IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 5, June 2023

Seismic Assessment of RC Frame Building using Gross and Cracked Section as per IS 1893: 2016 and IS 16700: 2017

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Abstract: *The primary objective of this research is to investigate the behaviour of tall concrete buildings featuring structural walls combined with Special Moment Resisting Frames (SMRF) when subjected to seismic loads, as defined by the IS 1893:2016 and IS 16700:2017 codes. To achieve this, a comprehensive seismic analysis was conducted using the Linear Dynamic Response Spectrum Method in ETABS 2020 software.*

Keywords: Stiffness modifiers, seismic performance, Cracked/Uncracked Section, Response Spectrum Method, Special Moment Resisting Frames (SMRF)

I. INTRODUCTION

In reinforced concrete structures, the occurrence of cracks in various elements is a common possibility. The severity of cracking can vary from one member to another, influenced by several factors. Previously, in structural analysis, the assumption was made that the cross-section of different elements had 100% gross moment of inertia, disregarding any cracks. However, in reality, tension cracks can develop in the reinforced concrete structure elements. To account for these cracks and their effects, stiffness modifiers are introduced.

The purpose of stiffness modifiers is to provide a more realistic analysis of the structure. These modifiers consider the presence of cracks in the tension zone of different reinforced concrete elements. By incorporating stiffness modifiers into the analytical model, we take into account the actual behaviour of the structure, resulting in a more accurate representation of its response.

In summary, the introduction of stiffness modifiers in the analysis of reinforced concrete structures acknowledges the existence of cracks and aims to enhance the realism of the analytical model. By considering these modifiers, we achieve a more accurate understanding of the structure's performance.

II. AIM OF STUDY

The aim of my study is "Comparative Seismic Performance assessment of G+15 storey RCC building using gross and cracked section as per IS 1893: 2016 & IS 16700: 2017"

III. STIFFNESS MODIFIERS GIVEN IN DIFFERENT CODES

Table 1 Stiffness Modifiers in Different Country Codes

SI NO.	Codes	Stiffness modifiers			
		Slab	Beam	Column	Wall
i)	IS 15988-2013	-	0.5	0.7	0.5
ii)	IS 1893-2016	-	0.5	0.7	-
iii)	IS 16700-2017	0.25	0.35	0.7	0.7
iv)	ACI 318-2019	0.25	0.3	0.7	0.35
v)	FEMA 356	-	0.5	0.7	0.5
vi)	TEC-2007	-	0.4	0.8	-

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IV. BUILDING CONFIGURATIONS AND RESULTS

