5. Commercial Buildings

5.1. Introduction

In contrast to the industrial structures discussed in Section 4, where the criterion controlling the framing arrangement was often building function, the commercial or office type building is usually of a more regular layout. It is this characteristic which allows the greatest economy to be obtained through standardisation and repetition of structural elements and connections.

This category of steel building comprises a grid of steel beams connected to steel columns (or composite columns or concrete shear walls) using either simple or rigid connections. Resistance to lateral loads may be provided by using some form of bracing with steel elements or other types such as in-fill walls or shear walls, or by frame action using rigid connections.

This type of building can be divided into two categories:

(a) Low-Rise Commercial – e.g. suburban office blocks of up to four storeys, schools, shopping centres, etc.

(b) High-Rise Commercial – e.g. city office buildings.

5.2 Low-Rise Commercial Buildings

This category can be further sub-divided into:

- Fully steel-framed structures.
- Composite frames (steel frames connected to concrete cores or utilising masonry in-fill panels).

5.2.1 FULLY STEEL-FRAMED

Low-rise buildings fully framed in steel offer advantages in building speed and therefore in the overall economy of the final building. Because low-rise buildings do not require large stabilising elements, a steel frame using only simple connections can be used, offering economy in both fabrication and erection. The stabilising element is usually provided in the form of a steel cross-bracing system in one or two directions which can be incorporated in a façade treatment so as not to intrude into window openings.

Another framing system which has been used successfully for low-rise buildings is the one-way-rigid, one-way-braced system (see Figure 5.1).

This is essentially an extension of the industrial portal frame structure and results in an economic solution for small commercial buildings where freedom of layout and planning can be provided across the building width since no internal columns or bracing elements are necessary.

In the design of such a building, it should be recognised that bays of equal size will assist in gaining maximum economy by allowing the repetitive use of similar sized beam and column sections. The economic detailing of beams and columns is most important in achieving overall economy and aspects of this are contained in Section 8.

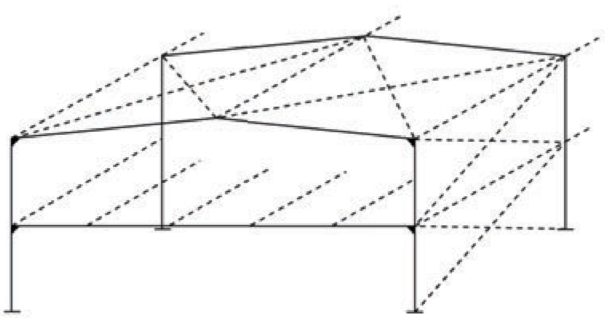

FIGURE 5.1: Framing system for low-rise commercial building

Undoubtedly the greatest advantage of a fully steel framed structure lies in the ability to erect the entire structural framework on prepared footings, as a self sustaining system before any other building trades are required onsite. With proper planning, this feature can lead to faster building speed and the elimination of many of the problems associated with diverse trades on site simultaneously.

5.2.2 COMPOSITE FRAMES

Currently a favoured type of construction for steel low-rise commercial buildings is the provision of a stabilising element comprising a masonry or reinforced concrete core, with the steel floor beams connected with simple connections between periphery steel columns and the concrete core. For the low-rise commercial building, it is also common to use in-fill masonry panels to provide lateral stability. Examples of these systems are shown in Figure 3.7.

Typical details of such a framing arrangement are shown in Figure 5.2 for the case where masonry panels are used to provide the stabilising element in a building frame.

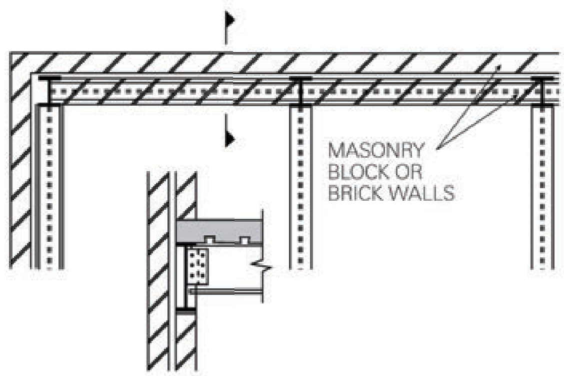

Figure 5.2: Stability by masonry

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For the case shown in Figure 5.2 it should be remembered that the steel frame must be effectively temporarily braced during erection and properly plumbed before the brickwork or blockwork can be laid. If the temporary bracing has to be removed after stability is provided by the infill panels, it could be placed on the inner flange of the columns in order to facilitate later removal and in order not to interfere unduly with the masonry work.

