



Ministry of Housing and Local Government
Whitehall, London, S.W.1

Sir,

20th December 1968

Flats constructed with pre-cast concrete panels.

Appraisal and strengthening of existing high blocks.

Design of new blocks.

I am directed by the Minister of Housing and Local Government to refer to Circular 62/68, dated 15th November 1968, and to say that the Institution of Structural Engineers have given further consideration to the advice given in the Appendix to that Circular. As a result the Institution have sent to all their members a document amplifying what was said in the Appendix. This document, a copy of which is enclosed, has been considered and approved by the Minister's panel of professional advisers referred to in paragraph 6 of Circular 62/68. The Minister accordingly wishes to commend it to the attention of local authorities and their professional advisers because it answers many of the technical questions which have arisen on the application of the standards set out in the Appendix to Circular 62/68.

I am, Sir, your obedient Servant,

R. LLOYD THOMAS, *Assistant Secretary*

The Clerk of the Authority.
Local Authorities
England

INSTITUTION OF STRUCTURAL ENGINEERSDecember 1968STRUCTURAL STABILITY AND THE PREVENTION OF PROGRESSIVE COLLAPSEINTRODUCTION

1. These recommendations are concerned primarily with large residential buildings composed of prefabricated concrete panels. They are also applicable in principle to other forms of concrete structure constructed of precast concrete components and also to load-bearing brickwork construction and other tall buildings which have no structural framework.
2. All corporate members were sent on the 19 November 1968 a copy of the Ministry of Housing and Local Government circular 62/68 (dated 15 November 1968) with a covering note stating that further general recommendations on design against the progressive collapse phenomenon would be made available as soon as possible. The advice set out in this note covers the measures that should be taken by the structural engineer to prevent progressive collapse in designing new building structures and also applies to the appraisal of existing ones.
3. These recommendations should be read in conjunction with the following:-
 - (i) The Report of the Inquiry into the Collapse of Flats at Ronan Point published by H. M. Stationery Office.
 - (ii) Ministry of Housing and Local Government Circular 62/68 - Flats Constructed with Precast Concrete Panels, Appraisal and Strengthening of existing Blocks, Design of New Blocks. This document has been circulated to Local Authorities and its Appendix sets out the standards to avoid progressive collapse which should be applied pending the revision of the Building Regulations and the relevant Codes of Practice.
 - (iii) 'Wind Loading on Buildings'. November 1968. A summary of the data on the nature of wind loading and methods of assessment of wind load (BRS Digests Nos 99 and 101 published in November 1968 and to be published in January 1969 respectively) published by and available free on application from the Building Research Station, Garston, Watford, Herts.
 - (iv) British Standard Code of Practice CP 116 (1965): Clause 101 - Scope (in part); Clause 340 - Bearings for Precast Units; Clause 346 - Connections are of sufficient importance that they are set out in full in Appendix I.
 - (v) Report of a Committee on Structural Safety - Institution of Structural Engineers 1958 (copies available on loan from the Institution's library).

BASIC PRINCIPLES

4. Structural engineers should consider in their designs all the loads, forces and conditions that the buildings are likely to be required to withstand during their lifetime.

Recent events and structural failures, many of which have occurred during construction, have emphasized the need to reappraise the basis of design that is used for some contemporary forms of structure.

5. In some conventional forms of construction, experience has shown that the structures are capable of safely sustaining abnormal conditions of loading and remaining stable after the removal of primary structural members. It has been shown that some forms of building structure and particularly some industrialised large panel systems have little reserve strength to resist forces not specifically catered for in the design.
6. The Report of the Inquiry into the partial collapse of the Ronan Point flats clearly reveals that in future structural designers must take into account the possibility of gas or other explosions or other similar accidents occurring which can remove primary structural elements and lead to the progressive collapse of a significant part of the building structure.
7. It is therefore necessary to consider the possibility of progressive collapse in which the failure or displacement of one element of a structure causes the failure or displacement of another element and results in the partial or total collapse of the building.
8. Structural engineers have not in general designed their buildings specifically to resist the direct impact of domestic explosions. Where gas is a service requirement it is essential that provision is made in the design of the structure for the possibility of a gas explosion.

The Report has also emphasized the need to give more detailed consideration to the effects of wind and fire and other secondary forces such as accidental damage from vehicles.

9. It is necessary to ensure that any local damage to a structure does not spread to other parts of the structure remote from the point of mishap and that the overall stability is not impaired, but it may not be necessary to stiffen all parts of the structure against local damage or collapse in the immediate vicinity of a mishap, unless the design brief specifically requires this to be done.
10. The measures required to achieve this additional safety should be related to the magnitude of the risk. In the case of an explosion, consideration should be given to the degree and the spread of local damage arising from an explosion of predictable intensity.
11. Provision in the design to reduce the probability of progressive collapse is essential in buildings of over six storeys and is of relatively higher priority than for buildings of lower height.
12. It is expected that the effect of the spread of fire and the relative movements arising from temperature variation may be deemed to be provided for by the measures listed above.
13. Additional protection may be required in respect of damage from vehicles; further, it is necessary to consider the effect of damage to or displacement of a load-bearing member by an uncontrolled vehicle. It is strongly recommended that important structural members are adequately protected by concrete kerbs or similar methods.
14. Where it is found that aspects of the same design problem are appropriate to more than one Code of Practice, particular care is required to ensure that the final structure conforms to a consistent and safe design procedure.

