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Evaluation of Shear and Moment Coefficient for Continuous Beam Considering Seismic Forces

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Abstract:
This paper represents the results of studies on the shear force and bending moments in continuous beams caused by uniformly distributed load exerted over full span lengths of beam and with point load (secondary beam) acting on beam. The analysis is done for four different plan areas and for G+3, G+5, G+7, G+9 storey buildings for different seismic zones. Half the total height of structure has been considered as base for comparison of results. The results are obtained for different earthquake load combinations and compared with 1.5(DL+LL) load combination and suitable coefficients are developed in the form of tables. The analysis is done using STAAD-Pro v8i software.

Keywords: Shear force, Bending moment, continuous beam, STAAD-Pro v8i.

I. INTRODUCTION

Urbanization is rapidly increasing in almost every city in India. Infrastructure developmental plans have been laid by government and private organizations. Large advertising boards of tall buildings (up to 30 or 40 floors) already started attracting people to invest in these infrastructure plans. However, from the point of view of seismic hazard prevailing in the country, "Will these buildings survive during future earthquakes?" is a question to be answered before proceeding for construction. Especially, in the last 25 years, the country has witnessed several moderate earthquakes (Bihar-Nepal border (M6.4) in 1988, Uttarkashi (M6.6) in 1991, Killari (M6.3) in 1993, Jabalpur (M6.0) in 1997, Chamoli (M6.8) in 1999, Bhuj (M6.9) in 2001, Sumatra (M8.9), Kashmir (M7.6) in 2005, Sikkim (M5.7) in 2006 and Sikkim (M6.8) in 2011 caused around 40,000 fatalities due to collapse of buildings. These earthquakes have clearly exposed the lack of understanding of seismic hazard of the country. Sometimes, even when the hazard is understood, the lack of knowledge is exposed on earthquake resistant design and construction practice of reinforced concrete structures. The professionals involved in building construction should be more concerned with the safety of building infrastructure during future earthquake events. As per seismic zone map given in the latest revision of IS 1893, India is divided into 4 seismic zones (Zone II, III, IV and V). However, the guidelines given in this code are useful for regular and relatively small, low-rise buildings. When it comes to tall buildings, every structure is special. The main structural design issues considered in this building is Dynamic Analysis. Initial static and dynamic analysis can be conducted in SAP/STAAD or other sophisticated packages. In case of earthquake analysis of tall buildings, site specific parameters need to develop for every structure and the building behaviour needs to be understood. Dynamic analysis must be performed for building. In the present study, the various models have been taken in to consideration and results have considered by keeping the structural member ie. Beam as common parameter of comparison for all the models.

II .LITERATURE REVIEW

1.Khuda S.N, and A.M.M.T. Anwar "Design aid for continuous beam", Military institute of science and technology. in this paper Analysis and design of beam has been discussed .To assist designers moment coefficients are developed for continuous beams in this work. This study is an attempt to develop moment coefficients for beams which will be applicable beyond ACI limitations.

2.Fathelrahman M. Adam, A. E. Hassaballa, H. E. M. Sallam. "Charts for Bending Moment Coefficients for Continuous Beams." International Journal of Engineering Innovation & Research (IJEIR) 4, no. 4 (2015): 613-622. in this paper the results of studies on the bending moments in continuous beams caused by uniformly distributed load exerted over full span lengths of beam has been discussed. An elastic analysis based on moment distribution method is attempted to deduce the coefficients of negative and positive moments for continuous beams through computing 2000 examples with adopting beams of two spans, three spans and four spans and changing their spans lengths.

3.Dipak J Varia and Dr.Harshvadan S Patel "Comparative study of classical method and relative deformation coefficient approach for continuous beam analysis ." International journal of engineering development and research (IJEDR) Volume 6, Issue 11, Nov 2015 this paper introduce Relative Deformation Coefficient method for analysis of continuous beam. Present study intends to compare this Relative Deformation Coefficient method to the results obtained from widely accepted classical methods like Slope Deflection and Moment Distribution method. The results obtained by the Relative Deformation Coefficient Approach are found to be act in accordance with those found out by implementing the classical methods.