Figure 5.3 shows an alternative method of providing a stabilising element in the form of a concrete panel cast between two adjacent steel columns and tied into each. In this case, the wall thus produced would normally be considered as load-bearing and would support stair-landings etc., throughout the height of the building.

In addition to the concept of composite frames, the use of composite beam-slab systems will provide best economy in these buildings. This is discussed in Clause 5.5.

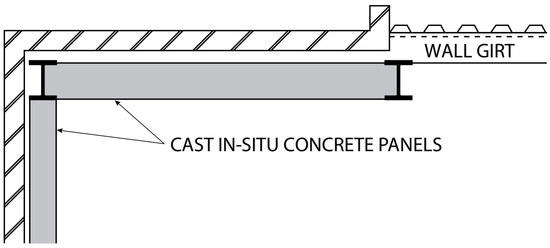

FIGURE 5.3: Stability by concrete panels

5.3 High-Rise Commercial Buildings

5.3.1 GENERAL

In Australia at present a high-rise commercial building will usually be a city office block of up to 50 floors. In these buildings, a regular column grid can be established resulting in repetitive bays in one or both directions. As previously mentioned, regularity of bays is important since it leads to maximum economy due to repetition.

The architectural and aesthetic requirements usually control the exterior column spacing and therefore the bay sizes. A panel wall design with columns contained within the wall thickness allows maximum freedom in bay size selection, whereas when columns are exposed externally as an architectural feature this results in the least flexibility in bay size selection. Bay sizes should be selected to produce minimum storey height. It is noteworthy that a saving of 75 mm per floor in a 20 storey building will save 1500 mm of exterior and interior wall, partitioning, columns, lifts, etc. On the other hand, columns cannot be spaced so closely as to detract from the usefulness of the space through which they pass. Selection of bay sizes is always a compromise between these two considerations.

In a way similar to low-rise commercial buildings, high-rise commercial buildings can be sub-divided into:

- Fully steel-framed structures.
- Steel frames connected to reinforced concrete cores.

In the selection of the best framing system, the most important consideration is to find a structural form which is highly efficient under lateral loadings and which does not require an unreasonable premium in frame cost to resist those forces.

A vast number of alternative steel framing systems have been successfully used in the past, but not all of these are economic under today's conditions. Figure 5.4 shows some of the frame types suitable for buildings of various heights.

5.3.2 FULLY RIGID FRAME

From a planning and layout point of view this system obviously creates maximum freedom since no stabilising elements are required in the vertical planes of the building framework.

The system is suitable for buildings up to 30 storeys in height but should be considered only when constraints of planning and layout are unavoidable.

It has the advan tage of allowing efficient use of material because of the considerable interaction between beams and columns due to the use of rigid connections with resultant continuity in beams. However, in today's situation, rigid connections are more costly to fabricate and this will often offset any savings in material. In addition columns will generally be more expensive because equal stiffness about both axes is required.

In the USA where frames of this type have been in use for many years, the basic method was to erect columns and field-weld beams at floor levels (see Figure 5.5).

However, since this method required the field welding of the most critical joints in the structure where both high quality welds and high construction speed was required (both being subject to weather and operator skill), this method has been refined by transferring the welding operation from the field back into the shop. This is accomplished by using the 'Christmas Tree' concept as shown in Figures 5.6 and 7.9.

In view of the relative costs of shop and field welding, the stub girder shop welded to the column will generally prove a more economic solution for rigid framework.

5.3.3 FULLY BRACED FRAMES

Fully braced frames of the type mentioned below are 'braced tubes' where stability against lateral forces is provided by the braced action of the external building wall framing.

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