International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 3.45 (SJIF-2015), e-ISSN: 2455-2585
Volume 4, Issue 4, April-2018

Comparative Study on Seismic Designed G+15 Story RC building by Using American and Indian Codes

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Abstract—This paper includes analysis and designs of a G+15 story RC building frame by commercial software Etabs 2016 according to Indian Standards as IS 456-2000, IS 1893(part 1)-2002, IS 875(part 5)1987 and American Standards as ACI 318-14, ASCE7-10. The average required reinforcement steel area for flexural, Shear and Torsion of the beams and columns are compared by the results obtained in both codes with the same plan, sections, materials, seismic characteristic and loads.

Keywords— Etabs, beams, columns, ACI 318-14, IS 456-2000

I. INTRODUCTION

Comparative studies based to structural codes, materials, standards and specifications are ordinary in the available literature. These studies are mostly required for Introduction of new codes and material. Presently, researches on comparative studies are one of the excited topics for students and researchers such researches provide inside into to various approaches to find the best of them many aspects of view.
These studies are useful in countries which various types of codes are allowed to be used as they help which codes have higher factor for safety and economy.

II. LITERATURE REVIEW

1)Sami W. tabsh "Structural Engineering and Mechanics, Vol. 48, No. 4" Comparison between reinforced concrete design based on the ACI 318 and BS 8110 codes. The study showed that the differences between the design capacities in the ACI 318 and BS 8110 codes are minor for flexure, moderate for axial compression, and major for shear. Also, the factored load combinations for dead load, live load and wind in the two codes yield minor- to-moderate differences, depending on the live-to-dead load ratio and intensity of wind.

2)B L Karihalooa "A new philosophy for the design of RC structures based on concepts of fracture mechanics" The present codes for the design of RC structures are based exclusively on the characteristic compressive strength f'_c of the concrete mix and ignore entirely its tensile capacity. This means that as the tensile strength and the brittleness of concrete increase with an increase in f'_c, the minimum reinforcement required to get the required ductility has to be increased without using the higher tensile strength. This often leads to depletion of reinforcement and to severe congestion, especially near joints which in turn leads to a lack of adequate compaction and cover, i.e. to honeycombing.

To avoid this, author proposed a completely new design philosophy based not on f'_c but on the characteristic length l_{ch} of the concrete mix. The mix characteristic length was first introduced more than three decades back by Hillerborg based on the concepts of fracture mechanics. It involves three independent properties of the mix; its stiffness (E), tensile strength f'_t and specific fracture energy or toughness G_F [$l_{ch} = (E\ G_F)/(f'_t)^2$]. It captures the intrinsic ductility of the mix; the larger the l_{ch}, the more ductile the mix. It is clear from the definition of l_{ch} that it decreases as f'_c (and therefore f'_t) increases. The new design philosophy suggests to base the design on a fixed l_{ch} of concrete mix used regardless of its f'_c. Thus, if the base l_{ch} is chosen to correspond to a mix with f'_c = 40MPa, but in the actual RC structure a mix with f'_c = 100 MPa is used whose l_{ch} would be much smaller than the base value, then it must be increased to coincide with the base value. In turn this means that the minimum reinforcement required for RC structures of same geometry made of mixes with different f'_c but the same l_{ch} will be the same and these structures will exhibit similar ductile response.

III. PROBLEM STATEMENT

A G+15 story building for a commercial complex has plan dimensions as shown in Figure

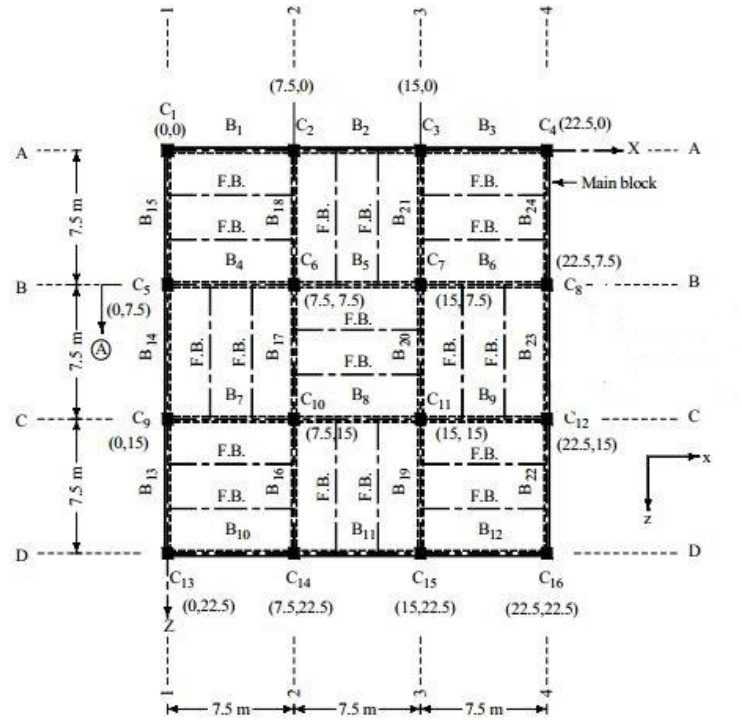

Fig. 1 Plan of G+15 story building

Design data considered as follow:

