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Comparative Seismic Response of Existing RC School Building With and Without Shear Walls

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ABSTRACT :*This paper evaluates the seismic performance of existing school reinforced cement concrete structure after addition of shear walls. The existing school building is a framed structure supported on beams and columns only. Shear walls has been added in the existing structure to evaluate the response of the structure under seismic loading. Main purpose of addition of shear walls in the structure is to improve the seismic load carrying capacity of the structure by limiting the lateral displacement of the structure*

KEYWORDS: Reinforced *Cement Concrete, Framed Structure, Seismic Analysis, Lateral Displacement, Shear walls etc.*

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I. INTRODUCTION

India has a long history of frequent earthquakes with high life loss and property damage figures. 2001 Bhujearthquake directly affected an estimatedthreemillion school childrenwitheducationalinfrastructure and processes affected in the whole state. More than15000schoolbuildings were reported damaged. Safety of schoolsbuildings against earthquakes is one of the most important criteria not only because of the life loss it may inflict, but also because after event they oftenserve as emergency shelter and are important resource for the reconstruction process.

The maintenance, rehabilitation and upgrading of structural members, is perhaps one of the most crucial problems in civil engineering applications. Moreover, a large number of structures constructed in the past using the older design codes in different parts of the world are structurally unsafe according to the new design codes. Since replacement of such deficient elements of structures incurs a huge amount of money and time, strengthening has become the acceptable way of improving their load carrying capacity and extending their service lives.

Recent earthquakes have shown the importance of rehabilitating seismicallydeficient structures to achieve an acceptable level of performance. This can beachieved by improving the strength, stiffness, and ductility of the existing structures.Significant advancements has been made in the research and development in thisfield. Many buildings have either collapsed or experienced different levels ofdamage during pastearthquakes. Several investigations have been carried out onbuildings that were damaged by earthquakes. Low-quality concrete, poorconfinement of the end regions, weak column-strong beam behavior, short columnbehavior, inadequate splice lengths and improper hooks of the stirrups were some ofthe important structural deficiencies (Yakut et al., 2005). Most of those buildingswere constructed before the introduction of modern building codes. They usuallycannot provide the required ductility, lateral stiffness and strength, which aredefinitely lower than the limits imposed by the modern building codes (Kaplan etal., 2011). Due to low lateral stiffness and strength, vulnerable structures aresubjected to large displacement demands, which cannot be met adequately as theyhave low ductility.

In the past, most of the reinforced concrete structures were designed primarily for gravity loads. They were also designed for lateral forces that may be much smaller than that prescribed by the current codes. Structures which have such kinds of deficiencies can be prevented from earthquake damages by proper rehabilitation. Therefore, seismic retrofitting has become an important and popular topic among researchers which is studied and applied to seismically deficient structures.

II. OBJECTIVE OF THIS PAPER

The objective of this paper is to evaluate the response of existing school reinforced cement concrete structure after addition of shear walls under seismic loading.

III.MODELLING & ANALYSIS OF BUILDING

The analysis of G+6 floors school structure is carried out using STAAD V8i software for special moment resisting frame situated in Lucknow (Seismic Zone 3). The RCC G+6 structure is analyzed with and without shear walls.. Bending moments, shear forces, lateral displacement and axial forces are compared for both type of structural systems i.e. with and without shear walls structural system.

Table 1.Modeling data for Building

Structure	SMRF
No. of stories	G+6
Type of building use	School
Young's modulus, E	$21.7 x 10^6$ kN/m^2
Grade of concrete	M25
Density of RCC	25 kN/m^3
Beam Size	230x500mm
Column Size	450x450mm
Dead Load Intensity	5 kN/m^2
Live Load Intensity	3 kN/m^2
Seismic Zone, Z	III
Importance Factor, I	1.5
Soil Type	Medium
Response Reduction Factor, R_F	5

