Linear Dynamic Behavior of Tall Steel Concrete Composite Building

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***Abstract* — Steel-concrete composite structures are very popular & have their advantages over concrete constructions. Concrete structures are bulky and have more seismic weight and more deflection as compare to composite construction, & it combines the better properties of both steel and concrete along with lesser cost, speedy construction, fire protection etc. The aim of the present study is to compare seismic performance of R.C.C. building and composite building from which is situated in earthquake zone III. Two models are modeled (R.C.C. and Composite) models are of G+6 storey buildings. All frames are designed for same gravity loadings. Column sections are made of either RCC and steel concrete composite sections. Response spectrum method are used for seismic analysis. Effect of each building is studied with respect to time period, storey base shear, displacement and drift.**

Keywords: Seismic behavior, Steel concrete composite Structure, Composite Sections, Response Spectrum Method.

I. INTRODUCTION

During severe earthquakes, structural design for seismic loading is primarily concerned with structural safety, serviceability, and the potential for economic losses. Therefore, it is necessary to study the structural behavior under large inelastic cyclic deformations. In principle, the behavior of a structure under earthquake loading is different from other lateral or gravity loads. Ensuring acceptable seismic performance outside the elastic range requires more detailed analysis. Inelastic energy dissipation in structural systems is allowed in almost all codes, due to which when the structure experiences an earthquake, most of the structural damage is done.

The performance of building during an earthquake depends upon several factors, such as stiffness, ductility, lateral strength and Simple and regular configuration. In the past, for the design of a building, the choice was normally between a concrete structure and a masonry structure. But the failure of many multi-storied and low-rise R.C.C. and masonry buildings due to earthquake. This problem forced the structural engineers to look for the alternative method of construction. Concrete structures are bulky and impart more seismic weight and less deflection whereas Steel structures instruct more deflections and ductility to the structure, which is beneficial in resisting seismic forces. In such circumstances, use of composite construction is of particular interest, due to its significant potential in improving the seismic performance of structure without much more changes in manufacturing and construction techniques.

II. CONCEPT OF STEEL-CONCRETE COMPOSITE STRUCTURES:

Steel-concrete composite structures are gaining high importance in the construction of bridges and highways, high rise buildings, etc. The sections in steel-concrete composite structures tend to use the compressive strength offered by concrete and the property of high resistance to tension and compression offered by the structural steel. Thus, when these properties are combined in a section, the resultant section is a highly efficient and comparatively light weight section which most commonly find its way in the construction of high-rise multi-storey buildings and highway bridges. Along with the goodness of strengths from concrete and structural steel, steel concrete structures offer certain more benefits as well. They offer high resistance to corrosion and thus are highly durable in nature, they are considerably low maintenance structures when compared with RCC or steel structures, which gives it an edge in becoming a preferred economic solution in life cycle of the structure.

III. PROBLEM FORMULATION

MODEL PROPERTIES:

A G+6 storey R.C. framed structure (Model-A) is selected for linear dynamic analysis. Since building was existed all the designed structural elements are analyzed, using linear dynamic analysis is performed for determination of displacement, and story drift and base shear results. All these assignments are carried out in ETAB's software. All frames were imposed by the dead, live, and lateral loads. The lateral loads were designed based on IS-1893-2016. The self-weight of the structures, weight of the permanent partition such as finishes, brick wall, and all permanent constructions are under dead load effect. The details of dead and live loads are as follows:

Floor finish = 1.1 KN/Sqm.
Floor finish (roof) = 1.5 KN/Sqm.
Live load = 2 KN/Sqm.
Wall load = 11.73 KN/m(External)
Wall load = 7.65 KN/m(Internal)
Response Spectra -IS 1893-2016
Seismic zone – III
Seismic zone factor Z = 0.16
Importance factor I = 1.5
Soil type = II
Response Reduction factor = 5
Damping Ratio = 0.05
Mechanical Property of Reinforcement Steel