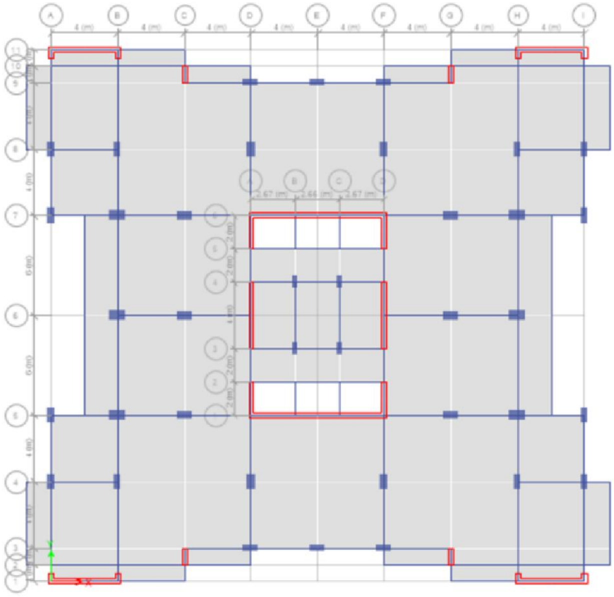

Figure 1 Structural Layout Plan

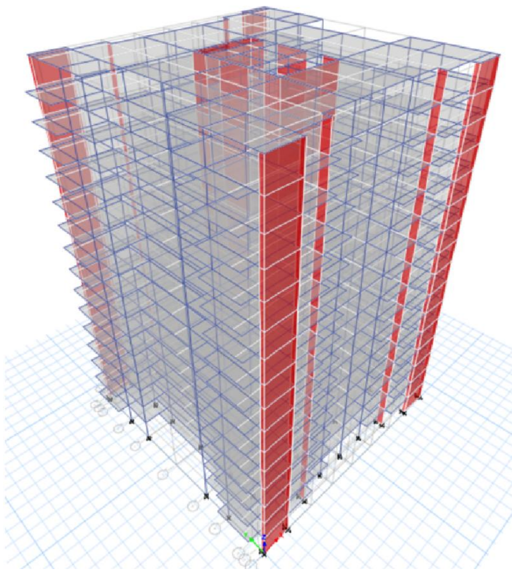

Figure 2 3D View of G+15 Structural Wall + SMRF

Table 2 Loading Parameters and Seismic definitions

Loading Parameter		
Live load	4 KN/m^2	
Floor finish	1.5 KN/m^2	
Wall load	11.25 KN/m at typical floor	
	5 KN/m at terrace floor	
Lift machine load	10 KN/m^2	
Material properties	Concrete	M40
	Steel	Steel Fe500 and Fe415 for Shear reinforcement
Seismic Definition		
Location	Vadodara	
Earthquake load:	As per IS 1893 (Part-1): 2016	
	Zone	III (Z=0.16)
	Importance factor	1.2
	Damping	5%
	Soil type	II (Medium)
	Response reduction factor	5

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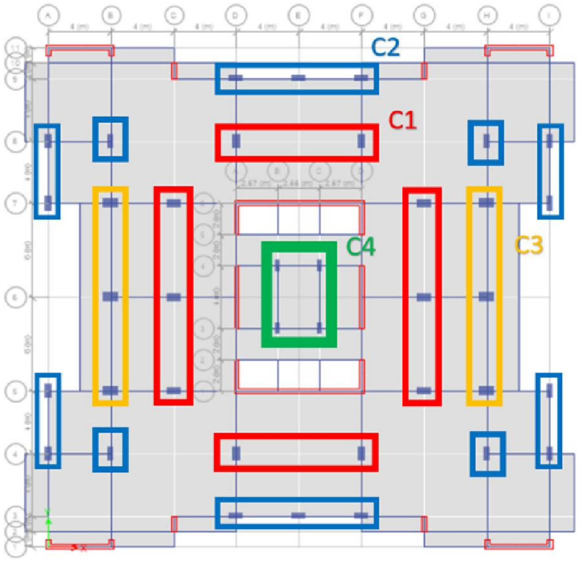

Figure 3Grouping of Column G+15 Dual System

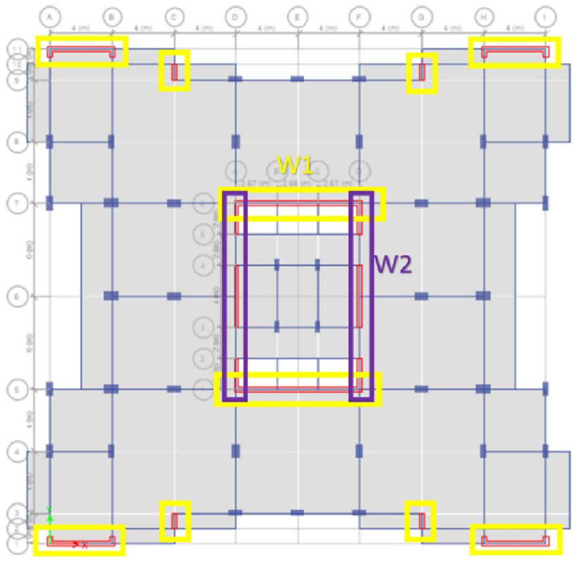

Figure 4Grouping of Walls G+15 Dual System

Table 3: Structural Element Dimensions of G+15 Dual System

(mm)	FLOOR	COLUMN								BEAM		WALLS	
		C1		C2		C3		C4		Peripheral	Internal	W1	W2
SIZE	Base to 4th	500	900	400	900	600	1000	300	750	300 x 750	300 x 600	300	230
	5th to 8th	400	900	300	900	500	900	300	750				
	9th to TRC	300	750	300	750	400	900	300	750				
Slab		200 mm											
Steel		Steel Fe500 & Fe415 for shear reinforcement											
Concrete		M40											