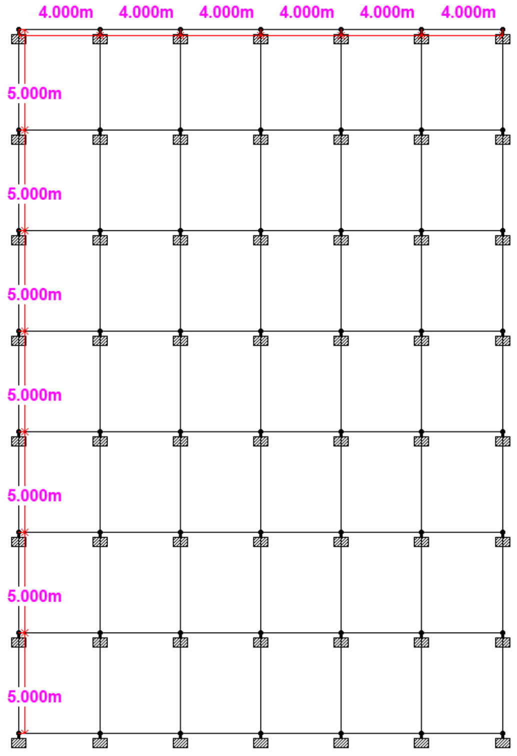

Fig. 1 Plan of a Structure

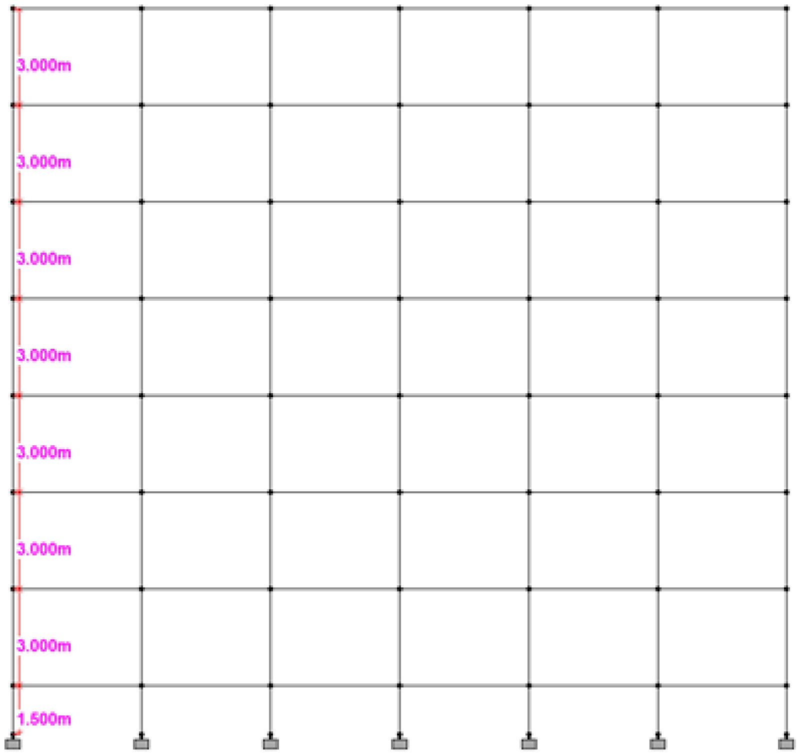

Fig. 2 Elevation of Structure

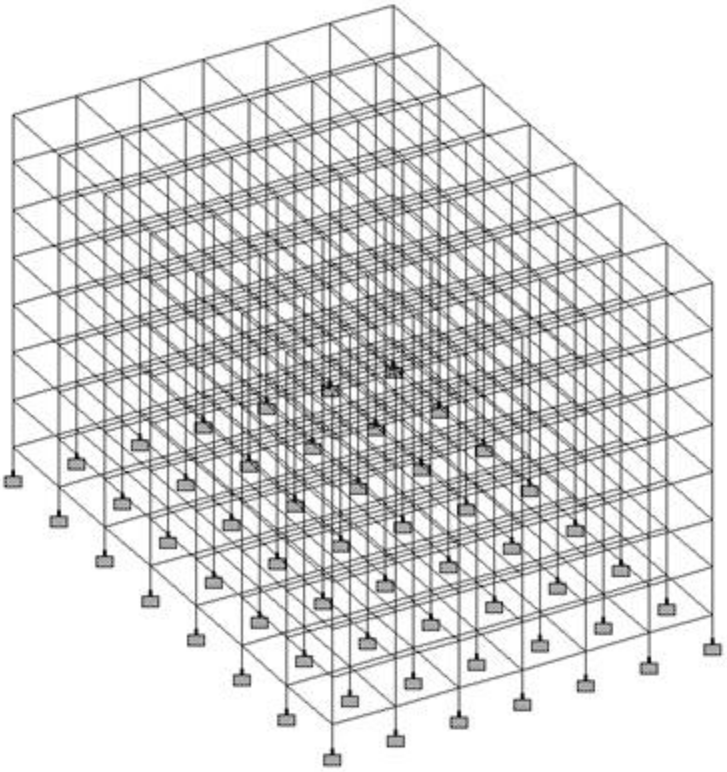

Fig. 3 Isometric View of Structure without Shear Walls

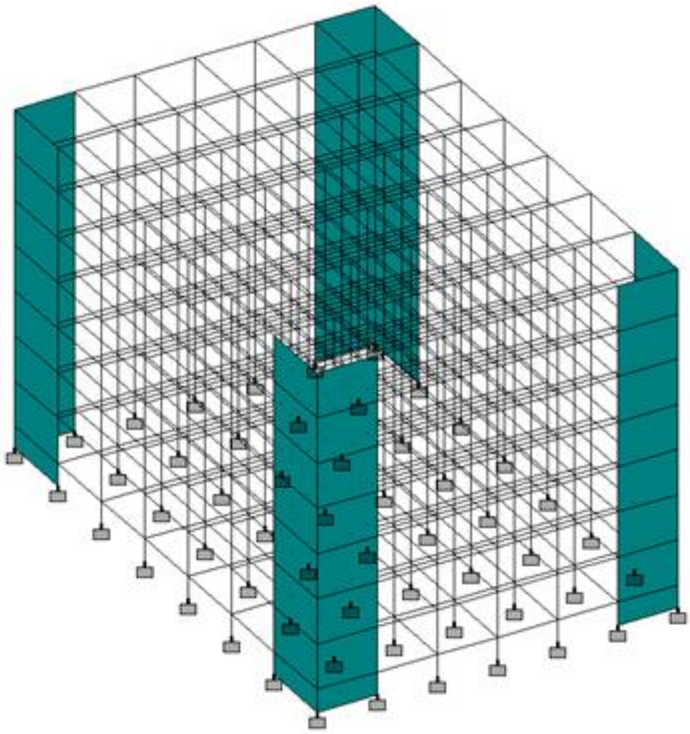

