

3. MULTI – STOREY BUILDINGS

3.1 Introduction

In developed countries a very large percentage of multi-storeyed buildings are built with steel where as steel is not so commonly used in construction of multi-storeyed frames in India even though it is a better material than reinforced concrete. The use of steel in multi-storey building construction results in many advantages for the builder and the user. The advantages of using steel frames in the construction of multi-storey buildings are listed below:

- Steel, by virtue of its high strength to weight ratio enables large spans and light weight construction.
- Steel structures can have a variety of structural forms like braced frames and moment resistant frames suitable to meet the specific requirements.
- Steel frames are faster to erect compared with reinforced concrete frames resulting in economy.
- The elements of framework are usually prefabricated in the factory under effective quality control thus enabling a better product.
- Subsequent alterations or strengthening of floors are relatively easy in steel frames compared with concrete frames.
- The steel frame construction is more suitable to withstand lateral loads caused by wind or earthquake.

3.1.1 Structural configurations

The structural components in a typical multi-storey building, consists of a floor system which transfers the floor loads to a set of plane frames in one or both directions. The floor system also acts as a diaphragm to transfer lateral loads from wind or earthquakes. The frames consist of beams and columns and in some cases braces or even reinforced concrete shear walls. As the height of the building increases beyond ten stories (tall building), it becomes necessary to reduce the weight of the structure for both functionality and economy. For example a 5% reduction in the floor and wall weight can lead to a 50% reduction in the weight at the ground storey. This means that the columns in the lower storeys will become smaller leading to more availability of space and further reduction in the foundation design.

Floor systems

Since concrete floors are functionally more suitable, have less vibration and more abrasion and fire resistance, the usual tendency is to make them act either with profiled steel decks and/or with steel beams to give a light weight floor system. Similarly masonry walls may be replaced with glazing and curtains or blinds to reduce the weight. The different types of floors used in steel-framed buildings are as follows:

- a) Concrete slabs supported by open-web joists
- b) One-way and two-way reinforced concrete slabs supported on steel beams
- c) Concrete slab and steel beam composite floors
- d) Profiled decking floors
- e) Precast concrete slab floors.

Concrete slabs supported with open-web joists

Steel forms or decks are usually attached to the joists by welding and concrete slabs are poured on top. This is one of the lightest types of concrete floors. For structures with light loading, this type is economical. A sketch of an open-web joist floor is shown in Fig.3.1.

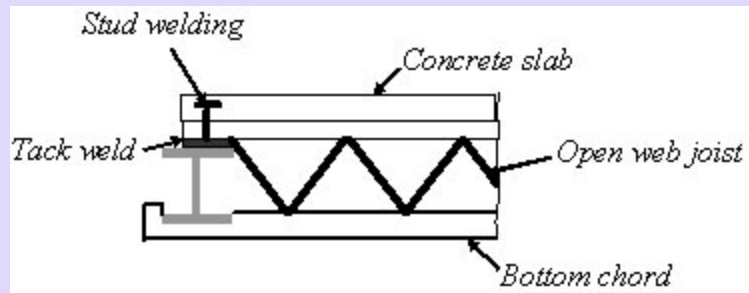


Fig.3.1 Open- web joists

One-way and two-way reinforced concrete slabs.

These are much heavier than most of the newer light weight floor systems and they take more time to construct, thus negating the advantage of speed inherent in steel construction. This floor system is adopted for heavy loads. One way slabs are used when the longitudinal span is two or more times the short span. In one-way slabs, the short span direction is the direction in which loads get transferred from slab to the beams. Hence the main reinforcing bars are provided along this direction. However, temperature, shrinkage and distribution steel is provided along the longer direction.

The two-way concrete slab is used when aspect ratio of the slab i.e. longitudinal span/transverse span is less than 2 and the slab is supported along all four edges. The main reinforcement runs in both the directions. A typical cross-section of a one-way slab floor with supporting steel beams is shown in Fig.3.2. Also shown is the case when the steel beam is encased in concrete for fire protection.