FLOORS	COLUMNS	A	B	C	D	E
		C1,C2,C4,C5, C11,C12,C15, C16,C17,C24	C25,C31,C32 C33,C34,C38	C3,C6,C7,C8 C10,C13 C18,C19,C22 C23	C26,C27,C28, C29,C30,C35 C36,C37,C39 C40	C9,C14
COLUMNS FOOTING TO FIRST SLAB	SIZE	9" X 18"	9" X 18"	9" X 18"	9" X 18"	9" X 21"
	VERTICAL STEEL	4 # 16+ 4 # 12	8 # 12	10 # 16	8 # 16	10 # 16
	TIES	2 Ø 8 @ 8"	2 Ø 8 @ 8"	2 Ø 8 @ 8"	2 Ø 8 @ 8"	2 Ø 8 @ 8"
	TIE PATTERN					
	REMARKS	---	---	---	---	---
COLUMNS FIRST TO SECOND SLAB	SIZE	9" X 18"	9" X 18"	9" X 18"	9" X 18"	9" X 21"
	VERTICAL STEEL	4 # 16+ 4 # 12	8 # 12	8 # 16	4 # 16+ 4 # 12	8 # 16
	TIES	2 Ø 8 @ 8"	2 Ø 8 @ 8"	2 Ø 8 @ 8"	2 Ø 8 @ 8"	2 Ø 8 @ 8"
	TIE PATTERN	4#16			4#16	
COLUMNS SECOND TO THIRED SLAB	SIZE	9" X 18"	9" X 18"	9" X 18"	9" X 18"	9" X 18"
	VERTICAL STEEL	8 # 12	8 # 12	4 # 16+ 4 # 12	8 # 12	8 # 16
	TIES	2 Ø 8 @ 8"	2 Ø 8 @ 8"	2 Ø 8 @ 8"	2 Ø 8 @ 8"	2 Ø 8 @ 8"
	TIE PATTERN			4#16		
COLUMNS THIRED TO FORTH SLAB	SIZE	9" X 15"	9" X 15"	9" X 18"	9" X 15"	9" X 18"
	VERTICAL STEEL	8 # 12	8 # 12	8 # 12	8 # 12	4 # 16+ 4 # 12
	TIES	2 Ø 8 @ 8"	2 Ø 8 @ 8"	2 Ø 8 @ 8"	2 Ø 8 @ 8"	2 Ø 8 @ 8"
	TIE PATTERN					4#16
	REMARKS					
COLUMNS FOURTH TO FIFTH SLAB	SIZE	9" X 15"	9" X 15"	9" X 18"	9" X 15"	9" X 18"
	VERTICAL STEEL	6 # 12	6 # 12	8 # 12	8 # 12	8 # 12
	TIES	2 Ø 8 @ 8"C/C	2 Ø 8 @ 8"C/C	2 Ø 8 @ 8"C/C	2 Ø 8 @ 8"C/C	2 Ø 8 @ 8"C/C
	TIE PATTERN					

Storey height	Beam size (R.C.C)	Beam Size (Composite)
G+6	230 X 380	300 X 600
	230 X 450	150 X 450
	230 X 600	150 X 600

Column Size (mm)	Rebar	Steel Section
230x300	4#12	ISLB-75
230X350	4#12	ISLB-125
230X400	4#12	ISJB-175
230X230	4#12	-(FC)

Types of Loads

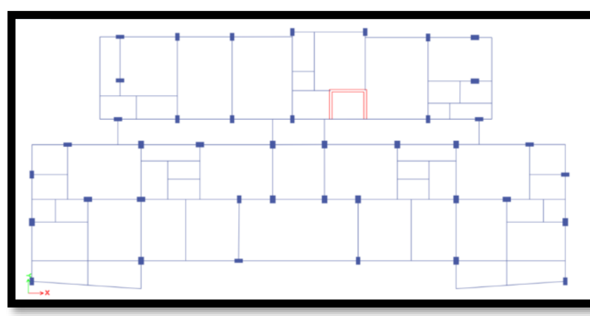
Unless otherwise specified, all loads listed, shall be considered in design for the Indian Code following load combinations shall be considered.

