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Seismic Analysis and Design of Shear Walls in Response Spectrum Method By Using Etabs

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ABSTRACT

Besides, food and clothing, shelter is a basic human need. India has been successful in meeting the food and clothing requirements of its vast population; however the problem of providing shelter of all is defying solutions. "While there has been an impressive growth in the total housing stock from 65 million in 1947 to 187.05 million in 2001, a large gap still exists between the demand and supply of housing units. The Working Group on Housing for the 9th five-year plan estimated the housing shortage in 2001 at 19.4 million units- 12.76 million in rural area and 6.64 million in urban area. The shortage of housing is acutely felt in urban areas –more so in the 35 Indian cities, which according to the 2001 census have a population of more than a million". Hence in order to overcome this problem construction process should be quick, tall and effective to accommodate huge population in a given area. So I have chosen this topic of " SEISMIC ANALYSIS AND DESIGN OF SHEAR WALLS IN RESPONSE SPECTRUM METHOD BY USING ETABS". This type of shear wall construction helps to build tall structure of about 13 floors within no time. Hence the construction process will become much quicker and efficient. Shear walls have a peculiar behavior towards various types of loads. Calculation of rigidity factor, reactions, shear center, shear force and bending moment is a topic of interest. I am going to check the building behavior. I am verifying and designing this structure using extended three dimensional analysis of buildings (ETABS) software.

Keywords : Shear Wall, Seismic Analysis, Response Spectrum, Etabs, Rigidity factor, Shear center, Shear force, Bending moment.

I. INTRODUCTION

Shear walls are vertical elements of the horizontal force resisting system. Shear walls are constructed to counter the effects of lateral loads acting on a structure. In residential construction, shear walls are straight external walls that typically form a box which provides all of the lateral support for the building. When shear walls are designed and constructed properly, and they will have the strength and stiffness to resist the horizontal forces. In building construction, a rigid vertical diaphragm capable of transferring lateral forces from exterior walls, floors, and roofs to the ground foundation in a direction parallel to their planes. Examples are the reinforced-concrete wall or vertical truss. Lateral forces caused by wind, earthquake, and uneven settlement loads, in addition to the weight of structure and occupants; create powerful twisting (torsion) forces. These forces can literally tear (shear) a building apart. Reinforcing a frame by attaching or placing a rigid wall inside it maintains the shape of the frame and prevents rotation at the joints. Shear walls are especially important in high-rise buildings subjected to lateral wind and seismic forces.

Scope of the work:

The aim of the shear wall is to investigate the different ways in which the tall structures can be stabilized against the effects of strong horizontal wind loading and seismic loading. Some other reasons why we use shear walls are tall structures can be constructed which reduces the area used and we can accommodate a large population in that particular area. Other objective is to construct a cost effective structure in less period of time. This study helps in the investigation of strength and ductility of walls.

Shearwall:

Shear walls are vertical elements of the horizontal force resisting system. Shear walls are constructed to counter the effects of lateral load acting on a structure. In residential construction, shear walls are straight external walls that typically form a box which provides all of the lateral support for the building. When shear walls are designed and constructed properly, and they will have the strength and stiffness to resist the horizontal forces.

Purpose of Constructing Shear Walls:

Shear walls are not only designed to resist gravity / vertical loads (due to its self-weight and other living / moving loads), but they are also designed for lateral loads of earthquakes / wind. The walls are structurally integrated with roofs / floors (diaphragms) and other lateral walls running across at right angles, thereby giving the three dimensional stability for the building structures.

Shear wall structural systems are more stable. Because, their supporting area (total cross- sectional area of all shear walls) with reference to total plans area of building, is comparatively more, unlike in the case of RCC framed structures.

Forces on Shear Wall:

Shear walls resist two types of forces: shear forces and uplift forces. Shear forces are generated in stationary buildings by accelerations resulting from ground movement and by external forces like wind and waves. This action creates shear forces throughout the height of the wall between the top and bottom shear wall connections. Uplift forces exist on shear walls because the horizontal forces are applied to the top of the wall. These uplift forces try to lift up one end of the wall and push the other end down. In some cases, the uplift force is large enough to tip the wall over. Uplift forces are greater on tall short walls and less on low long walls.