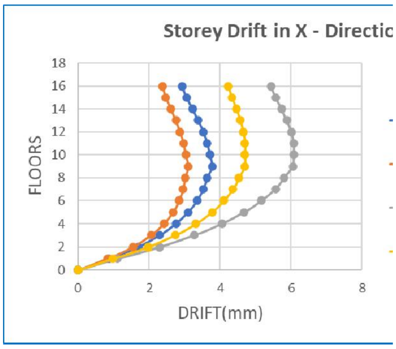

Figure 5Storey Drift in X-Direction for G+15

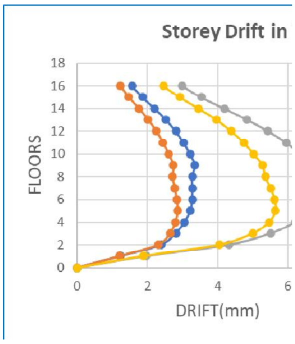

Figure 6Storey Drift in Y-Direction for G+15

Table 4 % Drift for G+15

Load Case	Without Stiffness modifier	With Stiffness Modifier	% Drift
EQ X	3.78	6.08	37.83
EQ Y	3.36	6.84	50.88
RS X	3.11	4.7	33.83
RS Y	2.86	5.65	49.38

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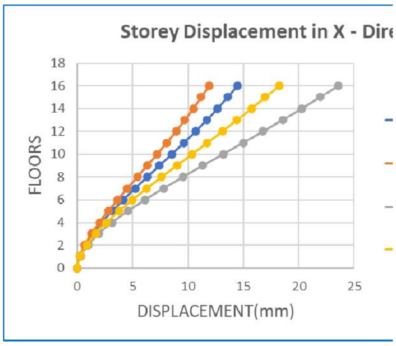


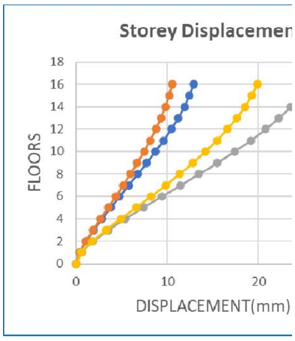
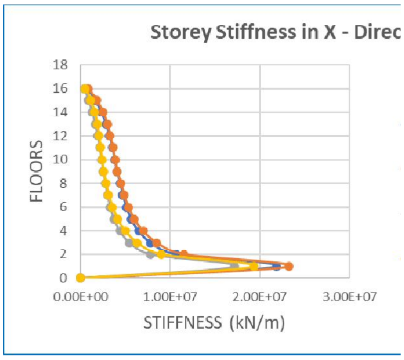


Figure 7Storey Displacement in X-Direction for G+15 Figure 8Storey Displacement in Y-Direction for G+15

Table 5 % Displacement for G+15

Load Case	Without Stiffness modifier	With Stiffness Modifier	% Displacement
EQ X	14.46	23.55	38.61
EQ Y	12.87	25.43	49.40
RS X	11.89	18.21	34.72
RS Y	10.53	19.87	46.98



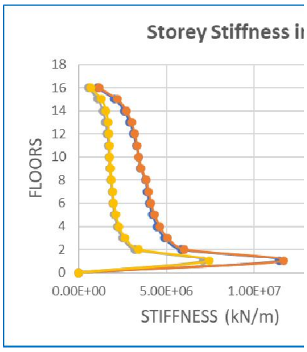


Figure 9Storey Stiffness in X-Direction for G+15 Figure 10Storey Stiffness in Y-Direction for G+15

Table 6 % Stiffness for G+15

Load Case	EQ X		EQ Y	
	Top	Bottom	Top	Bottom
Without Stiffness Modifier	7.39E+05	2.19E+07	1.06E+06	1.14E+07
With Stiffness Modifier	3.92E+05	1.72E+07	5.50E+05	7.09E+06
% Stiffness	47.00	21.36	48.38	37.96

Table 4 Modal Mass Participation for G+15

Without Stiffness Modifiers/Uncracked Section								
Case	Mode	Period sec	UX	UY	SumUX	SumUY	RZ	SumRZ
Modal	1	1.144	0	0.7575	0	0.7575	0	0
Modal	2	1.107	0	0	0	0.7575	0.7341	0.7341
Modal	3	1.012	0.7016	0	0.7016	0.7575	0	0.7341
With Stiffness Modifiers/Cracked Section								
Case	Mode	Period sec	UX	UY	SumUX	SumUY	RZ	SumRZ

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Modal	1	1.612	0	0.7507	0	0.7507	0	0
Modal	2	1.476	0	0	0	0.7507	0.7062	0.7062
Modal	3	1.267	0.6789	0	0.6789	0.7507	0	0.7062

