STRENGTH PROVISION OF RC BUILDINGS BY USE OF MODIFIED SHEAR WALL

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Abstract – *This study presents the strength imparting technique to the shear walls when subjected to reverse cyclic loading. If the proposed technique is used, there is no need for vacating the building during renovation, so there is no disturbance for occupants or users during strengthening and rehabilitation. Shear walls are installed in parallel direction to the exterior side of buildings in this proposed. The findings of this technique are such as there is quite improve in the capacity and sway stiffness of reinforced concrete structures. Also shear walls which were attached later, behave as a monolithic member of structure. This technique can be better utilized in India where we have a huge population and during renovation work of a building we have to vacate the building which ultimately disturbs the living life of humans. By this technique we not only strengthened the existing building quickly but this method also found to be more economical as compared to the other methods of Strengthening of vulnerable building or the buildings which was not constructed according to modern code provisions. As day by day seismic zones are changing the buildings which are earlier not prone to Earthquake, now came in severe zones, so for them this method of strengthening may be done very easily. We can provide sufficient stiffness to the building to resist the lateral loads significantly by constructing exterior shear wall of adequate strength as per Code provisions.*

This present study consists of the structural model having (G+8) storey, symmetrical along both the longitudinal and lateral directions simultaneously. The models are subjected to the external lateral loads in the form of seismic loads. The building is subjected to different load combinations as per the code recommends and base shear, displacement, drift values, time period, forces in columns and beams were obtained at different storey level. In addition to this, the same model is provided with the use of external shear walls along the same direction of loading in plan and provides a connection to external shear wall system with the beams and columns of existing building using links of (25 mm dia. HYSD bars of Fe-415). The analysis is subjected to various combinations of loads as per the IS codes. It is observed that lateral displacement of the structure, value of storey drift gets reduced to a reasonable extent which is within the permissible limit. Also this time those members which was found to be weak in carrying the lateral forces due to less stiffness earlier, are now strong enough in carrying lateral load.

1. INTRODUCTION

Earthquake is one of the major disasters natural hazards that cause huge loss of life, livelihood and natural vegetation. According to various studies & surveys, an average about 10000 people die each year due to earthquake, while economic losses are in billions of dollars and Gross National Product of a country is largely affected.
Earthquake is caused by instant release of energy in earth crust which shakes earth's crust. Earthquake is measured by richter's scale and is plotted on seismograph.

1.1 SHEAR WALL

Shear Wall is the structural component which consists of shear panels / braced panels that resist the effect of transverse loads acting on structures. Shear wall are designed to bear wind and seismic load.

1.2 TYPE OF COUPLED SHEAR WALLS

Shear walls which have opening at various positions are known as coupled shear walls.

- **One Row: -**These coupled shear walls which have opening in single vertical row are called one row shear wall.
- **Two Row: -** Shear wall having two row of vertical opening parallel to each other are known as two row shear wall.
- **Staggered Row: -** Shear walls having opening not in same vertical line but in alternate rows are called staggered rows.

2. RESEARCH OBJECTIVES

This thesis aims to know the effect of external shear wall connection to the existing building for strengthening purpose to resist the lateral load acting on it. The main research objectives of this present study are given as:

1. Formation of models (G+8) having Rigid Diaphragm using ETABS platform.
2. The model is subjected to earthquake load in both x and y direction. Considering the building symmetrical in plan and is located in zone IV on medium soil strata site.
3. Analyse of lateral displacement in both direction, storey shear forces, modal information, Column forces, beam forces etc.
4. Again another model as model – 2, of same dimension and properties as of model – 1, is created but this time external shear wall are connected to the building model with the help of steel bars as links and then the result of same parameters, as for model -1 is obtained.
5. Again another model as model – 3, is created same as that of model – 2, but this time opening are provided in the external shear wall and the model is analysed, then for same parameters results are obtained.