II. DESIGN OF SHEARWALLS

The walls, in a building, which resist lateral loads originating from wind or earthquakes, are known as shear walls. A large portion of the lateral load on a building, if not the whole amount, as well as the horizontal shear force resulting from the load, are often assigned to such structural elements made of RCC. These shear walls, may be may be added solely to resist horizontal force, or concrete walls enclosing stairways, elevated shafts, and utility cores may serve as shearwalls. Shear walls not only have very large in-plane stiffness and therefore resist lateral load and control deflection very efficiently, but may also help to ensure development of all available plastic hinge locations throughout the structure prior to failure. The other way to resist such loads may be to have the rigid frame augmented by the combination of masonry walls. The use of shear walls or their equivalent becomes imperative in certain high-rise buildings, if inter- storey deflections caused by lateral loadings are to be controlled. Well-designed shear walls not only provide adequate safety, but also give a great measure of protection against costly non-structural damage during moderate seismic disturbances.

General Requirements:

(a) The thickness of the shear wall should not be less than 150mm to avoid unusually thin sections. Very thin sections are susceptible to lateral instability in zones where inelastic cyclic loading may have to be sustained.

(b) The effective flange width for the flanged wall section from the face of web should be taken as least of

* Half the distance to an adjacent shear wall web, and
* One-tenth of total wall height.

(c) The minimum reinforcement in the longitudinal and transverse directions in the plan of the wall should be taken as 0.0025 times the gross area in each direction and distributed uniformly across the cross-section of wall. This helps in controlling the width of inclined cracks that are caused due to shear.

(d) If the factored shear stress in the wall exceeds $0.25\sqrt{fck}$ or if the wall thickness exceeds 200mm, the reinforcement should be provide in two curtains, each having bars running in both the longitudinal and transverse directions in the plane of the wall. The use of reinforcement in two curtains reduces fragmentation and premature deterioration of the concrete under cyclic loading.

To assign a beam, we can directly click on the icon create lines or region at click. The other way to do it is to click on Draw menu=>Draw line objects=>Create lines or regions at click command. A window appears which provides properties of the object in which the property is changed to the beam that we defined earlier. We can click on each grid point or directly select all at once and the beams are assigned to the grid.

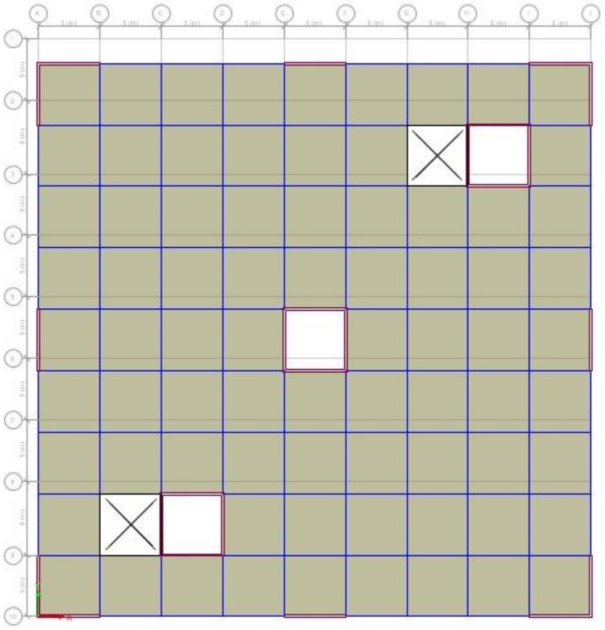

Figure 1. Beams and shear walls

To assign a column, we can click on create columns in region or at clicks or click on Draw menu=>Draw line objects=>Create columns in region or at clicks. In this the property is changed to the defined column and columns can be assigned to offsets in x and y directions. Columns are also assigned in the similar way as beams are assigned.