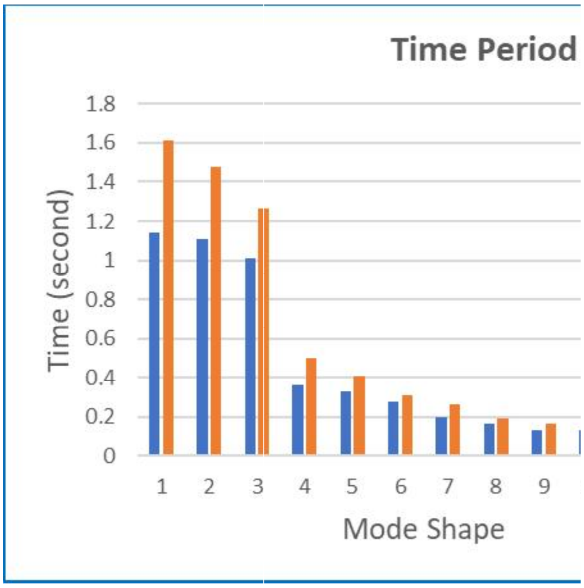

Figure 1 Time Period for G+15

V. CONCLUSION

This study focuses on the understanding of response of Tall Concrete Buildings having Structural Walls with Special Moment Resisting Frames (SMRF) under the Earthquake loading conditions considered as per IS 1893:2016 & IS 16700:2017. In this study, seismic analysis was carried out for the G+15 Storey Building using Linear Dynamic Response Spectrum Method in ETABS 2020 software.

The key findings by introduction of stiffness modifiers had significant effects on various aspects of the building's performance are as follows.

- The consideration of Stiffness modifiers in the structural elements allowed for a more realistic representation of the building's behaviour, resulting in enhanced ductility and energy dissipation during seismic events.
- The application of stiffness modifiers resulted in an increase in storey drift and top storey displacement up to 50% (i.e., 1.50 times)
- The Storey Drift and Displacement values found to be within the acceptable limits for both cracked and uncracked sections.
- However, it is important to note that as the total height of the building increases, the P-Delta effect may become critical for the cracked section.
- It was observed that after application of stiffness modifiers the Time Period is increased by 30% (i.e., 1.3 times).
- Furthermore, the application of stiffness modifiers resulted in a significant reduction in the overall stiffness of the structure.
- While the use of stiffness modifiers influenced storey drift, displacement, stiffness and time period, other parameters such as base shear, axial force, modal mass participation, and storey shear remained relatively constant.
- Stiffness modifiers effectively decrease the seismic demand by increasing the flexibility of the structure. However, it is essential to consider that this increased flexibility may lead to a reduction in the shear capacity of the building and may fail in serviceability criteria.

VI. ACKNOWLEDGEMENT

I feel immense pleasure in thanking my honourable guide Dr. V. R. Patel Sir, Assistant Professor, Applied Mechanics and Structural Engineering Department, for his invaluable guidance, innovative ideas, patience, inspirations, encouragement and moral support for my research work

REFERENCES

[1]. IS:16700-2017. 2017. "Criteria for Structural Safety of Tall Concrete Buildings." Indian Standard.

[2]. IS 1893. 2016. "'Criteria for Earthquake Resistant Design of Structures, Part 1: General Provisions and Buildings.'" Bureau Of Indian Standards, New Delhi.

[3]. ACI 318-19, "Building Code Requirements for Structural Concrete", American Concrete Institute, 2019.

[4]. FEMA 356. (2000). Prestandard and commentary for the seismic rehabilitation of buildings. Burlingame: Building Seismic Safety Council, National Institute of Building Sciences.

[5]. Ahmed, M., Dad Khan, M. K., & Wamiq, M. (2008). Effect of concrete cracking on the lateral response of RCC buildings. Asian Journal of Civil Engineering.

[6]. Bhavin Shah, https://www.linkedin.com/pulse/stiffness-modifiers-per-1893-part-1-2016-bhavin-shah

[7]. Gravity-force resisting system flexural stiffness modifiers for seismic analysis of tall reinforced concrete shear wall buildings by Camilo Sebastian Granda Valencia, B.Sc., Universidad San Francisco de Quito, 2018

[8]. Samir K. Prajapati & Jignesh A. Amin, "Seismic assessment of RC frame building designed using gross and cracked section as per Indian standards", Asian Journal of Civil Engineering (2019).

[9]. Sourav Das, Satyabrata Choudhury, "Influence of effective stiffness on the performance of RC frame buildings designed using displacement-based method and evaluation of column effective stiffness using ANN", Engineering Structures, Vol. 197 (2019)

[10]. "Seismic assessment of RC frame building designed using gross and cracked section as per Indian standards" by Samir K. Prajapati& Jignesh A. Amin in Asian Journal of Civil Engineering (2019).