Analysis and Design of Multi-Storeyed Building by Steel Concrete Composite Structure

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Abstract

This paper has been envisaged which consists of analysis and design of multi-storeyed building using steel concrete composites. The building is analysed by using Sap 2000 and designed according to codal provisions. Steel concrete composite means the concrete slab is connected to the steel beam with the help of shear connectors, so that they act as a single unit. Steel concrete composite construction is now a day’s very popular owing to their advantages over conventional concrete and steel structures. Concrete structure is bulky and imparts more seismic weight and less deflection whereas steel structure imparts more deflection and ductility to the structure, which is beneficial in resisting earthquake forces. In the present work a simplified method of composite slab, beam and composite column design is used and software is developed with pre and post processing facilities in Sap2000. The screenshots are included in the paper to illustrate the method employed for designing composite slab, beam and column.

Keywords: Composite Column, Composite Slab, Sap2000, Shear Connectors

I. INTRODUCTION

Steel-concrete composite systems have become quite popular in recent times because of their advantages against conventional construction. Composite construction combines the better properties of both i.e. concrete and steel and results in speedy construction with a possibility of working on parallel front. In case of a composite structure, steel imparts ductility to the structure which has ability to absorb seismic energy imparted on the structure by the earthquakes and concrete prevents steel from corrosion and fire. The key feature of this system is composite action between a concrete slab and a steel beam which is achieved through the shear connection system which significantly increases the rigidity and the ultimate moment capacity of the composite beam compared with the properties of a bare-steel or reinforced concrete beam. In this way much larger beam spans can be achieved.

Composite frames used for multi-storey buildings usually comprise of a bare-steel frame of H-section columns supporting I-section beams, laid out in a rectangular grid of primary (shortest span) and secondary members; supporting an overlaid composite floor deck. The composite deck system consists of cold-formed profiled steel sheets which act not only as the permanent formwork for an in situ cast concrete slab but also to some extent as tensile reinforcement.

Composite floors using profiled sheet decking have become quite popular for high-rise buildings. In composite floor, the structural behavior is similar to a reinforced concrete slab with the steel sheeting acting as the tension reinforcement. The main benefit of using composite floors with profiled steel decking is saving in steel weight up to 30 to 50% over non-composite construction.

II. LITERATURE REVIEW

A. Dr.W.N.Deulkar

Reported that the steel composite buildings are formed by connecting the steel beams with concrete or profiled deck slab with the help of mechanical shear connectors so that slab and beam acts as a single unit. He suggested that steel concrete composite building is found to be more safe and economical. The self-weight of the steel concrete composite structure is reduced by 9.48% as compared to reinforced concrete structure.
Analysis and Design of Multi-Storeyed Building by Steel Concrete Composite Structure

B. L.G.Kalurkar

Reported that the stiffness in composite structure is increased by 12% to 15% in transverse direction and about 6% to 10% in longitudinal direction as compared to reinforced concrete structure. In composite structure the lateral displacement are reduced from 41% to 58% in transverse direction and about 37% to 57% in longitudinal direction than the reinforced concrete structure.

III. ELEMENTS OF COMPOSITE STRUCTURE

Steel concrete composite system can provide economical structural system to resist lateral load with high durability, rapid erection and superior seismic performance characteristics. A steel concrete composite building consists of a composite column, structural steel beam, over which the reinforced concrete slab is cast with shear connectors between beam and slab.

A. Composite Slab

A composite slab is defined as a floor system comprising normal concrete placed permanently over cold formed steel deck in which the steel deck performs dual role of acting as a form work for the concrete during construction and tension reinforcement after the concrete has hardened. At the final stage the composite slab consists of a profiled steel sheet and an upper concrete topping which are interconnected in such a manner that horizontal shear force can be resisted the steel concrete interface.

B. Profile Sheet Decking

Profile sheets are basically cold formed sheets made of thin steel coils. The profile sheet generally ranges from 45mm to over 200mm, profile sheets are normally between 0.8mm and 1.5mm thick, and are protected from corrosion by a zinc coating about 0.02mm thick on each face. There are two types of profiles
- Re-entrant profile sheet
- Trapezoidal profile sheet

Re-entrant profile sheet are most widely because they provide better shear resistance comparing to trapezoidal profile sheet.

C. Shear Connector

The most widely used type of connector is the headed stud. The shear connector are device which are welded to the top flange of the steel section and intended to transmit the horizontal shear between the steel section and cast-in-situ concrete shear connectors are intended to resist the horizontal movement between the composite slab and steel beam and to transmit the horizontal shear between the two.

