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Consideration of Seismic Design of Multistoried Steel Structure using STAAD-Pro

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Abstract- **Structural design is a process to achieve dimensions of elements of structure, as far as design point of view is concern, to satisfy strength and stiffness for its intended use and life. Structural design does not evolve into a unique solution. But it is an art and skill which acquires by experience of lot of designs as well as guesswork. In the present work, the steel structure is the moment resisting frame with deck system for floors as well as brick work for wall. Study showed that the design of column using different types of Indian steel section such that I-section, double I-section, face to face channels section with IS 800:1984. Using above sections, the seismic design of (G+1), (G+3), & (G+6) steel frame was carried out by STAAD-Pro. Also the present work considered all important design parameter in STAAD-Pro. It is concluded that using double I-section with optimum weight per meter for the steel frame is the most economical section instead of single section with maximum weight per meter. The RCC frame (G+1) also designed by STAAD-Pro and compared with Steel frame with face to face channel section for columns.**

Keywords: STAAD-PRO; Seismic design; Steel sections; RCC frames

I. INTRODUCTION

In general, steel structures have been able to withstand severe earthquake shaking without collapses because of their good characteristic of ductility. Steel itself is considered a good earthquake resistant material because of its large strength to weight ratio. A nearly equal behavior pattern under not only tensile but also compressive load enhances its performance under cyclic loading.

The design of any structure such as steel and concrete includes functional planning, consideration of the various forces, strength of materials and the design methods. In addition the structure should be economical and easy to erect so that the time consumption should be minimum. An economical structure requires an efficient use of steel, skilled and unskilled labours. This objective can usually be accomplished by such a design that requires a minimum amount of steel and simpler structural form with less fabrication.

In the present work, all frames are considered as the moment resisting frames. Because moment resisting frames are rectilinear assemblages of beams as well as columns, with the beams rigidly connected to columns.

A. Orientation of column

Orientation of column is prime important for getting minimum section of column. From fig.1 better orientation of column is explained.

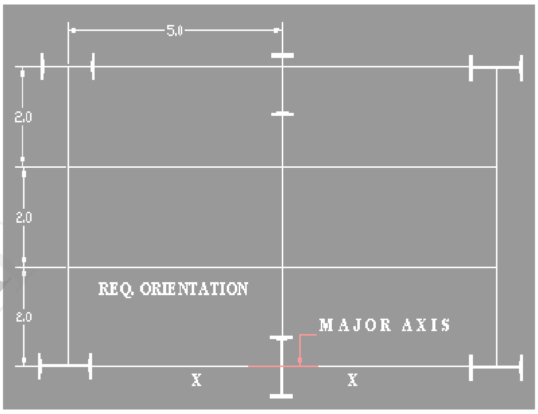

Fig. 1: Orientation of column

B. Floor

Trapezoidal Metal Profile sheets with not only strong but also reliable shear bond performance which is increased by cross decoration located in the profile. The composite floor profile offers the ultimate in the light weight steel decking with reduced concrete usage. Because of which it provide a cost effective and alternative floor solution that is easy to install.

The floor is constituted by a profiled sheet on which layer of concrete is poured. The sheet is bonded to the concrete by means of mouldings on the sheet which stop the concrete from slipping horizontally and detaching vertically. Once the concrete has hardened the sheet and concrete form a unified bond with all the characteristics of traditional reinforced concrete the sheet acts as a metal reinforcement. Appropriate crop ends must be provided to absorb the negative moments.

a. Advantages of Composite Floor Decking

1. It is usually applicable to high rise buildings, multiplexes/commercial buildings, power plant buildings, mezzanine floors in Industrial building & warehouses.
2. The thickness available for deck in the market is 0.8 mm/1 mm/1.2 mm.

3. Technical specification of floor decking is that the base metal is of high tensile structural grade steel, coating mass of 120, 180 & 275 GSM, yield strength having 240 MPa.
4. Available finish consist of cold rolled, Galvanized, both side primer coated (Galvanized).
5. Tensile steel for composite slab construction that cuts down on the slab thickness and dead weight of buildings. It provides a more sustainable solution and reducing costs.
6. No separate formwork required for slab casting.
7. Reduces construction time.