Load case

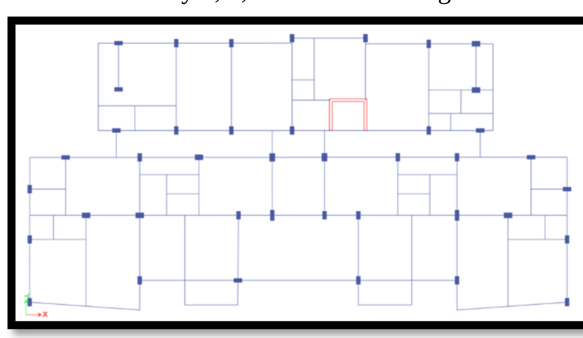
1) DL: Dead load
2) LL: Live load
3) EQ: Earthquake load

Load combination

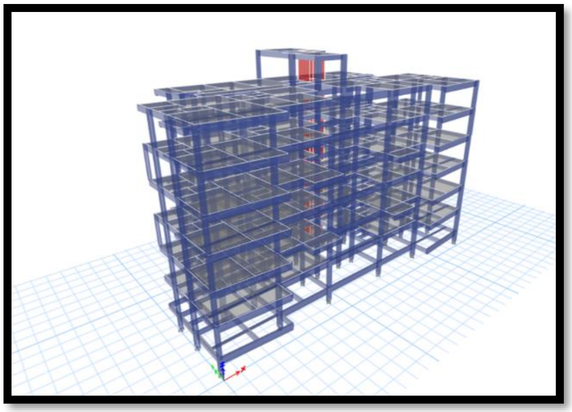
1. 1.5DL+1.5LL
2. 1.5DL+1.5EL
3. 1.5DL-1.5EL
4. 1.2DL+1.2LL + 1.2EX
5. 1.2DL+1.2LL- 1.2EX
6. 1.2DL-1.2LL+ 1.2EY
7. 1.2DL-1.2LL - 1.2EY
8. (0.9DL±1.5EQ)



Plan of storey 1, 3, 5 of G+6 Building Model



Plan of storey 2, 4 of G+6 Building Model



G+6 Story Building Model

IV. RESULTS

Modal Time Period - Following table shows the modal time period of mode for all models used to evaluate the structural performance.

Table 1 Modal Time Periods

	R.C.C	COMPOSITE
Mode	Period sec	Period sec
1	1.622	2.102
2	1.321	1.556
3	1.226	1.442

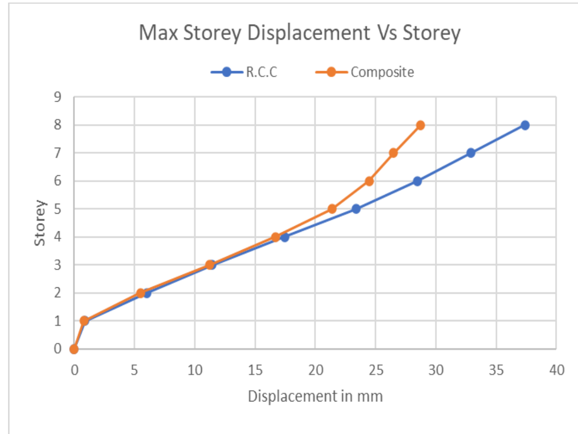
From above table shows that the modal time period for R.C.C Structure is less as compared to Composite Structure. Means, as we use composite Structure, gives better performance in accordance with modal analysis.

Storey Displacement -

Table 2 displacement for response spectrum case in x-direction.

Story	R.C.C Structure	Composite Structure
BASE	0	0
PLINTH	0.883	0.786
STORY 1	6.05	5.501
STORY 2	11.447	11.216
STORY 3	17.443	16.678
STORY 4	23.364	21.382
STORY 5	28.49	24.453
STORY 6	32.887	26.506
STORY 7	37.387	28.732

Graph 1 Comparison of Maximum Storey Displacement for Response spectrum Case in X-Direction

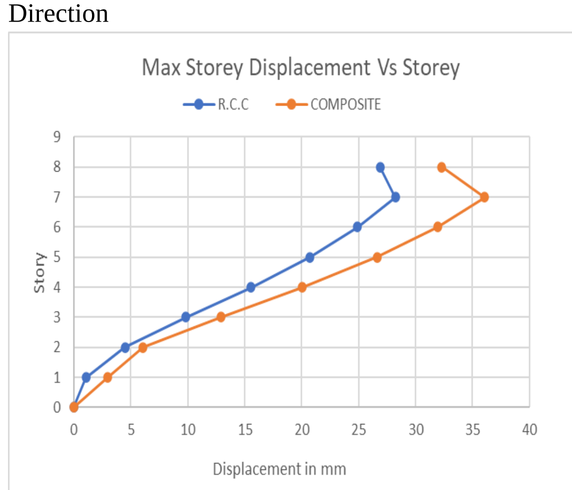


The graph 2 shows max storey displacement Vs storey for Response spectrum case in X-direction. Storey displacement in table no. 2 for composite structure is 28.732 mm and for R.C.C structure is 37.387 mm. The storey displacement for composite structure is less as compare to R.C.C structure in X-direction.