III. METHODOLOGY

In this we have considered four plan areas i.e.(9m*12m and 12m*15m) for uniformly distributed load and (18m*22.5m and

22.5m*27m) for point load (secondary beam) condition. The models of G+3,G+5,G+7 and G+9 are formed for different earthquake zones. The loading is done with referring to the code IS 1893:2002(Part-I).The modelling and analysis is done using STAAD-Pro v8i software and results are formulated in the form of tables.

The seismic coefficients (multiplication Factor) is investigated by dividing the gravity load combination ie. 1.5 (DL + LL) to the various seismic load combinations for different parametric variations. The seismic coefficient (multiplication factor) is calculated by following way,

$$C = \frac{\text{Forces obtained by seismic load cobinations}}{\text{Forces Obtained by Gravity load combination ie.1.5 (DL+LL)}}$$

Where, C = Seismic Coefficient (Multiplication Factor)

For Shear Force and Bending Moments we have taken the peripheral beams at the half the total height of structure for G+3,G+5,G+7 and G+9 storey buildings. Andcommen range for seismic coefficients (multiplication Factor) different cases has been formulated in the form of tables.

Table.1.Descriptions of Building Model

Sr.No.	Building Parameters	Description	
1	Type of Frame	SMRF	
2	Seismic Zone	All [As per IS 1893 (Part 1):2002]	
3	Importance Factor (I)	1	
4	Response Reduction Factor	5	
5	Type of Soil	Medium (Type II)	
6	Damping of Structure	5%	
7	Loadings		
	i) Dead Load	Self-weight of structural elements	
	ii) Floor Finishes	1 KN/m^2	
	iii) Live Load	3 KN/m^2	
8	Storey, 3bays in X and Z Direction	Four (G+3)	Eight (G+7)
		Six (G+5)	Ten (G+9)
9	i) Open Ground Storey Height	3 m	
10	ii) Upper Stories Height	3m (Each)	
11	Grade of Concrete	M25	
12	Grade of Steel (MPa)	Main Steel - Fe 500	Secondary Steel - 415
13	Specific Weight of RCC	25kN/m^3	
14	Seismic Load Combination	As per IS 1893 (Part 1):2002 a. 1.5(DL + LL) b. 1.5(DL±EQ) c.1.2(DL+LL±EQ)	
15	Size of Beam	230 x 450 mm	
16	Column Sizes	400 x 400 mm	
17	Thickness of Slab	150 mm	
18	Thickness Brick Wall	230 mm	
19	Grade of Concrete	M25	
20	Grade of Reinforcement	Fe 500	
21	Density of Concrete	25 KN/m^3	
22	Density of Brick Masonry	20 KN/m^3	
24	Depth of slab	150 mm	
25	Poisson Ratio of Brick Masonry	0.15	
26	Modulus of Elasticity of Concrete	25000 KN/m^2	