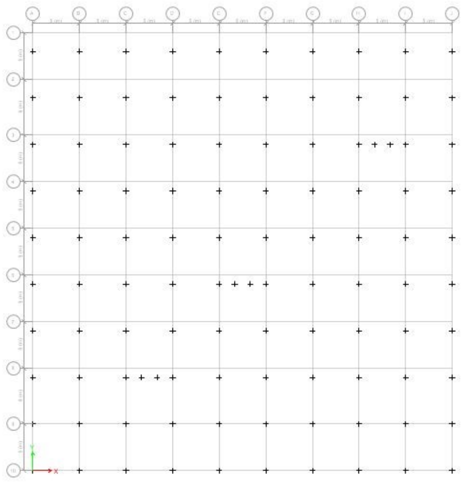

Figure 2. Columns after they are assigned

Further we have to provide slabs for which we have to select define menu=>wall sections after which a window appears with options add new, modify/show section and delete section. Click on add new slab and click on ok. A new window appears where provide the section name as slab and the material is changed to the already defined one. The other data is kept as it is. We can change the display colour to our convenience and then click ok.

III. Design of G+13 Shear Wall Building Using E-Tabs

ETABS is sophisticated software for analysis and design program developed specifically for buildings systems. ETABS version-2013.1.5 features in an intuitive and powerful graphical interface coupled with unmatched modeling, analytical, and design procedures, all integrated using common database. Although quick and easy for simple structures, ETABS can also handle the largest and most complex building models, including a wide range of nonlinear behaviors, making it the tool of choice for structural engineers in the building industry.

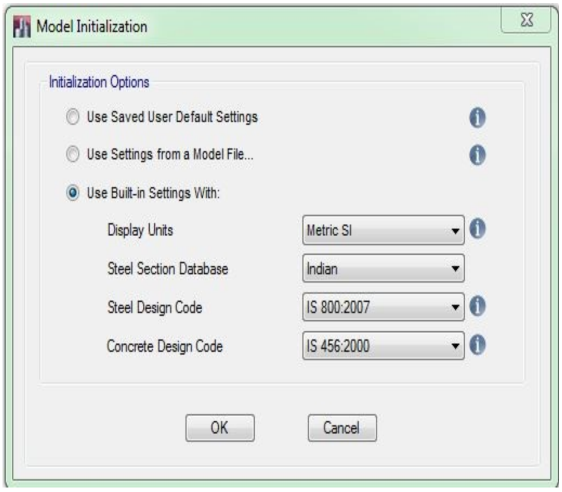

Figure 3. New model selection

In the story dimensions, we have simple story data and custom story data. In simple story data, use the defaults or specify values for the number of stories, typical story height, and bottom story height. The value specified for the typical story height will be used for all stories in the model, except the bottom story whereas in custom story data we can manually define story names, story levels of non-uniform height, and story similarity.

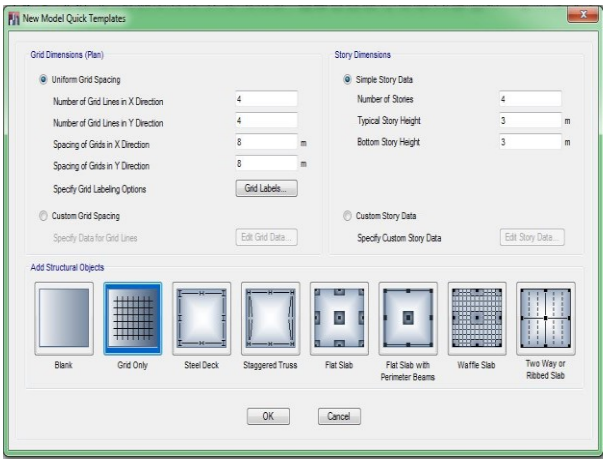

Figure 4. Provision of storey and grid data in Etabs

IV. ASSIGNING OF LOADS:

After the columns, beams, walls and slabs are assigned now the loads are to be applied to the structure. There are different load combinations used in this software. For shear walls, lateral loads and seismic loads play a vital role. To assign any particular load, click Define=>Static load cases. In this window dead load and live load are already assigned. To assign any other loads change the name of the load in load option, select the load type in type option, add the self weight multiplier as required. The auto lateral load options provide different code books that are used across the world. We use IS 1893-2002 code.

Design of load combinations:

The design loading combinations are the various combinations of the pre- scribed response cases for which the structure is to be checked/designed. The program creates a number of default design load combinations for a concrete frame design. Users can add their own design load combinations as well as modify or delete the program default design load combinations. An unlimited number of design load combinations can be specified.