Table 3 displacement for response spectrum case in Y-direction

Story	R.C.C	COMPOSITE
BASE	0	0
PLINTH	1.072	2.955
STORY 1	4.49	6.069
STORY 2	9.849	12.912
STORY 3	15.543	20.013
STORY 4	20.746	26.604
STORY 5	24.896	31.928
STORY 6	28.217	36.068
STORY 7	26.893	32.303

Graph 2 Comparison of Maximum Storey Displacement for Response spectrum Case in Y-Direction



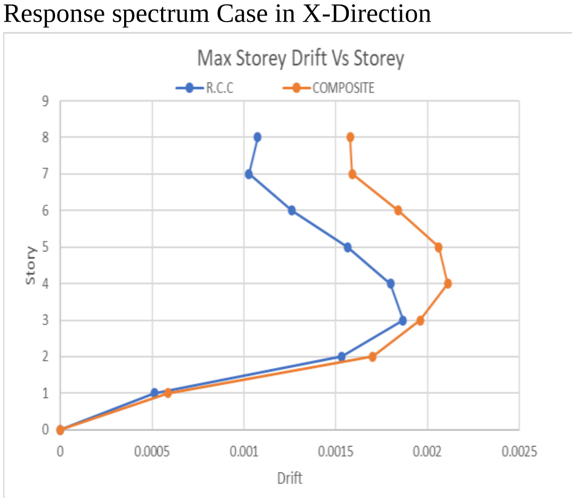
The graph 2 shows max storey displacement Vs storey for Response spectrum case in Y-direction. Storey displacement in table no 3 for composite structure is 32.303 mm and for R.C.C structure is 26.893 mm. The storey displacement for composite structure is more as compare to R.C.C structure in Y-direction.

Story Drift Results -

Table 4 Storey Drift for response spectrum case in X-direction

Story	R.C.C	COMPOSITE
BASE	0	0
PLINTH	0.000512	0.000585
STORY 1	0.001533	0.001702
STORY 2	0.001867	0.001959
STORY 3	0.001799	0.00211
STORY 4	0.001563	0.00206
STORY 5	0.001262	0.00184
STORY 6	0.001027	0.001589
STORY 7	0.001075	0.001578

Graph 3 Comparison of Maximum Storey Drift for Response spectrum Case in X-Direction

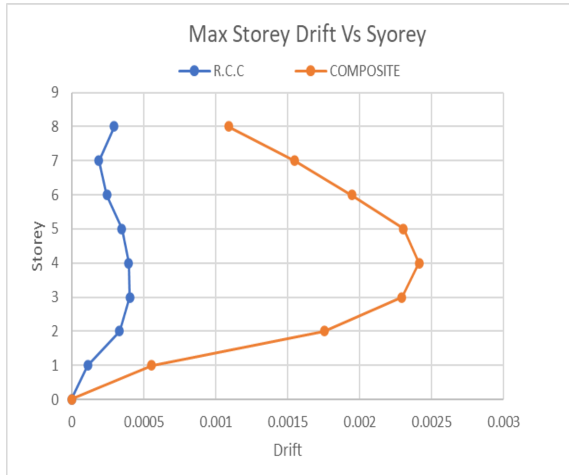


The graph 3 shows max storey drift Vs storey for Response spectrum case in X-direction. From table no 4 the maximum storey drift is obtained for composite structure is 0.00206 and for R.C.C structure is 0.001563. The storey drift for composite structure is more as compare to R.C.C structure in X-direction.

Table 5 Storey Drift for response spectrum case in Y-direction.