IV. PLAN AREA

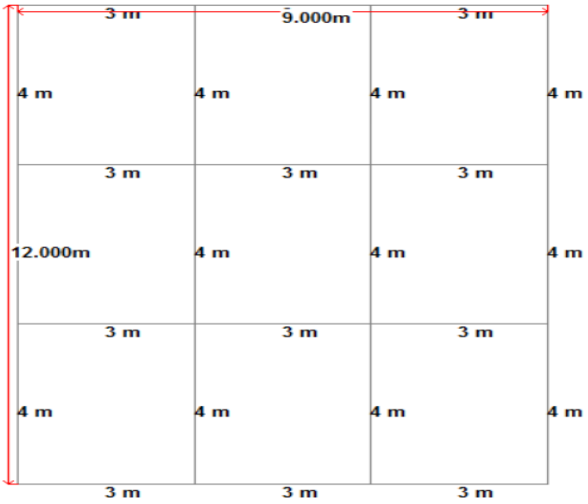

Figure.1.Plan area (9m*12m) M-I

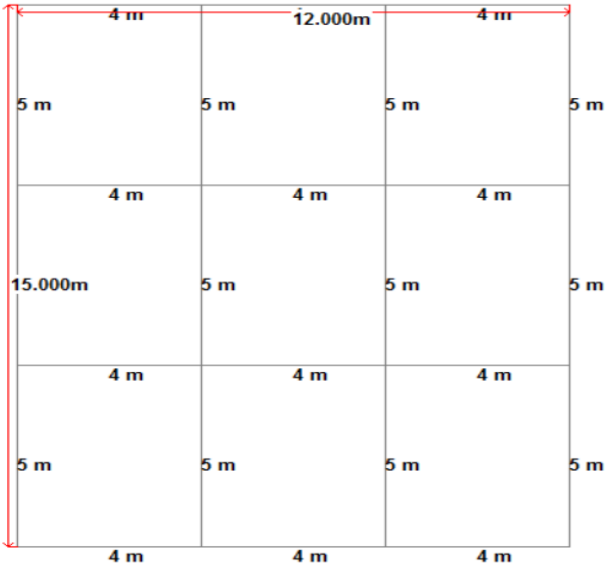

Figure.2.Plan area (12m*15m) M-II

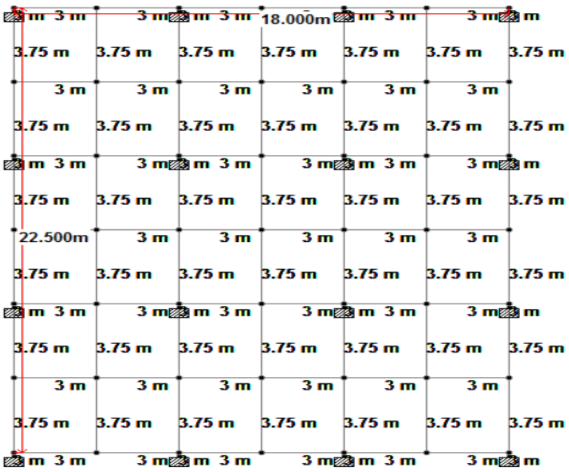

Figure.3.Plan area (18m*22.5m) with point load M-III

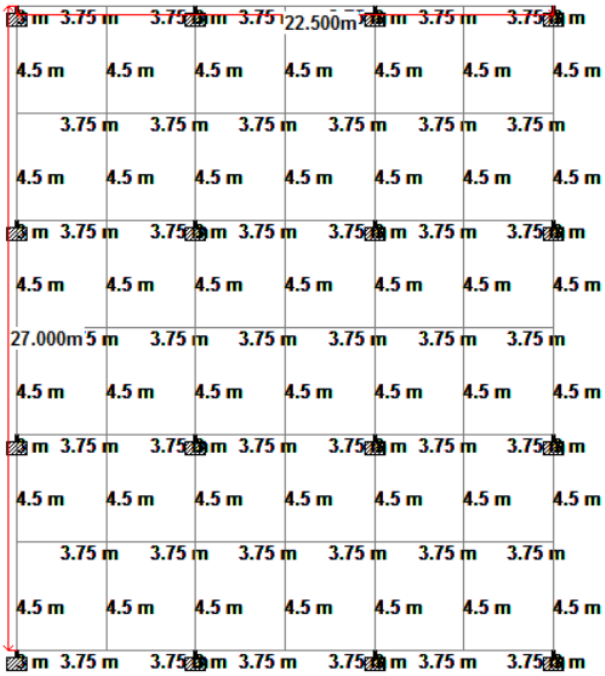

Figure.4.Plan area (22.5m*27m) with point load M-IV

V.TEST RESULT AND DISCUSSION

Table 2.For M-I case Range of multiplication factor for bending moment for1.5 (DL + EQX)

