Analysis and Design of Shear Wall for an Earthquake Resistant Building using ETABS

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Abstract

Shear walls generally used in high earth quake prone areas, as they are highly efficient in taking the loads. Not only the earthquake loads but also wind loads which are quite high in some zones can be taken by these shear walls efficiently and effectively. To determine the solution for shear wall location in multi-storey building based on its both elastic and elasto-plastic behaviors. The earthquake load is to be calculated and applied to a multi-storied building of plan 26mx26m and 10 no. of (G+9) floors with 40 meters height. For this model, results are calculated and analysed for the effective location of shear wall. The design above is verified for this same structure using extended three dimensional analysis of buildings (ETABS) software. The results are compared.

Keywords: Shear wall, ETABS, shear strength, flexure strength, shear force

I. INTRODUCTION

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. 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.

Shear wall buildings are usually regular in plan and in elevation. However, in some buildings, lower floors are used for commercial purposes and the buildings are characterized with larger plan dimensions at those floors. In other cases, there are setbacks at higher floor levels. Shear wall buildings are commonly used for residential purposes and can house from 100 to 500 inhabitants per building.

II. METHODOLOGY

Structural analysis was carried out by means of well-known computer program E-tabs issued for the linear structural analysis of buildings subjected to static and dynamic loads, is documented. Efficient model formulation and problem solution is achieved by idealizing the building as a system of frame and shear wall substructures inter-connected by floor diaphragms.

Design of 10 storey high rise building and optimization of shear wall is done by computer aided software E-Tabs. Plan generated in Auto cad is imported and modelled by manual and in ETABS. This model is analysed for axial and lateral loads and the results are studied. For optimization of shear wall location shear wall is placed in three different locations and the results obtained such as displacements, drifts, storey shears are studied and compared.

III. DESIGN OF COMMERCIAL BUILDING USING ETABS

The innovative and revolutionary new ETABS is the ultimate integrated software package for the structural analysis and design of buildings. Incorporating 40 years of continuous research and development, this latest ETABS offers unmatched 3D object based modelling and visualization tools, blazingly fast linear and nonlinear analytical power, sophisticated and comprehensive design capabilities for a wide-range of materials, and insightful graphic displays, reports, and schematic drawings that allow users to quickly and easily decipher and understand analysis and design results.

From the start of design conception through the production of schematic drawings, ETABS integrates every aspect of the engineering design process. Creation of models has never been easier - intuitive drawing commands allow for the rapid generation

of floor and elevation framing. CAD drawings can be converted directly into ETABS models or used as templates onto which ETABS objects may be overlaid. The state-of-the-art SAP Fire 64-bit solver allows extremely large and complex models to be rapidly analysed, and supports nonlinear modelling techniques such as construction sequencing and time effects (e.g., creep and shrinkage).

Design of steel and concrete frames (with automated optimization), composite beams, composite columns, steel joists, and concrete and masonry shear walls is included, as is the capacity check for steel connections and base plates. Models may be realistically rendered, and all results can be shown directly on the structure. Comprehensive and customizable reports are available for all analysis and design output, and schematic construction drawings of framing plans, schedules, details, and cross-sections may be generated for concrete and steel structures.

ETABS provides an unequalled suite of tools for structural engineers designing buildings, whether they are working on one-story industrial structures or the tallest commercial high-rises. Immensely capable, yet easy-to-use, has been the hallmark of ETABS since its introduction decades ago, and this latest release continues that tradition by providing engineers with the technologically-advanced, yet intuitive, software they require to be their most productive.

Procedure for design of shear wall for 10 storey building-

Firstly click on the ETABS icon .A window appears which shows a different tip every time you open the software.

This window provides us 3 options. You can click on previous or next tip to checkout some more tips or else click ok to move further.

Change the units at the right bottom to KN-m or any other as per your convenience.

Click on file option to create a new file or to open an already existing file

When you open a new file another window appears which again contain 3 options

- Choose. edb
- Default. edb and
- No

A. New model selection

- First option helps us to select an already existing file
- Second helps us to create a new file and
- The third displays the grid data and story data

As we are creating a new file, we click on default.edb

A new window appears which has Building plan grid system and Story data. In grid dimensions we can either use uniform spacing or we can customize the grid spacing. We have to provide no of lines in x and y directions as per the columns and beams used in the plan.

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.

After providing the entire data click on grid only in structural objects and then click on ok.

Now the screen is divided into two equal halves in which one is plan view and the other is 3-D view of the provided data.