Fig. 4 Isometric View of Structure with Shear Walls at Corners

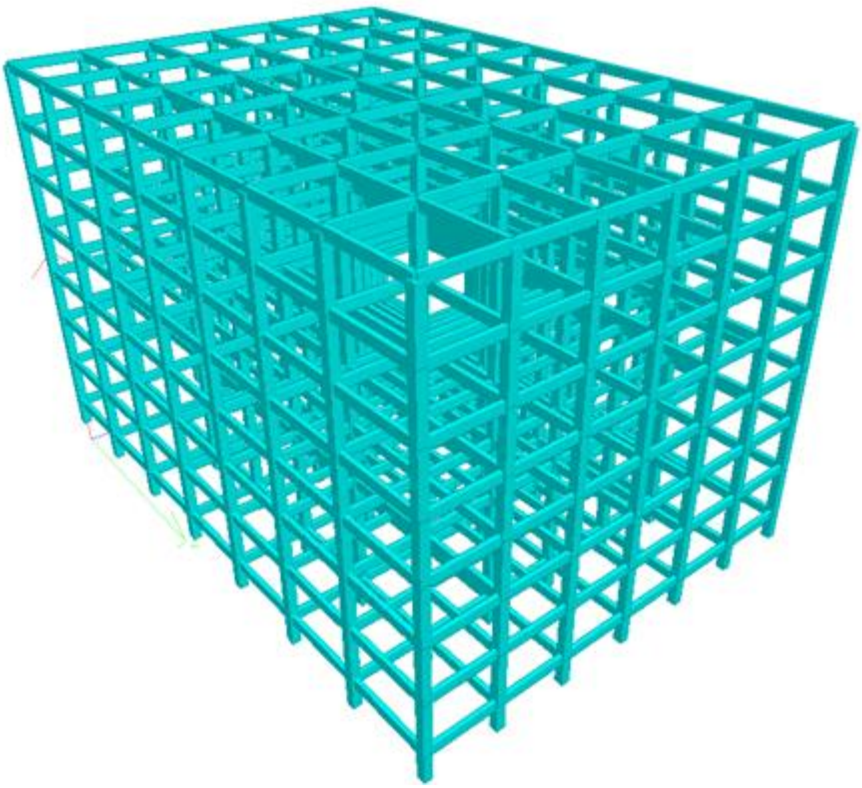

Fig. 5 3D View of Structure without Shear Walls

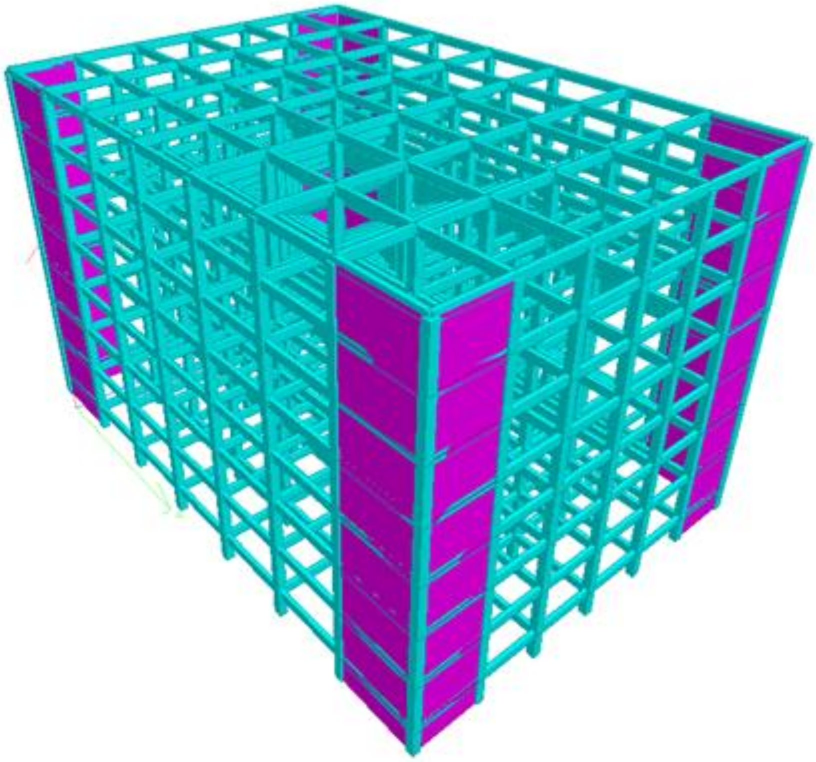

Fig. 63D View of Structure with Shear Walls at Corners

	Structure Type	
Level	With Shear Walls	Without Shear Walls
Base	0	0
First	0.391	0.636
Second	2.061	4.25
Third	4.19	8.443
Fourth	6.406	12.55
Fifth	8.584	16.36
Sixth	10.592	19.65
Seventh	12.255	22.15
Terrace	13.397	23.69

Table 2. Maximum Lateral Displacement (mm) in X Direction for Seismic Load in X Direction