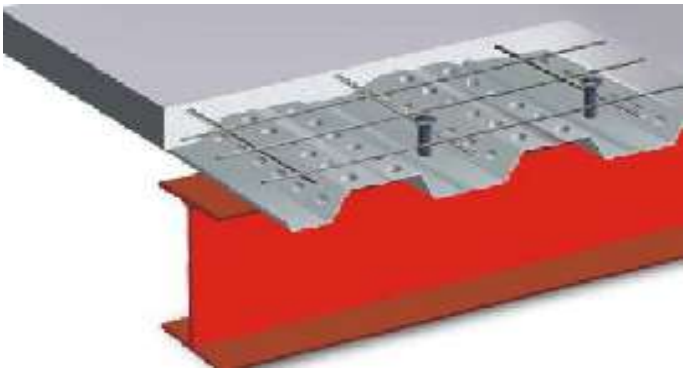

Fig. 2: Arrangement of deck profile with shear connector

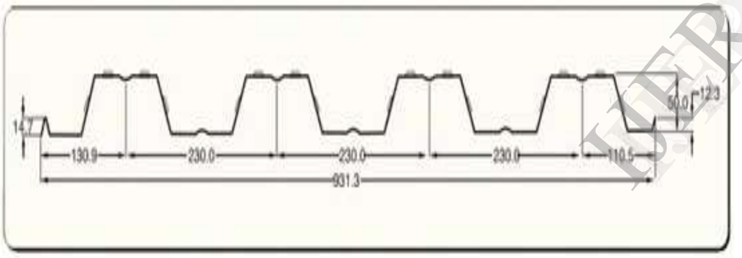

Fig. 3: Dimension of Floor deck

TABLE I: The load carrying capacity of deck as per span

Load carrying capacity for various spans in Kg							
Span in Meter		1.0 mtr	1.2 mtr	1.4 mtr	1.6 mtr	1.8 mtr	2.0 mtr
Thickness (mm)	0.8	2009	1395	1025	784	620	502
	1	2512	1744	1281	981	775	628
	1.2	2936	2038	1497	1146	96	731

TABLE II: The weight of profile as per thickness and depth of slab

Maximum span (m) single or double span					
Steel thickness	**Profile weight**	**Concrete slab depth above profile**			
Mm	KN/m²	100 mm	150 mm	200 mm	250 mm
0.8	0.82	2.9	2.57	2.33	2.15
1	0.103	3.23	2.87	2.6	2.4
1.2	0.124	3.54	3.14	2.85	2.63

a. Design Of Steel Frame By STAAD - Pro.

The relevant data taken for analysis and design of steel frame as below:

TABLE III: The weight of profile as per thickness and depth of slab

Plan	5 m x 6m
Depth of Foundation	1.5 m
Floor to Floor height	3.2 m
Depth of deck slab for steel frame (Including finishing)	125 mm
Depth of slab for RCC frame (Including finishing)	200 mm
Weight of deck profile for 1.0 mm thick deck	0.103 KN/m²
Live load on floor	3.0 KN/m²