We can change the view options to plan,3D or elevation views. We can select any of the stories as per the work to be done on that particular story. At the right corner we change the story options to either similar or all stories. This makes us to save time i.e. if we are working on a particular story, then that is transferred to remaining stories or similar stories as per the option selected. The top story is selected as default story.

After the entire grid data and story data is provided, then we have to define the properties of the material that is used.

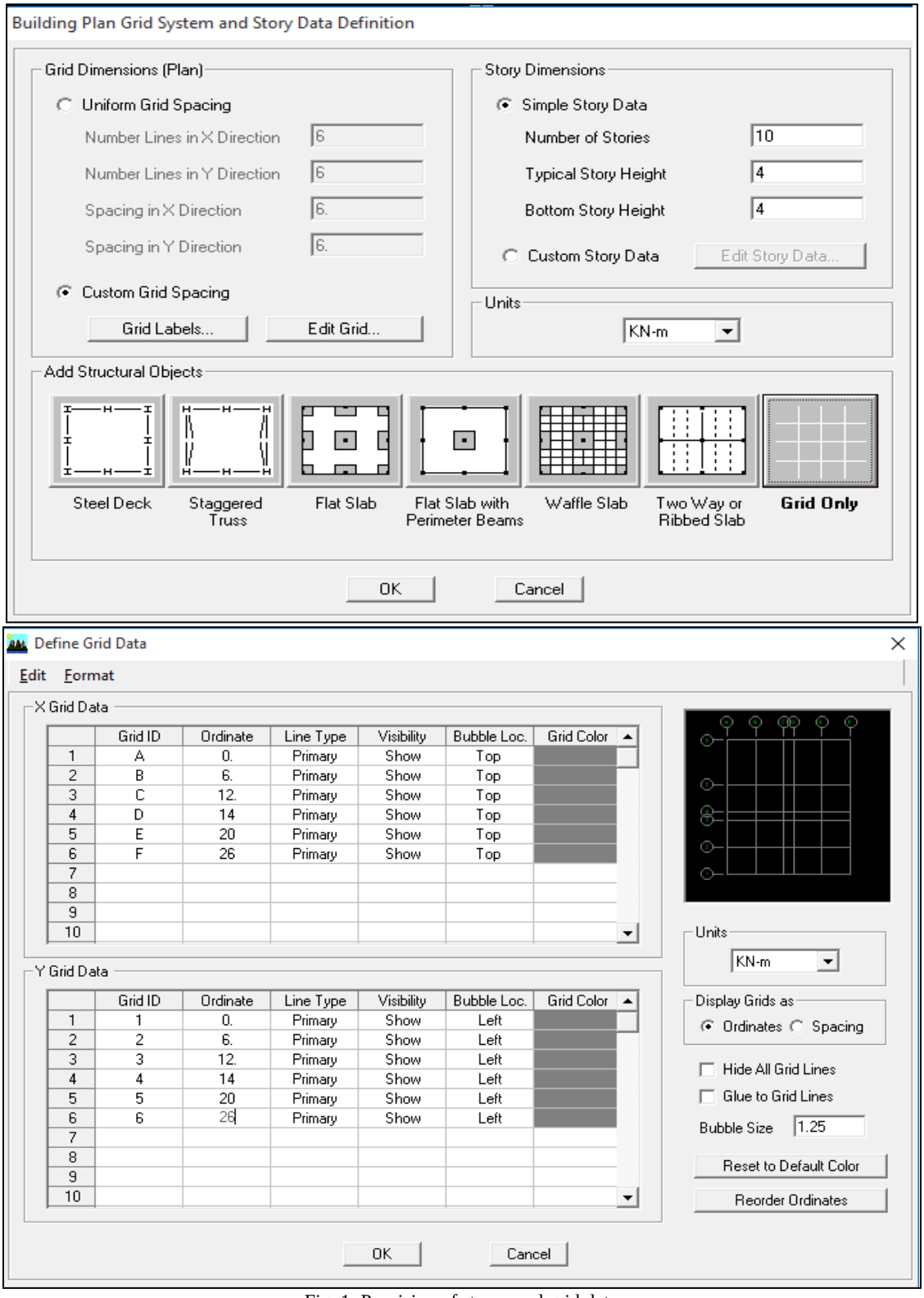

Fig. 1: Provision of storey and grid data

To define a material property, select define=>material properties. This makes us to either add new material, modify or delete an existing material. Click on add new material to create a new material with required properties.

