isolation from the structure as a whole, and the British Standards Institution Code of Practice (CP112: 1973 Part 3 Trussed rafters for roofs of dwellings) should be revised accordingly.

2.11 CAVITY WALL TIES AND METALLIC COMPONENTS

Cases have been reported in recent years of partial collapse or severe deformation of cavity walls in low-rise housing in which severe corrosion and breakage of wall ties has been found. Similarly, some high-rise brick-clad buildings have been found to have corroded ties and occasionally, on investigation, ties have been found to have been spaced more widely than customary, or, in some cases, they have been omitted altogether. Some other metallic components, with various types of protective coatings, have been found to last only a few years.

The extent of the problem and the implications for structural safety are not known at present, and, in view of the extensive use of this form of construction and the large stock of existing low- and high-rise buildings with cavity walls, the Committee considers that the matter should be investigated.

Various types of wall ties are used in cavity wall construction and, as a result of competition between manufacturers, there has been a marked trend towards the use of lighter gauge materials. The large majority of ties have been of galvanised steel flat or wire formed and twisted into various shapes to provide a bond into the mortar and to inhibit the passage of water from the outer to the inner leaf. Polypropylene or plastic coated ties are also available as are non-ferrous metallic ties.

The main function of the wall ties in house building is sometimes regarded as being to maintain the stability of the wall during construction and until the mortar has gained strength, but they are also believed to contribute substantially to the overall resistance of the wall to vertical and horizontal applied loads, eccentricities and the effects of differential settlements and movements. This contribution of the wall ties to the structural performance of a wall has not been evaluated, and rules governing their spacing and design are empirical. Similarly, very little information is available on the durability of ties, or their behaviour in fire. There is clearly a need for research to evaluate all these matters.

The amount of corrosion which occurs depends on many factors, including the corrosion protection of the ties, the chemistry of the mortar and brickwork, the porosity of the wall, the exposure of the wall to weather, humidity, temperatures, and pollution. In short, the environment must be considered as well as the components themselves and their structural action.

It is understood that BRE is investigating the problem of corrosion in wall ties and some other components, and that a publication dealing, in some depth, with the problem of wall ties is expected later in 1979. It is also known that several other organisations are formulating research proposals in collaboration with CIRIA. The Standing Committee welcomes these initiatives and urges that adequate resources should be allocated by government and industry for this work.

For future construction, it may be necessary to consider the use of possibly more expensive non-ferrous, stainless steel or other corrosion resistant ties, including polypropylene.

Until authoritative guidance becomes available, designers and builders should use care in specifying and detailing to avoid undue risk of corrosive conditions occurring and to provide appropriate durability of all metallic structural components in buildings, such as ties, joist hangers, and lintels.

APPENDIX 1 LIST OF TOPICS CONSIDERED: MARCH 1976 - MARCH 1979

	Topics considered	Problems identified	Warning issued	Actions suggested	Known resulting actions taken by others	Need for research	Need for better communication, care or management
1	Falsework	✓	-	-	-	✓	✓
2	Gas pipelines	✓	-	-	✓	✓	-
3	Fires in schools	✓	✓	✓	-	-	✓
4	British Rail structures - maintenance and inspection	-	-	-	-	-	-
5	Concrete Society Working Party on structural safety	-	-	-	-	-	-
6	Building Integrity Division (BRE)	-	-	-	-	-	-
7	Claddings - failures	✓	✓	✓	✓	-	✓
8	Influence of building regulations	✓	✓	✓	-	-	✓
9	Influence of safety factors	-	-	-	-	✓	✓
10	Structural failure investigations	-	-	✓	-	-	✓
11	Agrément certificates	-	-	-	-	-	-
12	Brittle fracture in high tensile steel	-	-	✓	-	-	-
13	LPG in dwellings	✓	✓	✓	✓	✓	✓
14	Timber roof trusses stability and durability	✓	-	-	-	✓	✓
15	Inaccuracy in building	-	-	-	-	✓	✓
16	Local authority inspectors. Duty of care and professional responsibility	-	-	-	-	-	✓
17	Strengthening RC bridges with resin bonded steel plates	-	✓	✓	✓	✓	-
18	Vehicle collision with bridges	✓	✓	✓	✓	✓	✓
19	Welding quality	-	-	-	-	✓	✓
20	Concrete admixtures	-	-	✓	-	✓	✓
21	Post-tensioned prestressed concrete	✓	-	✓	-	✓	✓
22	Building construction processes	-	-	-	-	-	✓
23	Role of the HSE in structural safety	✓	-	✓	-	-	✓
24	Cavity wall ties and metallic components	✓	-	✓	-	✓	-

APPENDIX 2 TERMS OF REFERENCE

To study trends and innovations in design, construction and maintenance of structures from the safety standpoint.

To consider where further research and development work, or some warning of risk, appears desirable from the safety standpoint.

To report to the three Presidents and to make recommendations.

To produce an annual report on its activities.

To seek, receive and authorise the expenditure of funds necessary for the implementation of these terms of reference.

To suggest to the three Institutions any changes to its terms of reference it considers to be necessary or desirable.

APPENDIX 3 : LIST OF MEMBERS

CHAIRMAN: The Rt Hon Lord Penney OM KBE MA PhD DSc FRS

S L Bragg MA MSc FIMechE FRAeS
Vice-Chancellor & Principal, Brunel University

C D Brown BSc FICE
Mott Hay and Anderson

J A Derrington BSc(Eng) DIC FEng FICE FIStructE FIArb
Sir Robert McAlpine & Sons Limited

A Gordon CBE LLD DipArch PPRIBA
Alex Gordon & Partners

The Hon Mr Justice Graham
High Court Judge (Chancery Division)

Professor E F Happold BSc FICE FIStructE
University of Bath

D N Rogers BSc(Tech) FICE FIMunE
City Engineer, Birmingham

R E Rowe CBE MA ScD FEng FICE FIStructE FIHE FASCE
Cement and Concrete Association

A C E Sandberg BSc ACGI MConsE MIMechE MIHE
Messrs Sandberg & Partners

R L Triggs BSc FICE
Sir Robert McAlpine Tunnelling Limited

F Walley CB MSc PhD FICE FIStructE
Consulting Engineer

SECRETARY: L S Blake BSc(Eng) PhD FICE FIStructE FIHE
CIRIA

TECHNICAL OFFICER: *J S Armitage BSc MICE MIStructE
CIRIA

*from June 1978

APPENDIX 4 STATEMENT OF COSTS AND ESTIMATES FOR 1979/80

Summary of expenditure for the twelve month period 1 April 1978 to 31 March 1979

CIRIA staff time and overheads		£7,940
Committee expenses		£ 544
		£8,484
	VAT @ 8%	£ 679
	TOTAL	£9,163

Budget for twelve month period 1 April 1979 to 31 March 1980

CIRIA staff time and overheads		£7,326
Committee expenses		£ 500
		£7,826
	VAT @ 15%	£1,174
	TOTAL	£9,000