Story	R.C.C	COMPOSITE
BASE	0	0
PLINTH	0.000112	0.000554
STORY 1	0.000331	0.001754
STORY 2	0.000403	0.002294
STORY 3	0.000395	0.002413
STORY 4	0.000347	0.002305
STORY 5	0.000243	0.001944
STORY 6	0.000188	0.00155
STORY 7	0.000294	0.00109

Graph 4 Comparison of Maximum Storey Drift for Response spectrum Case in Y-Direction



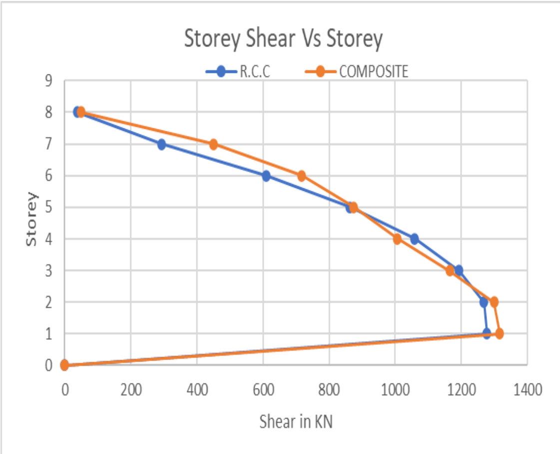
The graph 4 shows max storey drift Vs storey for Response spectrum case in Y-direction. From table no 5 the maximum storey drift is obtained for composite structure is 0.002305 and for R.C.C structure is 0.000347. The storey drift for composite structure is more as compare to R.C.C structure in Y-direction.

Storey Shear Results -

Table 6 Storey Shear for response spectrum case in X-direction.

Story	R.C.C	COMPOSITE
BASE	0	0
PLINTH	1277.6137	1316.2862
STORY 1	1268.2715	1298.737
STORY 2	1193.3846	1164.7751
STORY 3	1059.4406	1006.3264
STORY 4	862.9688	874.2632
STORY 5	608.9735	716.9573
STORY 6	293.7656	450.5226
STORY 7	38.0562	49.7393

Graph 5 Comparison of Maximum Storey Shear for Response spectrum Case in X-Direction.

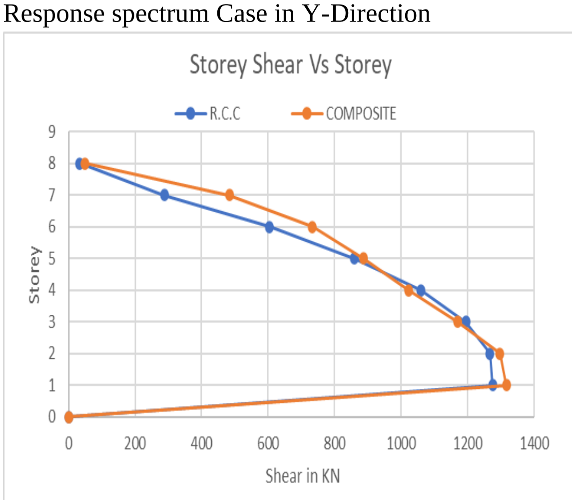


The graph 5 shows max storey shear Vs storey for Response spectrum case in x-direction. From table no. 6 the maximum storey Shear is obtained for composite structure is 1316.2862 KN and for R.C.C structure is 1277.6137 KN. The storey shear for composite structure is more as compare to R.C.C structure in X-direction.

Table 7 Storey Shear for response spectrum case in Y-direction.

Story	R.C.C	COMPOSITE
BASE	0	0
PLINTH	1275.781	1316.304
STORY 1	1266.939	1297.0999
STORY 2	1194.203	1170.7736
STORY 3	1058.928	1021.7765
STORY 4	859.4375	887.0223
STORY 5	603.972	733.7625
STORY 6	287.8404	484.0024
STORY 7	33.3837	49.7878

Graph 6 Comparison of Maximum Storey Shear for Response spectrum Case in Y-Direction



The graph no 6 shows max storey shear Vs storey for Response spectrum case in Y-direction. From table no 7 the maximum storey Shear is obtained for composite structure is 1316.304 KN and for R.C.C structure is 1275.781 KN. The storey shear for composite structure is more as compare to R.C.C structure in Y-direction.

V. CONCLUSION

The main objective of this study is to study linear dynamic analysis of R.C.C and Composite structure. To obtain these objectives, existing R.C.C structure is considered. Same model considered for Composite Structure.

1. For performing linear dynamic analysis of existing R.C.C Structure and Composite Structure. In Composite Structure column sizes are reduces where reinforcement area kept as it is.
2. After performing linear dynamic analysis for existing R.C.C Structure and Composite Structure, Composite Structure provides 23.14% less storey displacement, 13.01% more storey drift and 3% higher storey shear than R.C.C Structure.
3. This indicate that Composite Structure increases base shear of the Structure. Composite Structure is more Earthquake resisting Structure than R.C.C Structure.
4. For comparative economic viability of R.C.C Structure and Composite Structure 22% cost reduces for Composite Structure as compare to R.C.C Structure.
5. As Compared to R.C.C Structure column sizes are reducing in Composite Structure.