	Structure Type	
Level	WithShear Walls	Without Shear Walls
Base	0	0
First	0.311	0.702
Second	2.061	4.699
Third	4.19	9.381
Fourth	6.406	13.993
Fifth	8.584	18.254
Sixth	10.592	21.91
Seventh	12.255	24.681
Terrace	13.397	26.343

Table 3. Maximum Lateral Displacement (mm) in Z Directionfor Seismic Load in Z Direction

Level	Structure Type	
	With Shear Walls	Without Shear Walls
Base to Ground	1603	1603
Ground to First	1410	1410
First to Second	1209	1209
Second to third	1008	1008
Third to Fourth	806	806
Fourth to Fifth	605	605
Fifth to Sixth	404	404
Sixth to Terrace	202	203

Table 4. Maximum Axial Force (kN) in Columns for Dead and Live Load

Level	Structure Type	
	With Shear Walls	Without Shear Walls
Base to Ground	217	423
Ground to First	193	348
First to Second	155	257
Second to third	116	174
Third to Fourth	80	102
Fourth to Fifth	48	50
Fifth to Sixth	23	25
Sixth to Terrace	7	13

Table 5. Maximum Axial Force (kN) in Columns for Seismic Load in X Direction

Level	Structure Type	
	With Shear Walls	Without Shear Walls
Base to Ground	169	443
Ground to First	151	365
First to Second	122	273
Second to third	92	189
Third to Fourth	64	117
Fourth to Fifth	39	59
Fifth to Sixth	19	24
Sixth to Terrace	6	13

Table 6. Maximum Axial Force (kN) in Columns for Seismic Load in Z Direction

Level	Structure Type	
	With Shear Walls	Without Shear Walls
Base to Ground	23	23
Ground to First	18	18
First to Second	19	19
Second to third	20	20
Third to Fourth	21	21
Fourth to Fifth	21	21
Fifth to Sixth	21	21
Sixth to Terrace	29	29

Table7. Maximum Shear Force (kN) in Columns for Dead and Live Load

Level	Structure Type	
	With Shear Walls	Without Shear Walls
Base to Ground	45	50
Ground to First	45	50
First to Second	46	51
Second to third	45	49
Third to Fourth	42	46
Fourth to Fifth	37	40
Fifth to Sixth	28	31
Sixth to Terrace	17	19

Table 8. Maximum Shear Force (kN) in Columns for Seismic Load in X Direction

Level	Structure Type	
	With Shear Walls	Without Shear Walls
Base to Ground	35	49
Ground to First	35	48
First to Second	36	49
Second to third	35	47
Third to Fourth	33	44
Fourth to Fifth	30	38
Fifth to Sixth	23	29
Sixth to Terrace	14	17

Table 9. Maximum Shear Force (kN) in Columns for Seismic Load in Z Direction

Level	Structure Type	
	With Shear Walls	Without Shear Walls
Base to Ground	25.46	25.467
Ground to First	27.23	27.348
First to Second	28.603	28.866
Second to third	30.041	30.445
Third to Fourth	31.163	31.687
Fourth to Fifth	32.253	32.867
Fifth to Sixth	32.586	33.278
Sixth to Terrace	52.221	53.293

Table 10. Maximum Bending Moment (kN-m) in Columns for Dead & Live Load

Level	Structure Type	
	With Shear Walls	Without Shear Walls
Base to Ground	60.875	67.588
Ground to First	75.356	83.593
First to Second	70.256	77.631
Second to third	67.924	74.86
Third to Fourth	64.77	70.914
Fourth to Fifth	58.266	63.328
Fifth to Sixth	47.29	51.031
Sixth to Terrace	31.778	34.134

Table 11. Maximum Bending Moment (kN-m) in Columns for Seismic Load in X Direction

