INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

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COMPARATIVE STUDY OF R.C.C AND COMPOSITE STRUCTURE

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Accepted Date: 15/03/2016; Published Date: 01/05/2016

Abstract: Steel concrete composite construction means the concrete slab is connected to the steel beam with the help of shear connectors so that they act as a single unit. In the present work steel concrete composite with RCC options are considered for comparative study of G+15 story commercial building which is situated in earthquake zone-III and for earthquake loading, the provisions of IS: 1893(Part1)-2002 is considered. A three dimensional modeling and analysis of the structure are carried out with the help of SAP 2000 software. Equivalent Static Method of Analysis and Response spectrum analysis method are used for the analysis of both Composite & R.C.C. structures. The results are compared and found that composite structure more economical)

Key words: Composite beam, Column, RCC column, RCC beam, Shear Connector, SAP 2000 Software. etc

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Access Online On:

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How to Cite This Article:

Mahesh Suresh Kumawat, IJPRET, 2016; Volume 4 (9): 87-97

PAPER-QR CODE

INTRODUCTION

The use of Steel in construction industry is very low in India compared to many developing countries. Experiences of other countries indicate that this is not due to the lack of economy of Steel as a construction material. There is a great potential for increasing the volume of Steel in construction, especially the current development needs in India. Composite construction essentially different materials are completely compatible and complementary to each other; they have almost the same thermal expansion; they have an ideal combination of strengths with the concrete efficient in compression and the steel in tension; concrete also gives corrosion protection and thermal insulation to the steel at elevated temperatures and additionally can restrain slender steel sections from local or lateral-tensional buckling. This paper includes comparative study of R.C.C with Composite Story building Comparative study includes Storey Stiffness , Displacement, Drifts, Axial Force in column , Shear force in column, Twisting Moment, Bending Moments in composite with respect to R.C.C. Sections. Steel-concrete composite frame system can provide an effective and economic solution to most of these problems in medium to high-rise buildings.

a) Shear Connectors:-Shear connections are essential for steel concrete construction as they integrate the compression capacity of supported concrete slab with supporting steel beams to improve the load carrying capacity as well as overall rigidity.

b) Composite Slab:- The loads are applied in such a way that the load combination is most unfavorable. Load factors of 1.5 for both dead load and imposed load are employed in design calculations

c) 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.

d) Composite Column:- column is conventionally a compression member in which the steel element is a structural steel section. There are three types of composite columns used in practice.

2) Building Description:-

The building considered here is an office building having G+15 stories located in seismic zone III. The building is planned to facilitate the basic requirements of an office building. The building plan is kept symmetric about both axes. Separate provisions are made for car parking, lift, staircase, security room, pump house and other utilities. However they are excluded from scope of work. The plan dimension of the building is 24.00m by 36.00m which is on land area of about 1800m^2. Height of each storey is kept same as 3.5m and the total height of building is kept as 38.5m. Columns are placed at 6m center to center and are taken to be square, as the square columns are more suitable for earthquake resistant structures.

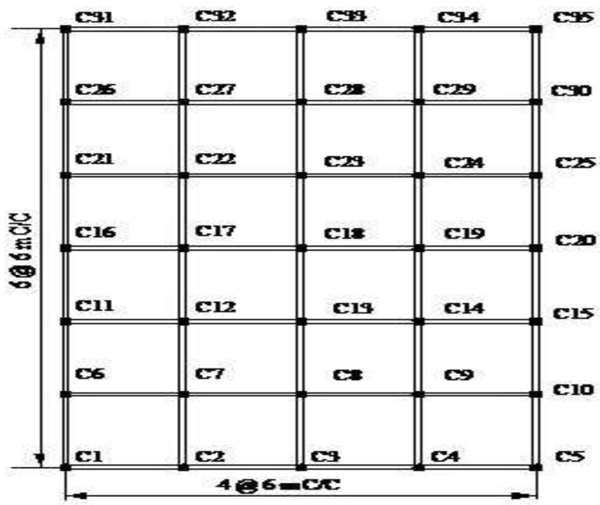


Fig:- 01 , Plan of building

3) Data for analysis of Composite & R.C.C structure

The study is carried on the same building plan for RCC and composite constructions with some basic assumptions made for deciding preliminary sections of both the structures. The basic loading on both type of structures are kept same.