To define a design load combination, simply specify one or more response cases, each with its own scale factor. The scale factors are applied to the forces and moments from the analysis cases to form the factored design forces and moments for each design load combination. There is one exception to the pre- ceding. For spectral analysis model combinations, any correspondence between the signs of the moments and axial loads is lost. The program uses eight design load combinations for each such loading combination specified, reversing the sign of axial loads and moments in major and minor directions.

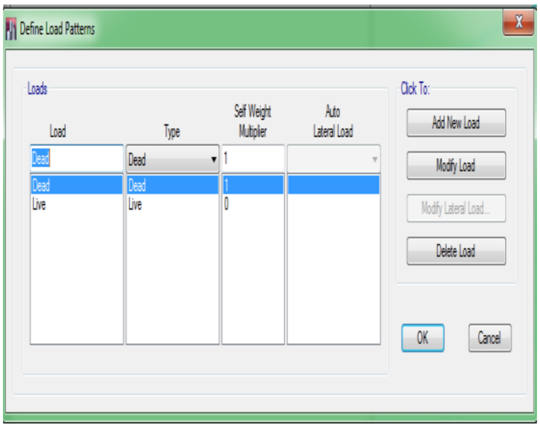

Figure 5. Defining Static loads

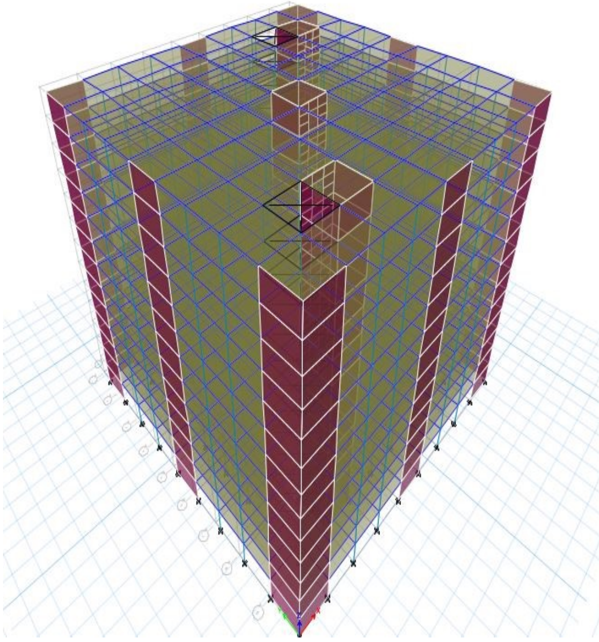

Figure 6. 3d view before analysis

After all the loads are assigned, now click analyze=>run analysis. After the complete structure is analyzed, the deformed shape of the structure is shown in 3D view. This is due to the loads that are acting on all the sections i.e., beams, columns, walls and slabs.

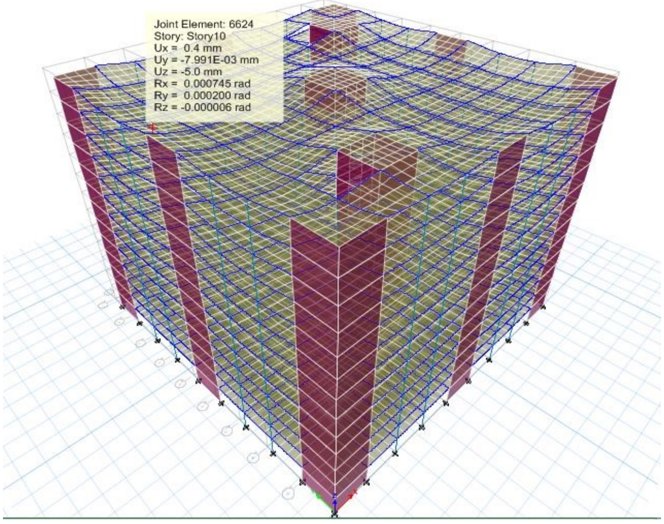

Figure 7. After analysis deflection diagram

V. ANALYSIS OFSHEARWALLS:

After the columns, beams, walls and slabs are assigned now the loads are to be applied to the structure. There are different load combinations used in this software. For shear walls, lateral loads and seismic loads play a vital role.