3.1 MATERIAL PROPERTIES

The material properties used in creating the model were as follows:-
1. Concrete Grade – M 20 (in case of Beams) and M 25 (In case of Columns)
2. Grade of Steel Used – HYSD Bars (Fe-415)
3. Poisson Ratio of Steel – 0.3
4. Poisson Ratio of Concrete – 0.2
5. Young's Modulus of concrete – 25000000KN/m^2 (M25) – 22360000KN/m^2 (M20)
6. Young's Modulus of reinforcement – 2.1X1010 KN/m^2
7. Damping Factor – 0.05

3.2 GEOMETRIC PROPERTIES

The geometrical properties measured and used to create model were as follows:
1. The slab thickness – 125 mm
2. Beam cross sections on all floors – 0.3mX0.50m
3. Column cross section on all floors – 0.3mX0.75m
4. Storey Height – 3.5m on the lower most story – 3.0m on all the above stories
5. Spans – 5.0m x 5.0m
6. Link1 of steel bars = 25mm
7. Wall thickness = 200mm

3.3 LOADING

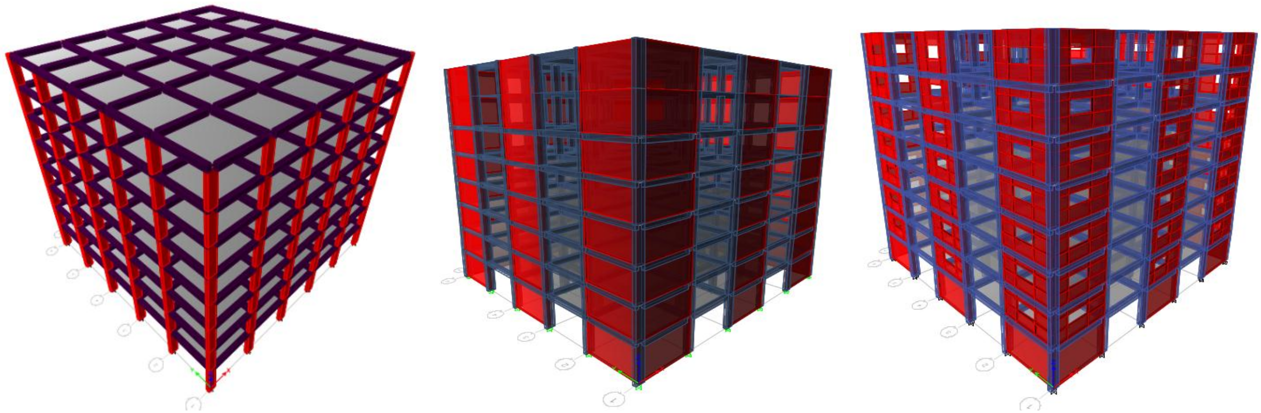
1. Self Weight of Structure is taken on the basis of their cross-section.
2. Imposed Load over the frame is taken as 4 KN/m^2 (On the Basis of Commercial Structures)
3. Brick wall load= 6.875 KN/m
4. Parapet wall load on top storey is = 3 KN/m

3.4 DESCRIPTION OF MODELS:

Table 1: Description of All three Models

	Model – 1	**Model – 2**	**Model – 3**
No. of Storey	G + 8	G + 8	G + 8
Seismic Zone	IV	IV	IV
Soil Type	Medium	Medium	Medium
Storey Height	Ground Storey = 3.5m Above Storey = 3.0m	Ground Storey = 3.5m Above Storey = 3.0m	Ground Storey = 3.5m Above Storey = 3.0m
Size of Beams	0.3 m x 0.5 m	0.3 m x 0.5 m	0.3 m x 0.5 m
Size of Columns	0.3m x 0.75m	0.3m x 0.75m	0.3m x 0.75m

Roof and Floor Thickness	125 mm	125 mm	125 mm
Thickness of Shear Wall	No shear Wall is provided	External Shear Wall of 200mm Thickness	External Shear Wall of 200mm Thickness with openings
Material Used	M20, M25, Fe-415	M20, M25, Fe-415	M20, M25, Fe-415



(a) Model – 1 (b) Model – 2 (c) Model – 3

Fig. 1: 3-D View of Various Models Considered

4. RESULTS AND ANALYSIS

4.1 FUNDAMENTAL TIME PERIOD OF VIBRATION UNDER VARIOUS MODES

Table 2: Time Period of Vibration for Model 1

Information of Model 1						
Mode	**Period**	**UX**	**UY**	**UZ**	**Sum UX**	**Sum UY**
	sec					
1	2.234	0	0.8712	0	0	0.8599
2	1.732	0.00613	0.0011	0	0.00623	0.8598
3	1.621	0.8125	0.01	0	0.8234	0.8598
4	0.699	0	0.0911	0	0.8012	0.9619
5	0.501	0.0012	1.61E-06	0	0.834	0.9619
6	0.5	0.1131	0	0	0.899	0.9619
7	0.409	0	0.031	0	0.899	0.9651
8	0.274	0	0.0132	0	0.899	0.9818
9	0.261	5.99E-06	5.123E-06	0	0.9201	0.9312
10	0.249	0.0411	0	0	0.9610	0.9312