PLANNING

15. In planning the accommodation, the building structure should be made as stiff as possible by incorporating substantial cross walls to buttress the main load-bearing walls and to minimise the length to be bridged if a wall section is displaced.
16. The importance of adequate buttressing of the external wall panels cannot be over-emphasized. These elements are not fully restrained on both sides by floor panels and experience shows the external wall panel connections to be the weakest points of a precast panel building.
17. It is equally important to provide restraint to all load-bearing elements at the corners of the building. These elements and the external ends of cross-wall units should be stiffened either by introducing columns as connecting units or by jointing them to nonstructural wall units which in emergency may support the load. Jointing of these units should be designed bearing in mind the need for load support in an emergency.

WORKMANSHIP AND ERECTION

18. Although large concrete panel structures have been designed specifically to keep onsite operations to a minimum, it is probable that the overall strength of this type of structure depends to a greater degree on the standard of workmanship achieved than do more traditional forms. It is therefore important that the detailing should facilitate good workmanship without difficulty.
19. Adequate site control must be established to ensure the quality and dimensional accuracy of the work as it proceeds.
20. Particular attention should be given to the soundness of any in-situ jointing operation between load-bearing members and to similar details that influence the stability of the structural framework.
21. In all aspects of the erection that affect the structural design, it is essential that the designer should agree the erection procedure with the contractor and provide the site with clear guidance upon the proper procedure to be followed.
22. Failures that have occurred during construction appear to be of two types. The first of these is the pack-of-cards type of collapse in which the absence of restraining elements such as partitions, cladding, or shear walls means that the structure is not stable during the construction period. The second is the situation in which one element falls during erection and lands on an element below. The connections of the lower element then give way under the loading, both static and dynamic, and a chain reaction of further collapse is set up.
23. To guard against the first form of failure the overall stability of a building must be considered in all its erection stages as well as in its completed state. All joints that may be required to resist moments and shears during the erection stage only, must be designed with these in mind. Temporary works required to provide stability during construction must be designed carefully.

24. To guard against the second form of failure, i.e. the dropping of a unit during erection, particular attention must be given to the details of all pre-formed units and their seatings to ensure that they are sufficiently robust to withstand the maximum stresses that can arise from site conditions. Precast concrete construction generally must be capable of withstanding the impact forces that can arise from bad workmanship on site.

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APPENDIX I

Extract from British Standard Code of Practice 116 - The Structural Use of Precast Concrete

Clause 101. Scope

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... Structural precast concrete elements are particularly suitable for incorporation in standard building systems. However, there is a danger that these standard designs may be adapted for uses different from those for which they were originally prepared, and it is therefore imperative that where any alteration of a standard design is contemplated, the strength and stability of the structure should be checked for the altered conditions...

Clause 340. Bearings for precast units

Wherever possible, precast units should have a bearing of at least 102mm (4 in) on masonry or brickwork supports and of at least 76 mm (3 in) on steel or concrete. Steel angle shelf bearings should have a 102mm (4 in) horizontal leg to allow for a 51mm (2 in) bearing exclusive of fixing clearances. When deciding to what extent, if any, these bearing widths may be reduced in special circumstances, consideration should be given to relevant factors such as tolerances, loading, span, height of wall and provision of continuity rods.

Clause 346. Connections

a) Structural requirements

- i) The overall stability of the building, including the stability during the period of construction, should be considered when designing and detailing the connections. All members should be adequately tied together at all times. Frequently, the most severe forces and stresses are applied to precast units during the various stages of handling and construction. The effects of these operations should be carefully studied, particularly at seatings and bearings, to avoid spalling of edges and corners which can lead to instability and failure.
- ii) Connections should, wherever possible, be designed in accordance with the generally accepted theories applicable to reinforced concrete, prestressed concrete or structural steel. Where, by the nature of the construction or material used, such theories are not applicable, the efficacy of the connection should be proven by tests and its use justified by reasoned analysis of the test results. Care should be taken to include in the design the effects of possible horizontal forces due to shrinkage or other causes and as far as possible provision for movement throughout the life of the building should be considered when designing and detailing the connections.
- iii) Detailed drawings of each type of connection should be made at the design stage to a sufficient scale to indicate the inter-relation of all parts of the connection. These details should allow for the effect of cumulative tolerances in dimensions allowed under Clause 407 and in addition for erection clearances in the assembly and location of projecting parts. The actual tolerances allowed by the designer should be stated on the drawings. This information should be available at the time of tender.

b) Protection

Connections should be designed to maintain the standard of protection against weather, fire and corrosion required for the remainder of the structure.

c) Appearance

Where connections are to be exposed, they should be so designed that the quality of appearance required for the remainder of the structure or building can be readily achieved. This may often be better done by expressing rather than by attempting to conceal the connections.

d) Manufacture, assembly and erection

Methods of manufacture and erection should be considered during design, and the following points should be given particular attention:

1. Where projecting bars or sections are required, they should be kept to a minimum and made as simple as possible. The lengths of such projections should not be more than necessary for security.
2. Fragile and projecting fins and nibs should be avoided.
3. Fixing devices should be located in concrete sections of adequate strength.
4. The practicability of both casting and assembly should be considered.
5. The required procedure of erection should be specified.
6. Most connections require the introduction of suitable jointing material. Sufficient space must be allowed in the design for such material to ensure that the proper filling of the joint is practicable.