Zone / Side	Sagging		Hogging	
	3M	4M	3M	4M
II	0.73 - 0.78	0.15 - 0.29	0.47 - 2.19	0.14 - 0.29
III	3.27 - 4.67	0.24 - 0.29	1.93 - 3,64	0.24 - 0.29
IV	3.85 - 7.31	0.27 - .29	2.12 - 5.41	0.24 - 0.29
V	7.55 - 11.21	0.27 - 0.29	4.13 - 8.06	0.25 - 0.29

Table.3.For M-I case Range of multiplication factor for bending moment for 1.5 (DL - EQX)

Zone / Side	Sagging		Hogging	
	3M	4M	3M	4M
II	1.28 - 2.21	0.84 - 1.56	1.94 - 3	0.86 - 1.78
III	1.98 - 4	1.33 - 1.56	2.77 - 4.42	1.21 - 1.78
IV	1.95 - 4.96	1.42 - 1.56	2.26 - 5	1.21 - 1.78
V	5 - 7.6	1.42	4.22 - 7.15	1.2 - 1.78

Table.4. For M-I case Range of multiplication factor for bending moment for for 1.2 (DL + LL + EQX)

Zone / Side	Sagging		Hogging	
	3M	4M	3M	4M
II	1.1 - 1.83	0.8 - 1.48	1.68 - 2.57	0.8 - 2.36
III	1.56 - 3.27	1.36 - 1.49	2.22 - 3.62	1.15 - 1.65
IV	1.95 - 4.96	1.35 - 1.48	4.22 - 7.15	1.17 - 1.66
V	5 - 7.6	1.36 - 1.48	4.22 - 7.15	1.17 - 1.66

Table.5. For M-I case Range of multiplication factor for bending moment for for 1.2 (DL + LL - EQX)

Zone / Side	Sagging		Hogging	
	3M	4M	3M	4M
II	1.1 - 1.83	0.8 - 1.48	0.8 - 2.57	1.18 - 1.65
III	1.56 - 3.27	1.36 - 1.48	1.22 - 3.62	1.17 - 1.65
IV	1 - 4.94	1.35 - 1.48	0.97 - 5	1.17 - 1.66
V	5 - 7.49	1.36 - 1.48	4.22 - 7.15	1.17 - 1.66

Table.6. For M-I case Range of Multiplication Factor for shear force along X-direction (12m side)

Load Combinations	Zone			
	II	III	IV	V
1.5 (DL + EQX)	0.54 - 0.8	0.8 - 1.22	0.95 - 1.77	1.66 - 2.61
1.5 (DL - EQX)	1.2 - 1.53	1.58 - 2	1.73 - 2.56	2.44 - 3.39
1.2 (DL + LL + EQX)	1.13 - 1.35	1.34 - 1.69	1.47 - 2.13	2 - 2.28
1.2 (DL + LL - EQX)	0.8 - 1.35	1.34 - 1.69	1.47 - 2.13	2 - 2.8

Table 7. For M-I case Range of Multiplication Factor for shear force along Z-direction (15m side)

Load Combinations	Zone			
	II	III	IV	V
1.5 (DL + EQX)	0.12 - 0.88	0.12	0.13	0.13
1.5 (DL - EQX)	0.73 - 0.88	0.88	0.88	0.88
1.2 (DL + LL + EQX)	0.8 - 0.95	0.8	0.8	0.8
1.2 (DL + LL - EQX)	0.8 - 1	0.8	0.8	0.8

Table.8. For M-II case Range of multiplication factor for bending moment for 1.5 (DL + EQX)

Zone / Side	**Sagging**		**Hogging**	
	4M	5M	4M	5M
II	1.24 – 2	0.18	0.94 – 1.51	0.16 – 0.18
III	2.13 – 3.8	0.18	1.43 – 2.33	0.16 – 0.18
IV	3.31 - 5	0.18	2 – 3.42	0.16 – 0.18
V	4.17 – 8	0.18	2.54 - 5	0.16 – 0.18