REFFERENCE

[1] Ashiru Muhammand, Chhavi Gupta, Ibrahim B. Mahmoud (2015) “Comparative analysis of seismic behavior of Multi-Storey composite steel and conventional reinforced concrete framed structures.”

[2] Athira K B, Linda Ann Mathew (2017) “Contrast of Seismic Behavior of RCC and Composite Columns in G+15 Storied Buildings with GFRG Infill”

[3] Darshan Kumar S, Dr. S Vijaya (2020) “A Comparative study of RC Column and Composite

column with Flat Slab system using Response Spectrum Analysis."

[4] Ioana-Emanuela Boita, Daniel Dan, Valeriu Stoian (2017) "Seismic Behaviour of Composite Steel Fibre Reinforced Concrete Shear Walls."

[5] J.M.Castro, A.Y. Elghazouli and B.A. Izzuddin (2008) "PERFORMA ASSESMENTOF COMPOSITE MOMENT- RESISTING FRAMES."

[6] Karthiga @ shenbagam, Santhosh R and Kannan V (2020) "Comparison of Seismic performance of reinforced concrete frame structure & composite frame structure using response spectrum analysis."

[7] Li LI and Chiaki MASTSUI (2000) "Effect of Axial Force on Deformation Capacity of Steel Encased Reinforced Concrete Beam-Columns."

[8] LIU Jingbo and LIU Yangbing (2008) "Seismic Behavior Analysis of Steel-Concrete Composite Frame Structure Systems."

[9] M.G. Farag, W.M. Hassan (2015) "Seismic Performance of Steel Reinforced Concrete Composite Columns."

[10] Mangesh Shivaji Sulke, Shilpa Kewate (2018) "Seismic Performance of Concrete Filled Steel Tubular Column Building."

[11] Marisa Pecce, Claudio Amadio, Fernando Rossi, Giovanni Rinaldin (2012) "Non-linear behaviour of steel-concrete composite moment resisting frames."

[12] Marisa Pecce, Fernando Rossi (2013) "Non-Linear Model of Embebbed Steel-Concrete Composite Column Bases."

[13] Naveen kumar C N, Ramesh B M, P S Ramesh (2018) "Seismic Performance of RC and Composite Frames with Plan Irregular Configurations"

[14] Preetha V Govindhan S, Eniyachandramouli G, Ranjith selvan K (2020) "Comparative study on Response Sepctrum analysis of building with composite columns & RCC columns."

[15] S.R. Sutar, P.M. Kulkarni (2016) "Comparative inelastic analysis of RCC and steel-concrete composite frame."

[16] Shivani, Dr, Gopinath Nayak (2018) "Comparative study on CEC and CIC in composite buildings."

[17] Sunita Dahal, Rajan Suwal (2018) "Seismic behavior analysis of composite buildings with respect to RCC building."

[18] Vignesh kini K, Rajeeva S V (2017) "Comparison of Response Spectrum Analysis and Construction Sequence Analysis of RC and Steel-Concrete Composite Multi-Storey Building with Floating Columns."

[19] Zheng Zhang, Zhongxian Li, Qingying Ren, Yong Xue, Junxian Pang (2019) "Seismic Behavior Analysis of Steel-Concrete Composite Frame-RC Core Tube Structures."

[20] Hemant B. Kaushik et al. Stress-Strain Characteristics of Clay Brick Masonry under Uniaxial Compression. J. Mater. Civ. Eng. 2007.19:728-739.

[21] Hemant B. Kaushik, Durgesh C. Rai and Sudhir K. Jain, "A rational approach to analytical modelling of masonry infill's in reinforced concrete frame buildings", 14th World Conf. on Earthquake Engg., Beijing, 2008, China, pp 12-17.

[22] IS 1893 (Part 1) :2002 "Criteria for Earthquake Resistant Design of Structures Part 1 General Provisions and Buildings" prepared by Bureau of Indian Standards Manak Bhavan, 9 Bahadur Shah Zafar Marg New Delhi 110002.