Firstly provide a name(say M20,M30 etc.) and then provide the other properties of the material such as mass per unit volume, weight per unit volume, elastic modulus, Poisson's ratio. The other design properties that are to be provided are characteristic compressive strength and yield strength values. You have other options such as change in display colour, type of material which is always isotropic. After the entire data is provided click on ok.

The next step is to create beams and columns. To create a beam or column, first we click on define=>frame sections command to create a beam or column. In this window we have import and add options further provided with modify or delete options of already existing properties.

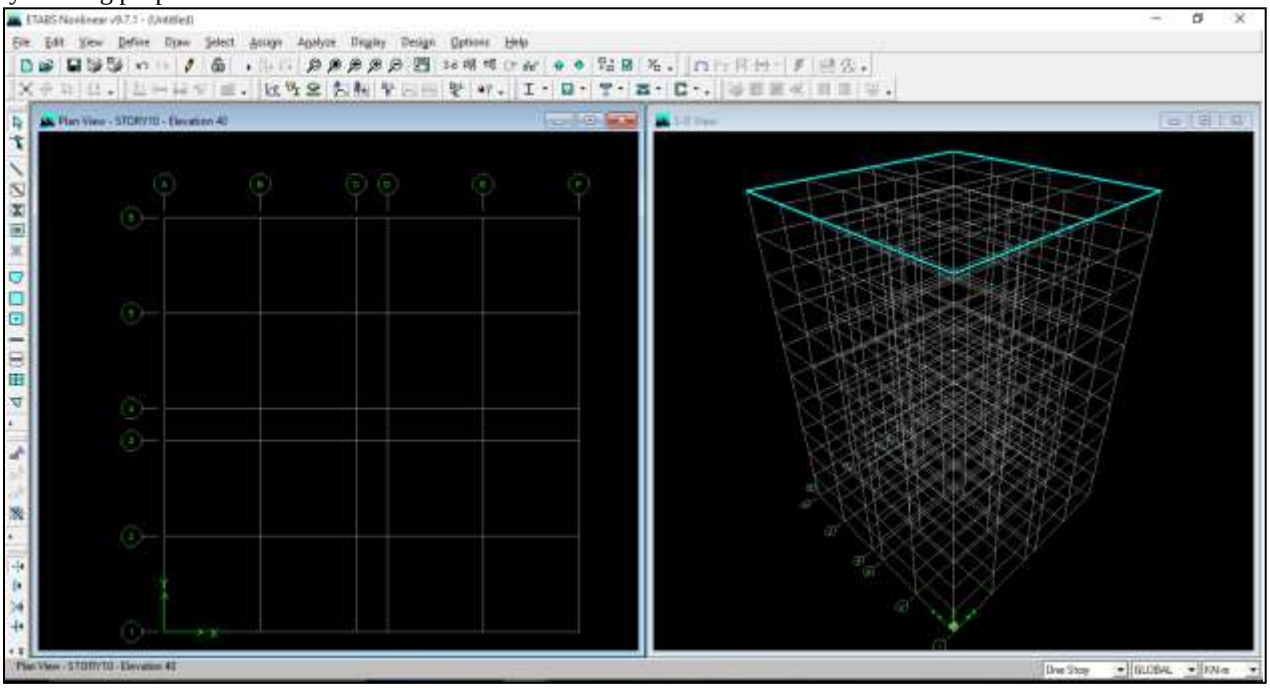

Fig. 2: ETABS main window

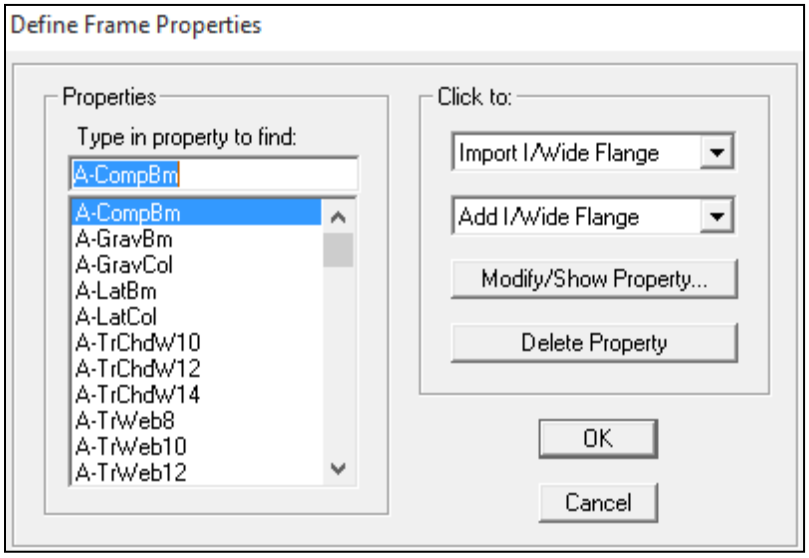

Fig. 3: Addition of frame sections

There are many options in add such as add circle, steel joints and furthermore but we provide rectangular columns or beams in common and hence we add a rectangular section and then click on ok. Another window appears which gives details about section. Here we can provide section name i.e., either a beam or column and change the material to the one that is defined above. Provide the dimensions of the section as required and change the data according to the section provided. If a beam is to be provided then select the design type to beam and provide the required dimensions to the cover and if a column is provided select design type to column and then nominal cover is provided.

Marking of columns, beams:

To create a column, the above process is repeated again and the only difference is the reinforcement data which is stated earlier both for beams and columns.

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.

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.