Table .01

Particulars	Composite	RCC
Size of beams	ISMB400@61.6kg/m	300mm X 600mm
Size of columns	500X500mm (SC250@85.6kg/m+125mmconcrete cover)	700mm X 700mm
Damping	5%	3%

4) Modeling of building:-

The RCC and Composite building are modeled using the finite element software SAP 2000. The analytical models of the building include all components that influence the mass, strength, stiffness and deformability of structure. The building structural system consists of beams, columns, slab, walls, and foundation. The non-structural elements that do not significantly influence the building behavior are not modeled. Beams and columns are modeled as two noded beam element with six DOF at each node. The floor slabs are assumed to act as diaphragms, which insure integral action of all the vertical load resisting elements and are modeled as four noded shell element with six DOF at each node. Walls are modeled by equivalent strut approach and wall load is uniformly distributed over beams. The diagonal length of the strut is same as the brick wall diagonal length with the same thickness of strut as brick wall, only width of strut is derived. Walls are considered to be rigidly connected to the columns and beams.

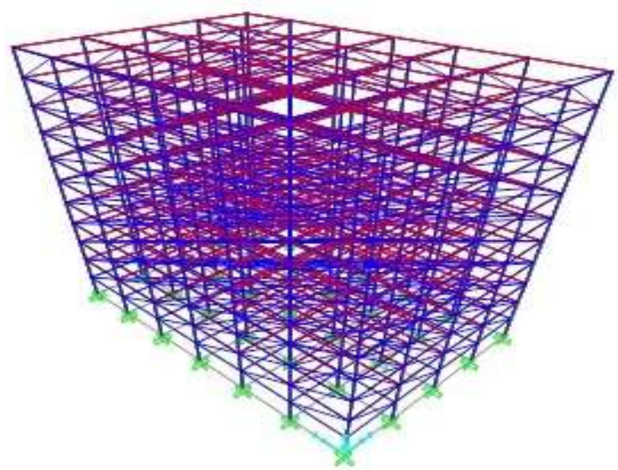


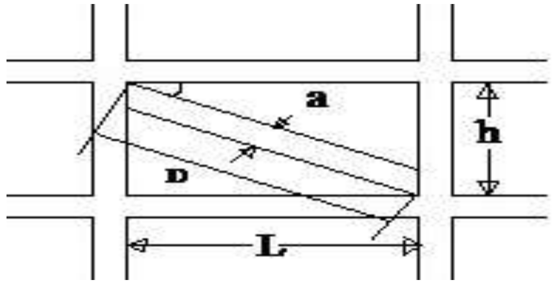
Fig:- 02, RCC and composite building model generated in SAP 2000

5) Modeling of masonry infill:-

Infill wall located in a lateral load resisting frame, the stiffness and strength contribution of the infill are considered by modeling the infill as an equivalent compression strut. The key to the equivalent diagonal strut approach lies in the determination of the effective width of the strut.

a) Equivalent strut method:-

Infill parameters (effective width, elastic modulus and strength) are calculated using the method recommended by Smith. The length of the strut is given by the diagonal distance "D" of the panel and its thickness is given by the thickness of wall. Calculation of equivalent width "a" of the strut.



i) Parameters of equivalent Strut

The initial elastic modulus of the strut E_i is equated to the E_m the elastic modulus of masonry, as per UBC (1997), E_m is given as $750 f_m$. where f_m is the compressive strength of masonry in MPa. The effective width depends on the relative stiffness of the infill frame, the magnitude of the diagonal load and the aspect ratio of the infilled panel. Calculation of equivalent width of strut for RCC structure. The relative stiffness of the infill to the frame is expressed in terms of parameter λ.

$\lambda = [E_m \, t \sin 2\theta / 4 \, Ec \, Ic \, h]^{1/4}$ &

$\theta = \tan^{-1}(h/L)$

Equivalent width of strut =

$a = 0.175 \, D \, (\lambda H)^{-0.4}$

Where, L = clear length of panel

E_m = Elastic modulus of infill material

Ec = Elastic modulus of concrete in column

Ic = Moment of inertia of each column

θ = Slope of infill diagonal to the horizontal

H = Overall height of column

h = clear height of column

D = diagonal length of strut

t = thickness of strut

6) Analysis of building:-

The code recommends following methods of analysis.

1. Equivalent static analysis

2. Dynamic Analysis

a. Response spectrum Analysis

1. Equivalent static analysis :-

The weight of all the floors and the roof is calculated and total seismic weight of the building is found out.

$$W = \sum_{i=1}^{n} Wi$$

The approximate fundamental natural period of vibration (T_a), in seconds, of all buildings, including moment-resisting frame buildings with brick infill panels, is estimated by the empirical expression.

$$Ta = \frac{0.09h}{\sqrt{d}}$$

h = Height of building & d = Base dimension of the building at the plinth level.

The design horizontal seismic coefficient A_h for a structure.

$$Ah = \frac{Z}{2} \, x \, \frac{I}{R} \, x \, \frac{Sa}{g}$$

Where,

Z = Zone factor for the maximum considered earthquake (MCE).