Table 3: Time Period of Vibration for Model 2

Information of Model 2						
Mode	**Period**	**UX**	**UY**	**UZ**	**Sum UX**	**Sum UY**
	sec					
1	0.635	0	0.7129	0	0	0.7129
2	0.615	0.7152	0	0	0.7152	0.7129
3	0.379	0	0	0	0.7152	0.7129
4	0.165	0	0.195	0	0.7152	0.9079
5	0.16	0.1907	0	0	0.9059	0.9079
6	0.096	0	1.93E-06	0	0.9059	0.9079
7	0.094	0	0.0518	0	0.9059	0.9598
8	0.091	0.0501	0	0	0.956	0.9598
9	0.075	0	0.0177	0	0.956	0.9775
10	0.07	0.0177	0	0	0.9736	0.9775

Table 4: Time Period of Vibration for Model 3

Information of Model 3						
Mode	**Period**	**UX**	**UY**	**UZ**	**Sum UX**	**Sum UY**
	Sec					
1	0.662	7.83E-06	0.7117	0	7.83E-06	0.7117
2	0.637	0.7152	7.86E-06	0	0.7152	0.7117
3	0.397	0	0	0	0.7152	0.7117
4	0.176	0	0.1852	0	0.7152	0.8969
5	0.17	0.1815	0	0	0.8967	0.8969
6	0.103	0	0	0	0.8967	0.8969
7	0.101	0	0.0513	0	0.8967	0.9481
8	0.096	0.0506	0	0	0.9473	0.9481

From above tables we can confirm that as less stiffness structures or rather flexibility have more time period for different modes, as this can be seen from table of model-1.

As soon as the stiffness is provided to the structure with the help of external shear wall, now time period of different modes comes out to be lesser than that of model – 1. We can see from table of modal information that for 1st mode time period of model- 1 is 2.169 seconds and for model – 2 for the same mode time period is 0.635seconds. But again in model – 3 time period of mode 1 is increased a little bit to the value 0.662seconds, because by providing opening in the shear wall stiffness of the structure as a whole has been reduced to some extent.

4.2 COLUMN FORCES RESULTS OF C36 LOCATED AT STOREY 1 DUE TO EQX AND EQY LOAD

Table 5: Value of Column Forces at Storey 1 of Model - 1

Building framed structure without external shear wall								
Story	**Column**	**Load Case/Combo**	**P**	**V2**	**V3**	**T**	**M2**	**M3**
			kN	kN	kN	kN-m	kN-m	kN-m
Story1	C36	EQ X	517.58	48.4271	0.2306	0.0376	0.1701	167.802
Story1	C36	EQ X	517.58	48.4271	0.2306	0.0376	-0.1798	93.3849
Story1	C36	EQ X	517.58	48.4271	0.2306	0.0376	-0.5045	16.8043
Story1	C36	EQ Y	489.23	0.1034	33.6676	-0.0109	81.4517	-0.8151
Story1	C36	EQ Y	489.23	0.1034	33.6676	-0.0109	26.2073	-0.9603
Story1	C36	EQ Y	489.23	0.1034	33.6676	-0.0109	-32.751	-1.0832

Table 6: Value of Column Forces at Storey 1 of Model - 2

Building framed structure with shear wall without opening								
Story	**Column**	**Load Case/Combo**	**P**	**V2**	**V3**	**T**	**M2**	**M3**
			kN	kN	kN	kN-m	kN-m	kN-m
Story1	C36	EQ X	245.23	13.2779	-0.3384	0.3513	-0.3255	43.2538
Story1	C36	EQ X	245.23	13.2779	-0.3384	0.3513	0.1995	22.626
Story1	C36	EQ X	245.23	13.2779	-0.3384	0.3513	0.6816	1.1818
Story1	C36	EQ Y	217.28	-1.7205	1.8167	-0.3653	7.347	-1.441
Story1	C36	EQ Y	217.28	-1.7205	1.8167	-0.3653	3.8851	1.1557
Story1	C36	EQ Y	217.28	-1.7205	1.8167	-0.3653	-0.4213	3.7108