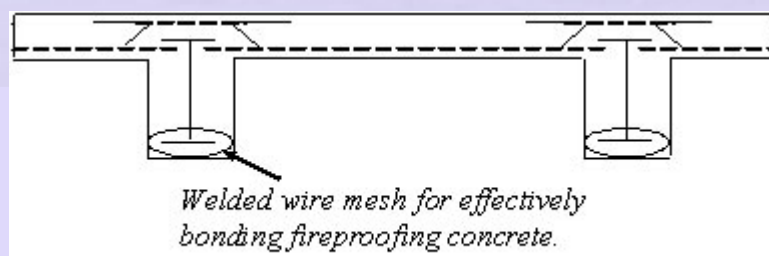


Fig.3.2 Cross section of one-way slab floor

Composite floors with a reinforced concrete slab and steel beams

Composite floors have steel beams bonded with concrete slab in such a way that both of them act as a unit in resisting the total loads. The sizes of steel beams are significantly smaller in composite floors, because the slab acts as an integral part of the beam in compression. The composite floors require less steel tonnage in the structure and also result in reduction of total floor depth. These advantages are achieved by utilising the compressive strength of concrete by keeping all or nearly all of the concrete in compression and at the same time utilises a large percentage of the steel in tension. The types of composite floor systems normally employed are shown in Fig. 3.3.

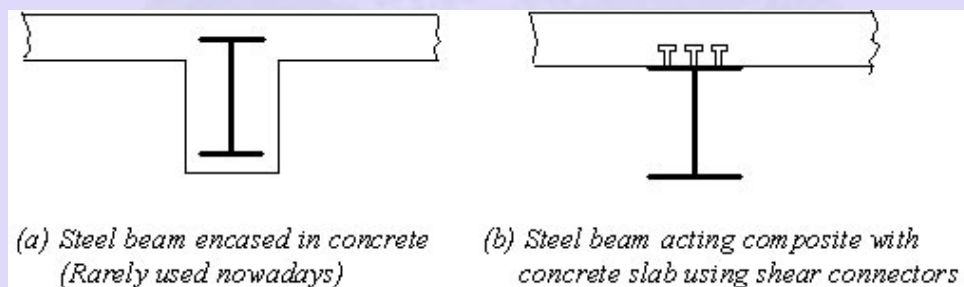


Fig.3.3 Composite floors

Profiled steel decking floors

Composite floor construction consisting of profiled and formed steel decking with a concrete topping is also popular for office and apartment buildings where the loads are not very heavy. The advantages of steel-decking floors are given below:

- (i) They do not need form work
- (ii) The lightweight concrete is used resulting in reduced dead weight
- (iii) The decking distributes shrinkage strains, thus prevents serious cracking
- (iv) The decking stabilises the beam against lateral buckling, until the concrete hardens
- (v) The cells in decking are convenient for locating services.

More details of composite construction using profiled decking floors are provided in the chapter on Industrial Buildings.

Precast concrete floors

Precast concrete floors offer speedy erection and require only minimal formwork. Light-weight aggregates are generally used in the concrete, making the elements light and easy to handle. Typical precast concrete floor slab sections are shown in Fig.4.4. It is necessary to use cast in place mortar topping of 25 to 50 mm before installing other floor coverings. Larger capacity cranes are required for this type of construction when compared with those required for profiled decking. Usually prestressing of the precast elements is also done.

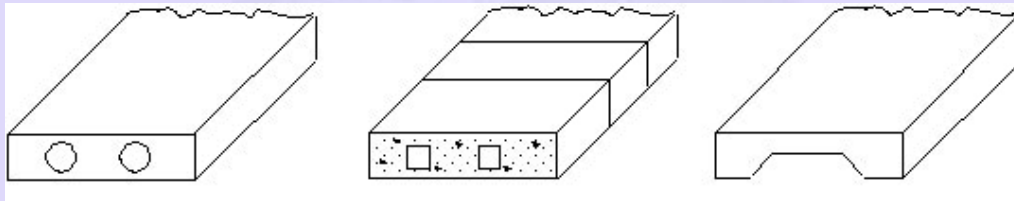


Fig.4.4 Precast concrete floor slabs

1.1.2 Lateral load resisting systems

The lateral loads from wind and earthquakes are resisted by a set of steel frames in orthogonal directions or by reinforced concrete shear walls. Steel frames are broadly classified as braced-frames and moment-resisting frames depending on the type of configuration and beam-to-column connection provided.