Table.9. For M-II case Range of multiplication factor for bending moment for 1.5 (DL - EQX)

Zone / Side	**Sagging**		**Hogging**	
	4M	5M	4M	5M
II	1.02 – 1.57	0.82	1.62 – 2.22	0.82 – 0.84
III	1.32 – 2.56	0.82 – 1.32	2.11 – 3	0.82 – 0.91
IV	1.98 – 4.22	0.82	2.75 – 4.13	0.82
V	2.93 – 6.71	0.82	3.22 – 5.77	0.81 – 0.84

Table;10. For M-II case Range of multiplication factor for bending moment for 1.2 (DL + LL + EQX)

Zone / Side	**Sagging**		**Hogging**	
	4M	5M	4M	5M
II	0.92 – 1.34	0.8	1.42 – 1.89	0.8
III	1.12 – 2	0.8	1.79 -2.55	0.8
IV	1.54 – 3.33	0.8	2.31 – 3.42	0.8
V	1.98 – 5.32	0.8	2.68 – 4.65	0.8

Table.11. For M-II case Range of multiplication factor for bending moment for 1.2 (DL + LL - EQX)

Zone / Side	**Sagging**		**Hogging**	
	4M	5M	4M	5M
II	0.92 – 1.34	0.8	1.42 -1.89	0.8
III	1.12 – 2	0.8	1.79 – 2.55	0.8
IV	1.54 – 3.34	0.8	2.31 – 3.42	0.8
V	1.98 – 5.32	0.8	2.68 – 4.67	0.8

Table.12. For M-II case Range ofMultiplication Factor for shear force along X-direction (12m side)

Load Combinations	**Zone**			
	II	**III**	**IV**	**V**
1.5 (DL + EQX)	0.54 - 0.8	0.8 - 1.22	0.95 - 1.77	1.66 - 2.61
1.5 (DL - EQX)	1.2 - 1.53	1.58 - 2	1.73 - 2.56	2.44 - 3.39
1.2 (DL + LL + EQX)	1.13 - 1.35	1.34 - 1.69	1.47 - 2.13	2 - 2.28
1.2 (DL + LL - EQX)	0.8 - 1.35	1.34 - 1.69	1.47 - 2.13	2 - 2.8

Table .13. For M-II case Range of Multiplication Factor for shear force along Z-direction (15m side)

Load Combinations	**Zone**			
	II	**III**	**IV**	**V**
1.5 (DL + EQX)	0.12 - 0.88	0.12	0.13	0.13
1.5 (DL - EQX)	0.73 - 0.88	0.88	0.88	0.88
1.2 (DL + LL + EQX)	0.8 - 0.95	0.8	0.8	0.8
1.2 (DL + LL - EQX)	0.8 - 1	0.8	0.8	0.8

Table.14. For M-III case Range of multiplication factor for bending moment for 1.5 (DL + EQX)

Zone / Side	**Sagging**		**Hogging**	
	6M	7.5M	6M	7.5M
II	0.41 – 1.16	0.17	0.6 – 0.85	0.16
III	0.78 – 0.32	0.18	0.87 – 1.32	0.17
IV	1.27 – 2.05	0.18 – 0.20	1.24 – 1.84	0.18
V	2 – 3.21	0.2 – 0.22	1.78 – 2.68	0.19

Table .15. For M-III case Range of multiplication factor for bending moment for 1.5 (DL - EQX)

Zone / Side	Sagging		Hogging	
	6M	7.5M	6M	7.5M
II	0.84 – 0.89	0.83 – 0.84	1.32 – 1.56	0.85
III	0.86 – 0.98	0.83	1.59 – 1.98	0.81 – 0.84
IV	0.87 – 1.26	0.82	1.95 – 2.55	0.83
V	1.11 – 2.37	0.78 – 0.8	2.5 – 3.39	0.81 – 0.83