I = Importance factor, depending upon the functional use of structure.

R = Response reduction factor.

Sa/g = Average response acceleration coefficient for rock or soil site based on appropriate natural period and damping of structure.

The total design lateral force or design seismic base shear.

$$Vb = Ah\ x\ W$$

The design base shear computed as above is distributed along the height of building.

$$Qi = Vb\ x\ \frac{WiHi^2}{\sum_{j=1}^{n} Wjhj^2}$$

Where, W_i = Seismic weight of floor i,

Q_i = Design lateral force at floor i,

h_i = Height of floor i measured from the base

n = Number of storeys in the building

2.a Response spectrum analysis:-

Response Spectrum analysis allow the users to analyze the structure for seismic loading. For any supplied response spectrum (either acceleration v/s period or displacement v/s period) joint displacements, member forces and support reaction may be calculated. Model response may be combined either square root of sum of squares (SRSS) or complete quadratic combination (CQC) method to obtain the resultant response, as given in clause 7.8.4.4 of code IS1893(Part I):2002.

Building with regular or nominally irregular plan configuration may be modeled as the system of masses lumped at the floor levels with each mass having one degree of freedom, that of lateral displacement in the direction under consideration. In such case, the following expressions shall hold in the computation of various quantities

The modal mass (M_k) of mode *k* is given by

$$Mk = \frac{[\sum_{i=1}^{n} Wi\emptyset ik]^2}{g\sum_{i=1}^{n} Wi[\emptyset ik]^2}$$

Where,

g = Acceleration due to gravity.

ϕ_{ik} = Mode shape coefficient at floor *i* in mode k. , W_i = Seismic weight of floor *i*.

The modal participation factor (P_k) of mode *k* is given by

$$Pk = \frac{[\sum_{i=1}^{n} Wi\emptyset ik]^2}{g\sum_{i=1}^{n} Wi[\emptyset ik]^2}$$

The peak lateral force (Q_{ik}) at floor *i* in mode *k* is given by

$$Qik = Ak\ \emptyset ik\ Pk\ Wi$$

Where,

A_k =Design horizontal acceleration spectrum value as per 6.4.2 of IS 1893-2002 using the natural period of vibration (T_k) of mode *k*

The peak shear force (V_{ik}) acting in the storey *i* in mode *k* is given.

$$Vik = \sum_{j=i+1}^{n} Qik$$

7) RESULT AND DISCUSSION:-

i) The storey stiffness for composite structures is about 12% to 15% more in transverse direction & 6% to 10% more in longitudinal directions than R.C.C

ii) The displacement in composite structures is reduced by 41% to 58% in transverse direction & 37% to 57% reduced in longitudinal directions than R.C.C

iii) The storey drift in composite structures is reduced by 35% to 50% in transverse direction & 27% to 38% reduced in longitudinal directions than R.C.C

iv) Axial force in composite column is reduced by 20% to 30% & reduction in the dead than R.C.C. columns

v) The shear force in composite column is reduced by 28% to 44% in transverse direction & 24% to 40% reduced in longitudinal directions than R.C.C

vi)The twisting moment observed exterior corner column are reduced by 48% to 63% in transverse direction & 49% to 65% reduced in longitudinal directions than R.C.C structures

vii) The bending moment in composite column are reduced up to 22% to 45% in transverse direction & 23% to 47% reduced in longitudinal directions than R.C.C

viii) Axial force in composite beam is reduced by 8% to 28% & reduction in the dead than R.C.C.

ix) The bending moment in composite beams are reduced up to 20% to 40% in positive direction & 16% to 32% reduced in negative directions than R.C.C, reduction in the dead weight& seismic forces.

Conclusion:-

i) In composite structures due to high ductile nature of steel it leads to increased seismic resistance of the composite section.

ii) Composite construction a little bit costly at the initial stages but due to its speedy construction work the project can be completed as early as possible than RCC construction.

iii) The reduces dimension of beam and column in composite construction leads to reduction in the dead weight of the structures which ultimately helps in reduction the cost of foundation.

iv)The dead weight of composite structures is found to be less than R.C.C structures & also reduced seismic forces. The reduction drift due to increased stiffness of composite structures as compared to R.C.C structures.

v) The displacement of composite structures found to be lower than R.C.C structures.

vi) The axial forces in composite column is found to be less than R.C.C column.

vii)The shear forces in composite column is found reduced by R.C.C column.

viii) The twisting moment in composite column is found less than R.C.C column.

ix) + ve & -ve bending moment in composite beam is found to be reduced than R.C.C beam.

ACKNOWLEDGEMENT

This paper too could not be completed without the help and support of many special persons.

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