Table 7: Value of Column Forces at Storey 1 of Model - 3

Building framed structure with external shear wall with the openings provided								
Story	Column	Load Case/Combo	P	V2	V3	T	M2	M3
			kN	kN	kN	kN-m	kN-m	kN-m
Story1	C36	EQ 1	248.56	9.8958	1.4353	0.4096	1.8814	37.7751
Story1	C36	EQ 1	248.56	9.8958	1.4353	0.4096	-0.3987	22.321
Story1	C36	EQ 1	248.56	9.8958	1.4353	0.4096	-2.5964	6.088
Story1	C36	EQ 2	221.69	7.5404	1.1978	-0.381	6.2564	8.9946
Story1	C36	EQ 2	221.69	7.5404	1.1978	-0.381	3.8328	-2.4308
Story1	C36	EQ 2	221.69	7.5404	1.1978	-0.381	0.603	-13.772

Form above table for three models in combined form, we clearly see that in model-1 all the values for forces comes out to be more than that of when compared with model-2 and model-3 , because in model-1 case, for EQX and EQY load acting at the storey level 1, most of the load is taken by framed structure as there is no special lateral load resisting element in the building (like shear wall) but in model-2 and model-3 Now most of the lateral load due to EQX and EQY is taken by the external shear wall which is created, so forces acting on the column members comes out to be less in value, Here we see a clear decrease in forces for the strengthened models withshear wall (Model-2 & Model-3). This clearly shows that the shear walls are playing its part in taking the lateral forces due to earthquake force.

5) BEAM FORCES RESULT OF B51 AT STOREY 8 LEVEL DUE TO EQX LOAD

Table 8: Beam Forces Result of B51 at Storey 8 Level

Storey	Beam	Load Case/Combo	Model 1		Model 2		Model 3	
			Shear force V2	MomentM3	Shear force V2	MomentM3	Shear force V2	MomentM3
			kN	kN-m	kN	kN-m	kN	kN-m
Story8	B51	EQX	11.5177	21.962	8.298	12.69	8.1173	11.695
Story8	B51	EQX	11.5177	16.922	8.298	11.69	8.1173	8.1432
Story8	B51	EQX	11.5177	11.883	7.956	9.023	7.0812	8.0079
Story8	B51	EQX	10.1967	11.692	7.956	6.59	7.0812	5.0575
Story8	B51	EQX	10.1967	7.4436	7.956	4.235	7.0812	2.1069
Story8	B51	EQX	10.1967	3.1948	7.956	-1.296	7.0812	-0.844
Story8	B51	EQX	10.1967	-1.054	7.125	-1.223	6.9916	-0.992
Story8	B51	EQX	10.1388	-1.271	7.125	-4.035	6.9916	-3.905
Story8	B51	EQX	10.1388	-5.496	7.125	-6.912	6.9916	-6.818
Story8	B51	EQX	10.1388	-9.722	7.125	-9.965	6.9916	-9.731
Story8	B51	EQX	10.1388	-13.95	7.6511	-10.235	7.6511	-9.872
Story8	B51	EQX	10.8321	-14.16	7.6511	-13.564	7.6511	-13.22

From the above table results we can say that by providing external shear wall in strengthened models as (model – 2, and model – 3). we have also reduced the load that is acting on the beams because shear wall created are taking most the load thus loads value has been decreased to a reasonable amount which shows that even weak beams do not fails due the above load and remains at stronger side.

6.2 Conclusion

From this study and the results obtained it is being concluded that the buildings which was constructed before the introduction of modern codes but their importance value is more (such as schools, hospitals, fire stations and power stations etc. Such buildings cannot sustain the lateral load (mainly earthquake load) effectively as these were not designed for these loads or due to various types of faulty construction work.

But now as seismic zones are changing day by day and now these buildings exist in severe to very severe zones we cannot vacate these building for a longer period during renovation work, which causes disturbance to the living life of population.

- From this study and its outcomes clearly indicates that we can strengthened these building by inspecting the degree of their vulnerability, by the use of external shear walls along the parallel sides of the building and connection can be made effectively between the exterior shear wall and existing building using dowel bars of sufficient diameter (steel bars) to act as a monolithic structure during lateral forces acting on it.

- From that stiffness of the structure can be increased as a whole and most of the lateral loads is taken by the shear wall, with the help of which the structures can be damaged to a lesser extent.

- This method is also of a great importance that instead of doing elemental strengthening of building

- Thus various parameters like displacement, storey shear, time period, forces in column and beams have been reduced to a greater percentage which makes the building on stronger side then earlier condition.

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