Table .16. For M-III case Range of multiplication factor for bending moment for 1.2 (DL + LL + EQX)

Zone / Side	Sagging		Hogging	
	6M	7.5M	6M	7.5M
II	0.81 – 0.84	0.79 – 0.82	1.17 – 1.39	0.79 – 0.84
III	0.81 – 0.86	0.79 – 0.82	1.39 – 1.7	0.82
IV	0.82 – 0.99	0.84	1.68 – 2.15	0.82
V	0.9 – 1.78	0.84 – 0.86	2.12 – 2.83	0.82 – 0.84

Table .17. For M-III case Range of multiplication factor for bending moment for 1.2 (DL + LL - EQX)

Zone / Side	Sagging		Hogging	
	6M	7.5M	6M	7.5M
II	0.81 – 0.84	0.79	1.17 – 1.39	0.79
III	0.81 – 0.86	0.66 - .82	1.39 – 1.7	0.79 – 0.82
IV	0.82 – 0.99	0.76 – 0.78	1.68 – 2.15	0.53 – 0.78
V	0.9 – 1.78	0.74 – 0.76	2.12 – 2.83	0.76 – 0.78

Table .18. For M-III case Range of Multiplication Factor for shear force along X-direction (18m side)

Load Combinations	Zone			
	II	III	IV	V
1.5 (DL + EQX)	0.33 – 0.43	0.44 – 0.61	0.55 – 1.54	0.82 – 1.2
1.5 (DL - EQX)	1.05 – 1.15	1.17 – 1.32	1.32 – 1.56	1.55 – 1.9
1.2 (DL + LL + EQX)	0.92 – 1.03	1.04 – 1.35	1.17 – 1.36	1.03 – 1.63
1.2 (DL + LL - EQX)	0.95 – 1.03	1.04 – 1.35	1.17 – 1.36	1.17 – 1.63

Table.19. For M-III case Range ofMultiplication Factor for shear force along Z-direction (22.5m side)

Load Combinations	Zone			
	II	III	IV	V
1.5 (DL + EQX)	0.15	0.15	0.16	0.17
1.5 (DL - EQX)	0.86	0.86 – 1.2	0.85	0.84
1.2 (DL + LL + EQX)	0.81	0.81	0.82 – .84	0.83
1.2 (DL + LL - EQX)	0.75 – 0.79	0.79	0.77 – 0.79	0.78

Table .20. For M-IV case Range of multiplication factor for bending moment for 1.5 (DL + EQX)

Zone / Side	Sagging		Hogging	
	7.5M	9M	7.5M	9M
II	0.24 – 0.33	0.13 – 0.21	0.5 – 0.62	0.18
III	0.53 – 0.79	0.14 – 0.19	0.71 – 0.9	0.18
IV	0.91 – 1.08	0.15 – 0.21	0.98 – 1.27	0.19
V	1.48 – 1.72	0.16 – 0.24	1.39 – 1.82	0.2

Table.21. For M-IVRange of multiplication factor for bending moment for 1.5 (DL - EQX)

Zone / Side	Sagging		Hogging	
	7.5M	9M	7.5M	9M
II	0.8 – 0.87	0.61 – 0.82	1.18 – 1.24	0.83
III	0.85 – 0.88	0.59 – 0.81	0.63 – 1.58	0.81 – 0.83
IV	0.85 – 0.9	0.59 – 0.9	1.66 – 1.84	0.82
V	0.87 – 1.09	0.57 – 0.78	2.07 – 2.5	0.8

Table.22. For M-IV Range of multiplication factor for bending moment for 1.2 (DL + LL + EQX)