Live load: 4.0 KN/m^2 at typical floor, 1.5 KN/m^2 on terrace
Floor &Terrace finish: 1.0 KN/m^2
Water Proofing: 2 KN/m^2

Location: Vadodara City, Gujarat-India for IS standard and for American standards, Las Vegas City, Navada-USA (almost same in same seismic hazards zone) for Seismic analysis propose.
Wind Load: As per IS:875-part5 .an ASCE7-10 almost same input data
Type of Soil: Type II, Medium as per IS:1893-02
Floor: G.F. + 15 upper floors (all stories with 4 m height)
Walls: 230 mm thick brick masonry wall only at periphery
Plinth level :1.1 m
Slab: 100 mm thickness
Concrete Mark: M40 for Columns and beams
Steel: HYSD reinforcement of grade 415 for main bars and Fe 215 for confinement bars
Columns dimensions are 700 x700 mm, Main and Edge beams 400 x700 mm

IV. STRUCTURAL MODELLING AND ANALYSIS STEPS IN COMMERCIAL SOFTWARE ETABS 2016

Step-1: Creating and modifying grid lines and story height.
Step-2: Defining frame properties.
Step-3: Assigning beams, columns and creating 2d,3d models
Step-4: Defining load patterns, Response spectrum function, load cases (Response Spectrum function IS 1893-02 and ASCE 7-10 is used for seismic load cases).
Step-5: Creating load combinations by selection of default load combination option for concrete frame in both codes.
Step-6: Check model, run analysis,
Step-7: Design of RC frame model and finally checked that all members are passed out (with No failure).

V. RESULTS

a) Main beams 400x700 mm, Secondary beams 200x500 mm

1) Flexural envelope

TABLE 1. BEAM FLEXURE ENVELOPE

Beam Type	Location	As Top mm²		As Bottom mm²		Total As		Total As %	
		ACI 318-14	IS 456-2000	ACI 318-14	IS 456-2000	ACI 318-14	IS 456-2000	ACI 318-14	IS 456-2000
Main Beams	End-I	674	1072	653	1043	1327	2115	0.47	0.76
	Middle	356	583	869	1611	1225	2194	0.44	0.78
	End-J	1016	1970	636	1043	1652	3013	0.59	1.08
Secondary beams	End-I	641	531	424	579	1065	1110	1.07	1.11
	Middle	216	286	843	1149	1059	1435	1.06	1.44
	End-J	641	531	423	579	1064	1110	1.06	1.11

2) Area of transverse reinforcement for shear and torsion

TABLE 2. TRANSVERSE REINFORCEMENT AREA FOR BEAM

Beam type	Location	At for Shear mm²/m		At for Torsion mm²/m	
		ACI 318-14	IS 456-2000	ACI 318-14	IS 456-2000
Main Beams	End-I	859	3223	1525	2873
	Middle	668	3031	1250	2707
	End-J	859	3223	1209	2885
Secondary beams	End-I	637	783	0	512
	Middle	73	368	0	212
	End-J	634	783	0	512

b) Column 700x700 mm

TABLE 3. LONGITUDINAL AND TRANSVERSE REINFORCEMENT FOR COLUMN

Type of reinforcement Steel	ACI318-14		IS456-2000	
	Top	Bottom	Top	Bottom
Area of transverse steel for V Major,mm²/m	922	1029	1288	1288
Area of transverse Steel for V Minor mm²/m	1030	1070	1288	1288
% Area of Longitudinal Steel PMM envelope	1.20%	1.20%	1.90%	2%

VI. CONCLUSIONS

This paper presents an approach for the comparison of different types of required steel reinforcement for G+15 multi-story reinforced concrete frame by using Indian standards and American standards for the same loads, sections and plans. For comparison by selecting the almost same location in India(Vadodara-Gujrat) and in USA (Las Vegas City-Navada) design of required steel reinforcement of longitudinal and transverse is done.

For design purpose Commercial software Etabs 2016 is used and design codes are American codes and Indian codes (ACI 318-14, ASCE 7-10 and IS 456-2000, IS 1893-2002, IS 875 part-III) respectively.

The result show that

a) IS 456-2000 required 0.37 %, 0.16 % more longitudinal steel for main and secondary beams respectively.

b) For Shear reinforcement IS 456-2000 designed 3.9 and 1.4 times more reinforcement for main and secondary beams.

c) For torsion forces IS 456-2000 designed 2.1 time more steel than ACI 318-14 for main beams sometime ACI 318-14 has not designed steel for torsion in secondary beams while IS 456-2000 designed somewhat steel.

d) ACI 318-14 designed 0.75 % lesser longitudinal reinforcement for column.

e) Transverse reinforcement area in IS 456-2000 is required 1.3 and 1.2 times more than the ACI 318-14 codes in Major and Minor Shear respectively

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[5] ASCE 7-10 Minimum design loads for building and other structures.

[6] IS 456-2000 Code of practice for plain and reinforced concrete.

[7] IS 1893(part 1):2002 Criteria For Earthquake Resistant Design Of Structures.

[8] IS 875(part 3):1987 Code of practice for design loads (other than earthquake) for building and structures.