Fig. 1: Composite slab

D. Composite Column

A steel concrete composite column is a compression member, comprising either a partially concrete encased hot-rolled steel section or concrete filled in hollow section of hot-rolled steel. It is generally used as a load bearing member in a composite framed structure. In composite column both the steel and concrete would resist the external loading by interacting together by bond and friction. The use of composite column along with composite decking and composite beam it is possible to erect high
rise structure in an extremely efficient manner. Composite column increase the strength and stiffness and provides increased buckling resistance. Partially concrete encased provides high bearing resistance.

E. Composite beam

Steel concrete composite beam consists of a steel beam over which a reinforced concrete slab is cast with the shear connectors. In conventional composite construction, concrete slabs are simply rested over steel beams and supported by them. These two components act independently under the action of loads because there are no connection between concrete and steel beam. when shear connector is provided between concrete slab and steel beam the slip between them is eliminated and steel beam and concrete slab act as a composite beam.

IV. BUILDING DESCRIPTION

The building considered here is a commercial (office) building having G+ 3 storeys. The building is planned in a manner to facilitate the basic requirement of an office building. Separate provision for car parking, staircase has been made in the plan. The plan dimension of the building is 19.81mX24.39m. The height of each storey is kept as 3.7m and total height of the building is 14.8m. The plan of the building along with position of the column and beam is shown in figure 2.

The grade of concrete is considered as M20 and grade of structural steel is Fe250. The live load at roof level is 1.5KN/m² and the live load at all other floor is 4KN/m². The density of concrete is 25KN/m³ and the density of brick masonry is 20KN/m³.

![Fig. 2: Position of Beam and Column](image)

V. PROCEDURE OF MODELING AND ANALYSIS

The building is modelled by using Sap2000. The main objective of modelling the structure is to study the performance of the structure which is implemented with steel concrete composite construction. By using grid line option in sap2000 the model of the building can be generated. The properties of material are assigned by using define menu. For beam ISMB300 is assigned and for composite column ISMB450 is assigned. In section designer option, properties of beam and column are assigned according to codal provisions (IS 800-2007). The thickness of composite slab is 130mm.

Composite slab which consists of re-entrant profile sheet along with upper concrete topping is also created by using section designer. The base joint of all columns are restrained against translation and rotation about all the three global axes. The fixed support is assigned. After creation of model, the various loading condition are assigned and then the building is analysed by sap2000.
F. Design Aspect of Composite Slab

The design of composite slab is carried out according to codal provisions. Here plastic analysis of composite section under factor load is also considered. Shear connectors such as studs are welded to the top flange of steel section and are intended to transmit the horizontal shear between the steel section and concrete and also prevent the vertical separation of the interface. Here screen shots of a program developed in sap2000 for design of composite slab are shown.
G. Design Aspect of Composite Column

Steel column in multi-storey buildings need protection from, this is often provided by encasement in concrete. The presence of the concrete is allowed for in two ways. It is assumed to resist a small axial load and to reduce the effective slenderness of the steel member, which increases its resistance to axial load. Resistance to bending moment is assumed to be provided entirely by the steel. No account is taken of the resistance of the longitudinal reinforcement in the concrete. In composite constructions, the bare steel sections support the initial construction loads, including the weight of structure during construction. Concrete is later cast around the steel section, or filled inside the tubular sections. In case of concrete filled hollow sections, the steel provides a permanent formwork to the concrete core. This leads to the appreciable saving in the time and cost of erection. Partially encased sections have the advantage of acting as permanent formwork; the concrete is placed in two stages with the section. In order to ensure adequate force transfer between the steel and concrete it is necessary sometime to use stud connectors. Here screen shots of a program developed in sap2000 for design of composite column are shown.

![Composite slab created by section designer in sap2000.](image)

![Assigning material properties for composite column](image)
Design Aspect of Composite Beam

A steel concrete composite beam consists of a steel beam over which a reinforced concrete slab is cast with shear connectors. The composite action reduces the beam depth. When a shear connector is provided between concrete slab and steel beam, the slip between them is eliminated. The basic concept of composite beam lies in the fact that the concrete is stronger in compression than steel which is susceptible to buckling under compression and steel is stronger in tension. By using the composite action of these two, the advantage of both materials is utilized.

Fig. 8: Assigning material properties and creation of beam
VI. RESULTS

Fig. 9: Assigning loading conditions

Fig. 10: 3-D model generated by sap2000
VII. CONCLUSION

Sap 2000 is a standalone finite element based structural program for analysis and design of civil structures. It offers an intuitive yet powerful user interface with many tools to aid in the quick and accurate construction of models, along with the sophisticated analytical techniques to do the most complex projects. Composite column, beam and composite slab is designed by using section designer in sap2000 and analysed.

REFERENCES