Level	Structure Type	
	With Shear Walls	Without Shear Walls
Base to Ground	50.359	70.42
Ground to First	59.376	82.816
First to Second	54.819	75.333
Second to third	53.042	72.377
Third to Fourth	51.477	68.512
Fourth to Fifth	47.442	61.489
Fifth to Sixth	39.516	49.877
Sixth to Terrace	26.72	33.092

Table 11. Maximum Bending Moment (kN-m) in Columns for Seismic Load in Z Direction

IV. DISCUSSION ON RESULTS

Table 2 & Table 3 show the maximum lateral displacement for seismic load in X & Z direction respectively at different storey levels for structure with and without shear wall system. The maximum lateral displacement at terrace level in X direction is 13.397 mm & 23.69 mm respectively for the structure with and without shear wall system, whereas the lateral displacement at the same storey level in Z direction for the above said structural systems are 13.397 mm &26.343 mm respectively. It has been noted that the lateral displacement is drastically reduced after the introduction of shear walls in the existing structure.

In Table 4, Table 5 & Table 6 maximum axial force in columns for dead & live load, seismic load in X-direction and seismic load in Z direction respectively for the structural systems of with & without shear wallsare compared. For dead & live load case, it is observed that there is no change in axial forces but the axial force values in the columns for the seismic loads has been reduced after the addition of shear walls in the existing structure. The axial force for seismic load in X direction for the structure without shear walls at the base level is 423kN which has been reduced considerably to 217 kN after addition of shear walls.The axial force for seismic load in Z direction for the structure without shear walls at the base level is 443kN which has been also been reduced considerably to 169 kN after addition of shear walls.

Table 7, Table 8 & Table 9 show the shear forces at different stories for both the structural systems i.e. with and without shear wall system, for dead & live load, seismic load in X direction and seismic load in Z direction respectively. It can be seen that there is no change in the shear force for dead & Live load case for both the structural system, but there is a considerable change in the shear forces for seismic loads for both the structural systems .It has been observed that maximum shear force for without shear wall structural system for seismic load at base level in X direction is 50kN and it has been reduced to 45kN, for structural system comprising of shear walls.

Table 10, Table 11 & Table 12 show the maximum values of bending moments at different stories for both the structural systems i.e. with and without shear wall structural system for dead & live load, seismic load in X and Z direction respectively. It has been observed that there is not much change in bending moments for columns for dead & live load for both the structural systemsbut there is a considerable change in bending moments for seismic loads for both the structural systems The maximum bending moments for columns for without shear wall structural system at base level for seismic load in X direction is 67.588 kN-m which has been reduced considerably to 60.875 kN-m for the structural system comprising of shear walls

V. CONCLUSION

After the analysis of the structure for both the structural system i.e. with and without shear wall structural systems, it has been concluded that the lateral displacement in the structurearises due to lateral load i.e. seismic load decreases after the introduction of shear walls in the existing structure. Addition of shear walls in the existing structure also reduces the axial forces, bending moments and shear forces in the columns thereby reduces the lateral loads on columns. However there is no change in axial forces, bending moments & shear forces for dead & live load case.

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BIOGRAPHY

Mohammed Nauman received his B.Tech. degree in Civil Engineering from JamiaMilliaIslamia, New Delhi, India, in 2008 and the M.Tech degree in Earthquake Engineering from JamiaMilliaIslamia, New Delhi, India, in 2013. Currently, he is a practicing structural engineer. His areas of designing are design of multistorey RCC and steel structures. His main area of interest is the retrofitting of the existing RCC and steel structures.

Dr. Nazrul Islam received has published more than 60 research papers in International journals and conferences along with the degrees like obtained his Bachelor's Degree in Civil Engineering from AMU Aligarh, India in the year 1984, Master's degree in Structures from IIT Roorkee, India (then known as University of Roorkee) in the year 1990. He has obtained his Ph.D. degree in Structures from IIT Delhi, India in the year 1998. Currently he is serving as a teaching faculty in Department of Civil Engineering, Faculty of Engineering and Technology,JamiaMilliaIslamia,New Delhi, India

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