Moment resisting frames

Moment resisting frames (Fig. 3.5a) rely on the ability of the frame itself to act as a partially (semi-) or fully rigid jointed frame while resisting the lateral loads. Due to their flexibility, moment resisting frames experience a large horizontal deflection called drift (Fig. 3.5), especially in tall buildings but can be used for medium rise buildings having up to ten stories. The rigid connection types discussed in the chapter on beam-to-column connections can be used in such frames.

Braced frames

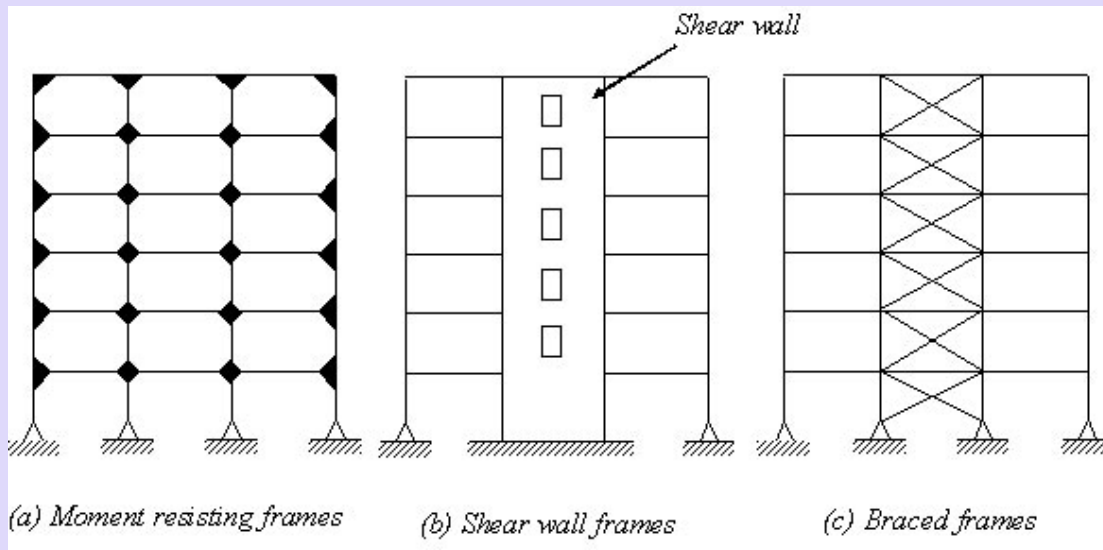


Fig. 3.5 Lateral load resisting systems

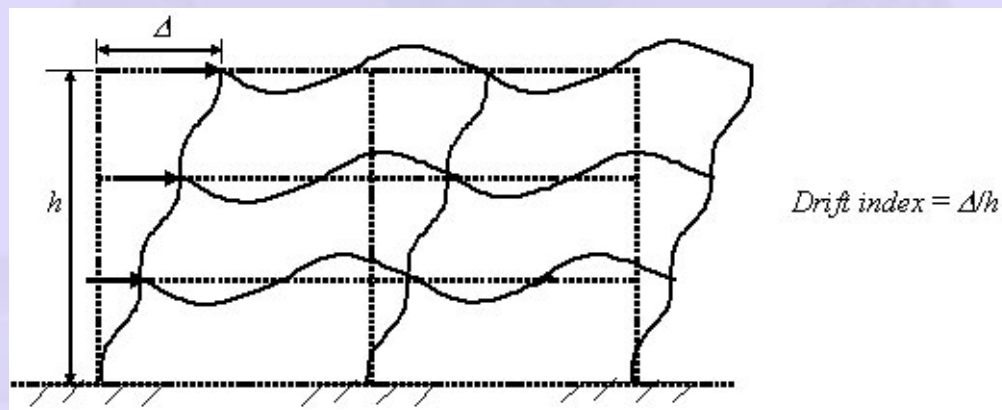


Fig. 3.6 Lateral drift

Braced Frames (Fig. 3.5c) are usually designed with simple beam-to-column connections where only shear transfer takes place but may occasionally be combined with moment resisting frames. In braced frames, the beam and column system takes the gravity load such as dead and live loads. Lateral loads such as wind and earthquake loads are taken by a system of braces. Usually bracings are provided sloping in all four directions because they are effective only in tension and buckle easily in compression. Therefore in the analysis, only the tension brace is considered effective. Braced frames are quite stiff and have been used in very tall buildings.