Zone / Side	Sagging		Hogging	
	7.5M	9M	7.5M	9M
II	0.81 – 0.83	0.59 – 0.81	1.07 – 1.17	0.81
III	0.81 – 0.84	0.6 – 0.82	1.24 – 1.39	0.82
IV	0.82 – 0.87	0.61 – 0.83	1.45 – 1.69	0.82
V	0.83 – 0.89	0.61 – 0.993	1.78 – 2.08	0.83

Table.23. For M-IV Range of multiplication factor for bending moment for 1.2 (DL + LL - EQX)

Zone / Side	Sagging		Hogging	
	7.5M	9M	7.5M	9M
II	0.81 – 0.83	0.59 – 0.79	1.07 – 1.17	0.79 – 0.81
III	0.81 – 0.84	0.78 – 1.1	1.24 – 1.39	0.79
IV	0.82 – 0.87	0.57 – 0.78	1.45 – 1.69	0.77 – 0.79
V	0.83 – 0.89	0.56 – 0.76	1.78 – 2.08	0.76 – 1.03

Table.24. For M-IV Range of Multiplication Factor for shear force along X-direction (18m side)

Load Combinations	Zone			
	II	**III**	**IV**	**V**
1.5 (DL + EQX)	0.3 – 0.33	0.39 – 0.43	0.5 – 0.57	0.68 – 0.78
1.5 (DL - EQX)	1	1 – 1.13	1.14 – 1.27	1.38 – 1.48
1.2 (DL + LL + EQX)	0.92 – 0.94	1	1.08 – 1.14	0.83 – 1.3
1.2 (DL + LL - EQX)	0.92 – 0.94	1	1.08 – 1.14	0.83 – 1.3

Table. 25. For M-IV Range of Multiplication Factor for shear force along Z-direction (22.5m side)

Load Combinations	Zone			
	II	III	IV	V
1.5 (DL + EQX)	0.16	0.16	0.17	0.18
1.5 (DL - EQX)	0.84	0.84	0.83	0.82
1.2 (DL + LL + EQX)	0.79 – 0.91	0.79	0.76 – 0.78	0.78

VI. CONCLUSIONS

As we can see from tables the multiplication factors got in Z-direction are very less and the dissertation is to generate these factors for only in X-direction. Following are those multiplication factors which gives direct member forces by multiplying the investigated factor to the member forces got from 1.5(DL+LL).

1. The bending moment multiplication factor for all seismic zones for load combination **1.5(DL+EQX)**, the can be taken as **1.2** for M-I (9m x 12m).

2. The bending moment multiplication factor for all considered load combinations for **Zone-II** can be taken as **2** for M-I (12m x 15m).

3. For bending moment for **Zone-III** and for all load combinations, the multiplication factor can be taken as **3** for M-I (12m X 15m).

4. For bending moment for **Zone-IV** and load combination **1.2(DL+LL+EQX)**, the multiplication factor can be taken as **6** for M-I (12m X 15m).

5. For bending moment for Zone-V and for all load combinations, the multiplication factor can be taken as **1.5** for M-I (12m X 15m).

6. For bending moment multiplication factor for **Zone-II** and **Zone-III** for all load combinations can be taken as **2** and for **Zone-IV** and **Zone-V** it can be taken as **2.7** for **M-II** (18m X 22.5m).

7. For bending moment multiplication factor for **Zone-II**, **Zone-III** and **Zone-IV** for all load combinations can be taken as **1.5** and for **Zone-V** it can be taken as **2.5 for M-II** (22.5m X 27m).

8. The Shear Force multiplication factor for all load combinations and for M-I case, can be taken as **1.7** for **Zone-II and III** (for 9m x 12m and 12 m x 15m).

9. The Shear Force multiplication factor for all load combinations and for M-I case, can be taken as **3.2** for **Zone-III** and **IV** (for 9m x 12m and 12 m x 15m).

10. The Shear Force multiplication factor for all load combinations and for M-II case, can be taken as **2** for all sesmic zones (for 18m x 22.5m and 22.5 m x 27m).

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