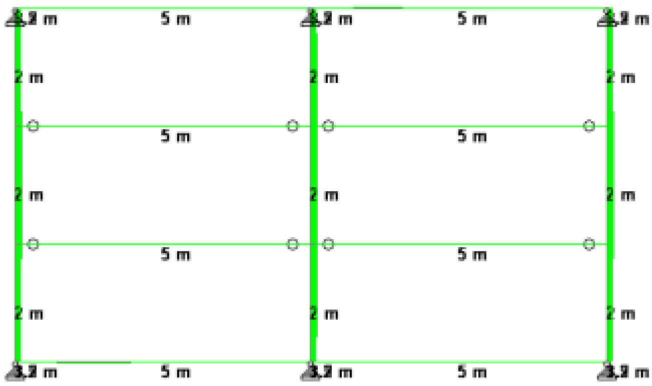

Fig. 4: Plan for design of all types of Model

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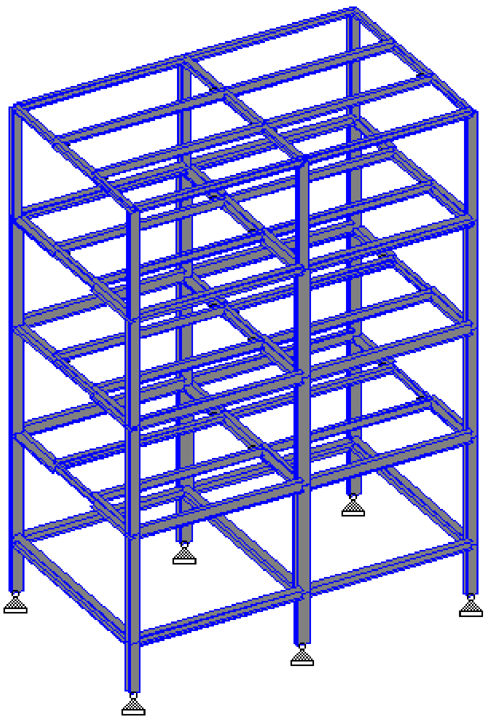

Fig. 5: 3D view of Model in Staad-pro.

II. LITERATURE REVIEW

Theodore V. Galambos, et al [1] studied 'Behavior of Steel Structure' in a critical state-of-the art of understanding the behavior of steel structure. Almost half a century passed without much change since the recognition of the concept of the tangent and reduced moduli by Engesser and Considere at the turn of nineteenth century until Shanley's resolution of the column paradox in 1945. Owing to the cost and importance of individual steel structure, much more thinking and money has been expended than, say, for masonry building which represent perhaps a much larger overall expenditure of construction amount. For this reason, there is little that is not known about the behavior of steel structure.

Mozzolani, F. M, et al [2] studied Steel structures which been always considered as a suitable solution for construction in high seismicity areas, due to the very good strength and ductility exhibited by the structural material, the high quality assurance guaranteed by the industrial production of steel shapes and plates and reliability of connectors built up both in workshop & site. Moment resisting frames are rectilinear assemblage of beams and columns, with the beam rigidity connected to the column.

A.Ghersi, et al [3] studied the "N2" method and the "global" approach, which aimed at obtaining global collapse mechanism, were well known by scientific community. They were both useful tools, but each of them does not consider all the aspects of seismic design. It proposed a procedure for steel moment resisting frames, which combines together the two aforementioned methods. The procedure, which is a simple and effective design method, allows achieving the best dissipative mechanism of the frame and does not require pushover analysis, differently from the standard application of N2 method.

T. L. Karavasilis, et al [4] studied a new seismic design method for plane steel frames were presented. This was a hybrid procedure as it combines elements from both the displacement based and the force-based methods. According to this method, the framed structure is replaced by an elastic single degree of freedom substitute structure for which the design displacement, associated with the local damage of the limit state under consideration, is established.

M. A. Conti, et al [5] presented the results of the research carried out by the Research Unit of Salerno University within the frame work of the national research project PRIN2003 on "Innovative Steel Structure for Seismic Protection of Building". In particular, three main topics have been dealt with: seismic response of eccentrically braced frames; plastic design of knee braced (KB) frames; steel bracings as a technique for seismic retrofitting of existing RC building.

V. Gioncu, et al [6] studied the actual codes consider the damaging earthquake only, the one having strong accelerations. But in many cases, the structural damage is very important, even for moderate accelerations, showing that the high ground acceleration are not the alone parameter which must be considered in design. The paper presented the doubtful question rising in steel structure design subjected to theses exceptional earthquake.

U. D. Dabhade, et al [7] studied the concept of composite slab with steel decking. Slab consists of steel deck, which acts composite with concrete. The construction of composite slab consists of four activities such as erection of steel beam section, installation of steel deck shear studs, welded wire mesh and concrete slab. It also highlighted the construction procedure of composite concrete slab.

III. RESULT & DISCUSSION

The result from STAAD-Pro i.e. Postprocessing result of Beam-Unity Check of each steel frame and its discussion on comparatively study with using different types of Indian Steel section for column is discussed. Result showing of best performance of double I-sections and face to face channel section in multistoried steel structure.

The following table consists of Postprocessing-Beam Unity Check result for different models and table contains the beam number, analysis property and design property by optimization of that member.