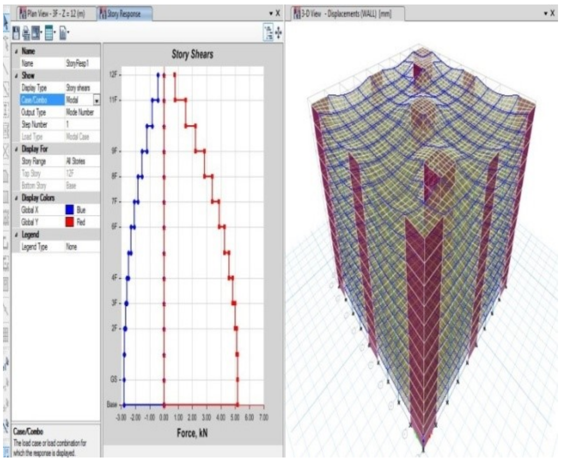

Figure 8. After analysis storey Shear

1	TABLE: int Dis cements									
2	Story	Label	Unique Name	Load Case/Combo	UX	UY	UZ	RX	RY	RZ
3					mm	mm	mm	rad	rad	rad
4	12F	2	4	UDCon19 Max	30.4	1.1	-13.6	0.001211	0.000732	0.000066
5	12F	2	4	UDWal19 Max	30.4	1.1	-13.6	0.001211	0.000732	0.000066
6	12F	3	6	UDCon19 Max	30.4	0.4	-12.7	0.001284	-0.000478	0.000066
7	12F	3	6	UDWal19 Max	30.4	0.4	-12.7	0.001284	-0.000478	0.000066
8	12F	6	12	UDCon19 Max	30.4	-0.2	-12.4	0.000691	0.000207	0.000066
9	12F	6	12	UDWal19 Max	30.4	-0.2	-12.4	0.000691	0.000207	0.000066
10	12F	5	111	UDCon19 Max	30.4	-0.5	-9.2	0.002001	0.000848	0.000066
11	12F	5	111	UDWal19 Max	30.4	-0.5	-9.2	0.002001	0.000848	0.000066
12	12F	7	14	UDCon19 Max	30.4	0.2	-8	-0.000091	-0.000628	0.000066
13	12F	7	14	UDWal19 Max	30.4	0.2	-8	-0.000091	-0.000628	0.000066
14	12F	32	66	UDCon19 Max	30.4	1.7	-7	0.002436	0.000891	0.000066
15	12F	32	66	UDWal19 Max	30.4	1.7	-7	0.002436	0.000891	0.000066
16	12F	4	112	UDCon19 Max	30.4	-0.2	-5.4	0.002931	0.000727	0.000066
17	12F	4	112	UDWal19 Max	30.4	-0.2	-5.4	0.002931	0.000727	0.000066
18	12F	34	69	UDCon19 Max	30.4	0.8	-5.1	0.00014	0.000824	0.000066
19	12F	34	69	UDWal19 Max	30.4	0.8	-5.1	0.00014	0.000824	0.000066
20	12F	31	63	UDCon19 Max	30.4	2.4	-3.2	0.000065	0.000856	0.000066
21	12F	31	63	UDWal19 Max	30.4	2.4	-3.2	0.000065	0.000856	0.000066
22	12F	33	70	UDCon19 Max	30.4	0.5	-1.1	0.001776	0.000732	0.000066
23	12F	33	70	UDWal19 Max	30.4	0.5	-1.1	0.001776	0.000732	0.000066
24	12F	65	130	UDCon19 Max	29.8	1.1	-20.4	0.000556	0.000414	0.000066
25	12F	65	130	UDWal19 Max	29.8	1.1	-20.4	0.000556	0.000414	0.000066
26	12F	69	134	UDCon19 Max	29.8	0.4	-20.3	0.000629	0.000114	0.000066

Figure 9. After analysis storey diplacements

VI. RESULTS AND CONCLUSION:

Thus shear walls are one of the most effective building elements in resisting lateral forces during earthquake. By constructing the shear walls, the damages due to effect of lateral forces due to earthquake and high winds can be minimized. Shear walls construction will provide larger stiffness to the buildings there by reducing the damage to the structure and its contents. Not only its strength, in order to accommodate huge number of population in a small area tall structures with shear walls are considered to be most useful. Hence for a developing nation like India the structures with shear walls construction is considered to be a back bone for construction industry.

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[7]. As per clause 32, design for wall describes, design of horizontal shear in clause 32.4 given details of how shear wall have to be constructed.