STRUCTURAL BRICKWORK

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PREFACE

It is commonplace to observe that brick masonry is one of man's oldest building materials, but the design of brickwork building structures in accordance with modern structural engineering principles is quite new. It is true that isolated series of tests on walls and piers were carried out in various countries in the late nineteenth and early twentieth centuries but it was not until around the middle of the twentieth century that sufficient information was available to permit the preparation of codes of practice containing essential data on masonry strength and reduction factors for slenderness and eccentricity. The early codes provided a basis for the design of compression elements and were used on the structural design of many high-rise buildings from the late 1950s onwards.

The application of engineering principles, however, necessarily remained incomplete, as the theoretical basis for the design of masonry elements had not then been evolved and analytical procedures were rudimentary as compared to those applied to structural design in steel and concrete. The essential problem in masonry design is that of the compression element of brittle material. The theory of brittle columns having idealised end conditions was therefore the first to receive attention. A solution was in fact produced as early as 1937 but seems to have been largely overlooked and the main development of brittle column theory took place from the mid-1950s with new and modified solutions still being produced.

The practical application of these theories is limited by the difficulty of relating the assumed end conditions to the actual conditions in a building where the eccentricity of loading and the behaviour of the element are influenced by interaction between masonry walls and concrete floors. The codes of practice include empirical rules which permit the designer to arrive at a practically satisfactory result, but which have little established correlation with the real behaviour of structures. Research work on wall-floor slab interaction was undertaken in Scandinavia in the early 1960s and is reflected in the Swedish code which takes into account the position of a wall relative to the top of the building in relation to the capacity reduction factors for slenderness and eccentricity. This example has not yet been followed in other national codes but further research work has been carried out on the problem with a view to improving the rational foundation for the design of brick masonry walls and columns.

The interaction between walls and floor slabs is also of importance in relation to wind loading. This became of importance with the construction of high-rise

buildings with slender walls for which accurate methods of lateral load analysis were required. The earliest methods omitted consideration of the bending moments in inter-connecting floors or beams and distributed the wind moment among the walls in proportion to their stiffness. This method was extended in the 1950s to deal with torsional effects. Later, more refined methods, originally derived for reinforced concrete shear walls, were applied to brickwork structures and their validity was checked by large-scale tests on sections of brickwork construction.

While these analytical methods were being developed, a more complete understanding of the behaviour of brickwork under compressive and shear stresses was being promoted and, although still incomplete, has strengthened the purely empirical basis of the design codes.

Experience has shown that brickwork structures are remarkably resistant to accidental forces, such as gas explosion and vehicle impact, but during the late 1960s and early 1970s public concern developed as a result of a number of building failures from such causes. A considerable amount of research work was therefore carried out during this period to provide quantitative information on the resistance of brickwork structures and elements to accidental damage. This work has been carried out mainly in the United Kingdom, where the concern seems to have been greatest.

The strength of brick panels under lateral loading has also attracted a great deal of attention during the past decade. This has arisen from the requirement in a number of countries to justify the stability of such walls against prescribed wind loadings, which have been increased in recent years, and to arrive at wall thicknesses that would be economically acceptable and consistent with existing experience. This has proved to be a difficult task and although partially solved by extensive testing still awaits a comprehensive theoretical solution. Laterally loaded walls with precompression or with boundary restraint giving rise to in-plane forces have also been investigated. These are capable of resisting very much higher lateral pressures than the non-loadbearing panels referred to above, and in this case theoretical treatment has proved easier to develop and is relevant to consideration of resistance of brickwork structures to explosive forces.

Reinforced brickwork has been used on occasions for a great many years especially in countries such as India and the United States, which have to contend with earthquakes. Research work on reinforced masonry beams was carried out early in the twentieth century, but only recently has interest in this form of construction emerged in Western Europe, giving rise to research programmes in this field. It is probable that economic factors will favour this development which is likely to extend to the application of prestressing techniques to brickwork elements.

The whole field of research in brickwork construction has developed remarkably since the mid-1960s, and has been reflected by the holding of regular conferences devoted to the subject since 1967. Many papers have also appeared in technical journals and in the proceedings of national symposia during the same period, so that a considerable literature exists on most of the problems outlined above. The object of this book is to review existing knowledge of the

structural engineering aspects of brick masonry construction. It is hoped that this will be of service to structural engineers by enabling them to extend their knowledge of the subject beyond the limits of codes of practice, and that it will help to place the structural design of brick masonry on a scientific and technical basis comparable to that of steel and concrete.

I acknowledge my debt to the numerous authors whose work I have quoted. I am particularly indebted to my colleagues and research students in Edinburgh University who, over the years, have contributed greatly to our practical and theoretical knowledge of brickwork. Finally, I express my thanks to the brick industry in the United Kingdom for their support of my research work and to my many friends in the masonry world for their comradeship and for their encouragement in pursuing my studies of brickwork construction.

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