TABLE IV: Result of STAAD-Pro for column for Model 1

Beam	Design Property	Ratio	L/C	Ax cm2	Lz cm^4	Ly cm^4	Lx cm^4
7	ISHB350	0.994	16	85.9	19160	2451	33.8
8	ISHB300A	0.985	9	80.3	12950	2247	28.9
10	ISWB550	0.881	12	143.3	74906.01	3741.001	116.1
11	ISHB400	0.933	9	98.7	28084	2728	45.7
13	ISWB600	0.957	8	170.4	1.06E+05	4703.001	196.3

TABLE V: Cost Comparison

Sr. No	Type of Frame	Weight (Kg)	Cost (Rs)
1	Steel frame having channel section for columns	8040.16	4, 41,229
2	Reinforced Cement Concrete sections	2104.28	1, 88,092

TABLE VI: Result from STAAD-Pro of columns for Model 3

Beam	Design Property	Ratio	L/C	Ax cm2	Lz cm^4	Ly cm^4	Lx cm^4
14	ISWB250 D	0.824	8	104	11886	33566	25.2
26	ISWB250	0.785	8	122.6	19644	39526.25	36
29	ISWB250 D	0.824	8	104	11886	33566	25.2
105	ISWB250 D	0.703	8	104	11886	33566	25.2

TABLE VII: Result from STAAD-Pro of columns for Model 4

Beam	Design Property	Ratio	L/C	Ax cm^2	Lz cm^4	Ly cm^4	Lx cm^4
8	ISWB300 D	0.889	8	122.6	19644	39526.3	36
14	ISWB300 D	0.949	8	122.6	19644	39526.3	36
23	ISWB300 D	0.895	9	122.6	19644	39526.3	36
29	ISWB300 D	0.951	8	122.6	19644	39526.3	36
115	ISWB300 D	0.866	9	122.6	19644	39526.3	36

TABLE VIII: Result from STAAD-Pro of columns for Model 5

Beam	Design Property	Ratio	L/C	Ax cm^2	Lz cm^4	Ly cm^4	Lx cm^4
8	ISLC300 FR	0.985	12	84.22	12095.8	5429.38	27.6
23	ISLC300 FR	0.984	11	84.22	12095.8	5429.38	27.6
94	ISLC250 FR	0.918	8	71.3	7375.8	4396.38	20.8
115	ISLC300 FR	0.939	8	84.22	12095.8	5429.38	27.6

TABLE IX: Result from STAAD-Pro of column for Model 6

Beam	Design Property	Ratio	L/C	Ax cm^2	Lz cm^4	Ly cm^4	Lx cm^4
15	ISLC400	0.965	8	116.5	27979	7649.84	51.6
30	ISLC400	0.967	8	116.5	27979	7649.84	51.6
94	ISLC350	0.92	8	98.94	18625.2	6503.98	36.6
150	ISLC300	0.824	8	84.22	12095.8	5429.38	27.6
179	ISLC250	0.939	8	71.3	7375.8	4396.38	20.8

IV. CONCLUSION

1. Model 1 deals with the designs of steel frame (G+1) using single I-section for columns. In this design, columns are required with very heavy single I-sections such as ISWB 600 of weight per meter 145.1 Kg/m.
2. When RCC slab was used in Model 1 (G+1) steel frame with single I-section used for columns, the section for column required is heaviest section such as ISWB 600A.
3. When tube or pipe sections were used in Model 1 then standard sections were not sufficient for column.
4. Floor decking systems were light weight and also serve as a formwork for slab casting.
5. In Model 3 (G+3) steel frame with double I-section for columns having 0.15 m spacing between flange to flange, all columns designed with section ISWB 250 with weight per meter 40.9 Kg/m. In case of single I-section for above Model 3, even heaviest section was unsafe.
6. In Model 4 (G+6) steel frame with double I-section used for columns, columns sections required were ISWB 200 & ISWB 300.
7. In Model 5 (G+3) steel frame with face to face channel section for columns. With this arrangement, the section of columns required were heavy section such as ISMC 350.
8. In Model 6 (G+6), the columns designed with face to face channel sections, the maximum available section i.e. ISMC 400 was not found sufficient for some of the columns.

9. RCC (G+1) frame i.e. Model 2 compared with steel frame having face to face channel section for column, it is observed that the cost of beam & column of RCC frame was 1,88,092/- and cost of sections in steel frame for beam & columns was 4,41,229/-.
10. Orientation of column is important for single column section. If columns are properly oriented (as per fig. 1) then design will be economical.
11. Steel frame compared with RCC frame, time saving in construction of steel frame is very much.
12. Steel buildings are having maximum scarp value while in case of RCC buildings scrap value is negative.

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