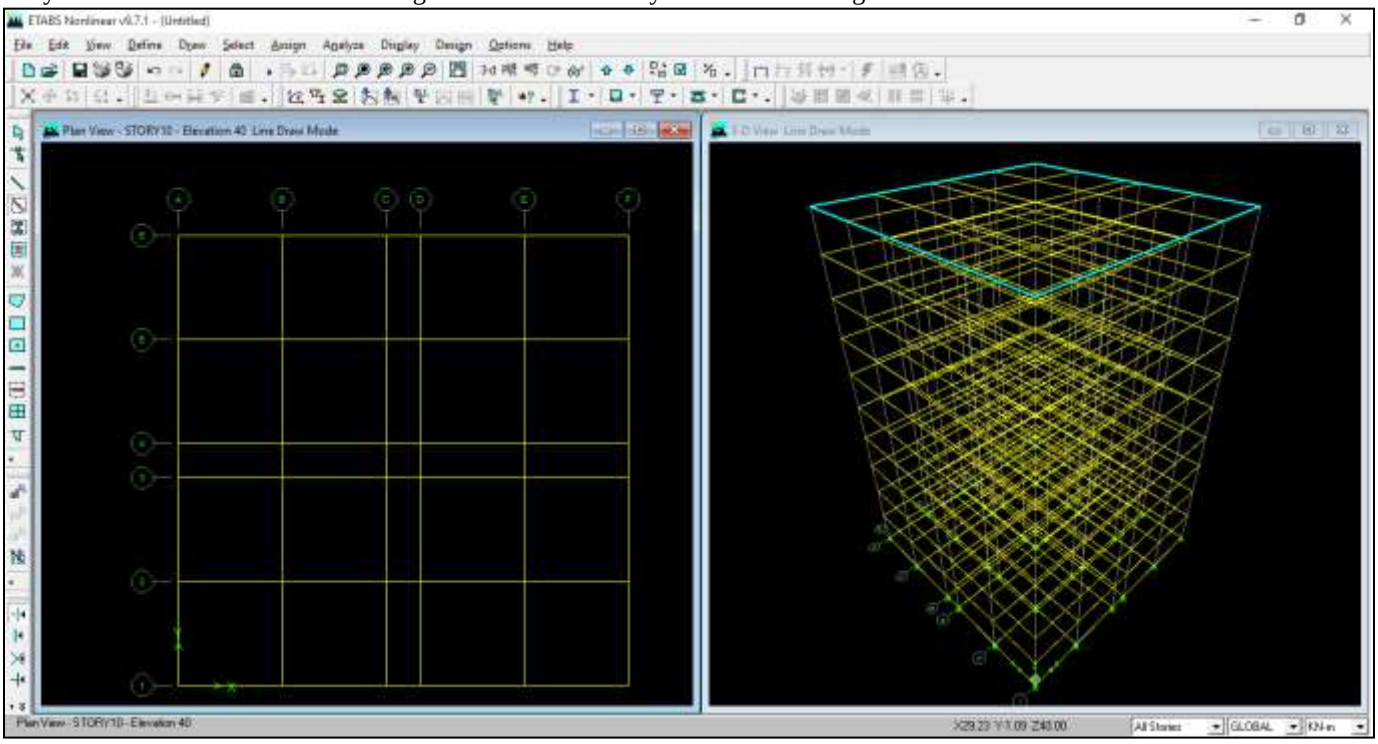

Fig. 4: Beams after they are assigned

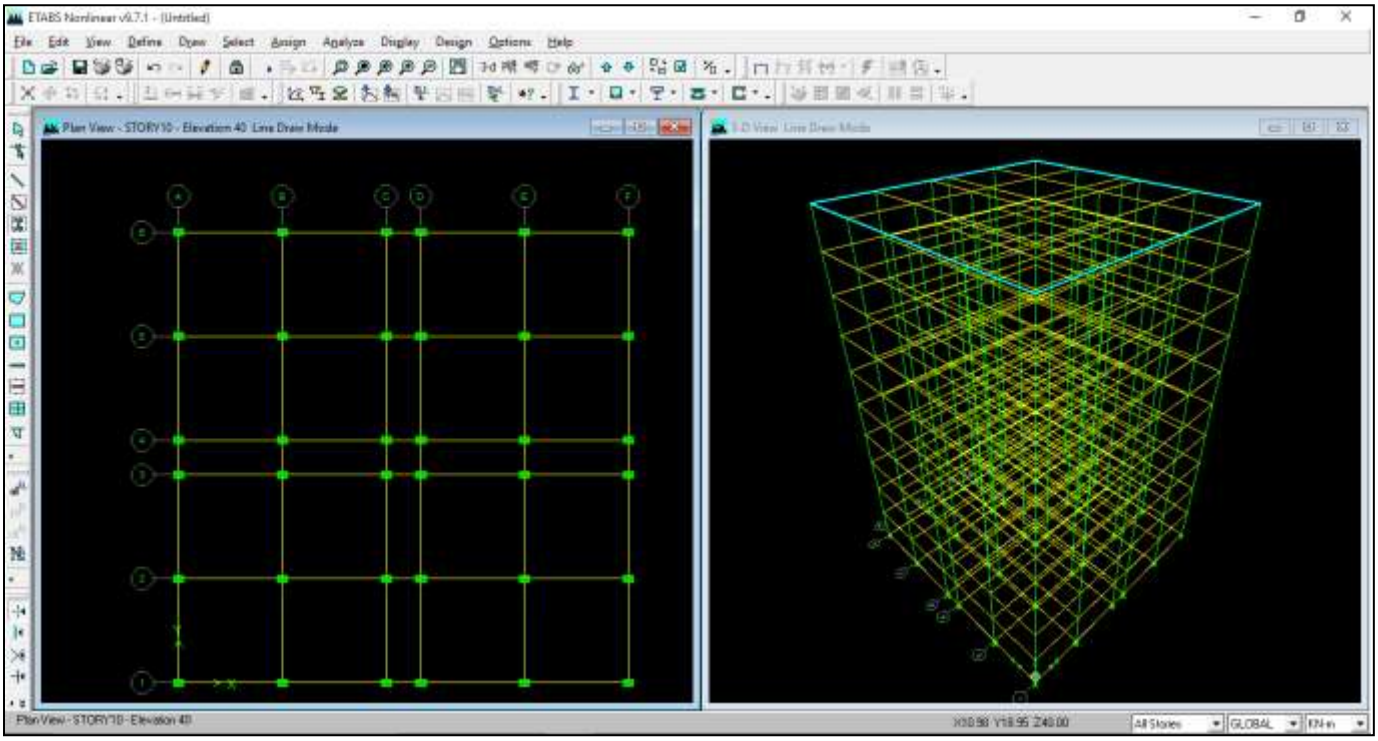

Fig. 5: columns after they are assigned

IV. CONSTRUCTION OF SHEAR WALL

A. Shear Walls:

Shear walls are generally casted monolithically, in this type of construction the beams and columns are placed inside the walls so that you can never find beams inside any floor in this type of construction.

B. Schedule of reinforcements:

After the horizontal reinforcement is placed in accordance with the design, vertical reinforcement is placed.

Fig. 6: Horizontal reinforcement of shear wall

As per the design details the reinforcement of size 10mm spacing 30mm is placed in the middle of the wall of length 0.8 = 0.8 x 25 = 200 m and the edge reinforcement of 20 mm P 20 bars are placed in the remaining 0.2 space.

The horizontal bars on the vertical reinforcement are placed of diameter 10 mm spacing 300 mm distance.

Fig. 7: Vertical Reinforcement of shear wall

V. CONCLUSIONS

1) Thus shear walls are one of the most effective building elements in resisting lateral forces during earthquake.
2) By constructing shear walls damages due to effect of lateral forces due to earthquake and high winds can be optimised.
3) Shear walls construction will provide larger stiffness to the buildings there by reducing the damage to structure and its contents.
4) Not only for its strength and also in order to accommodate huge number of population in a small area are tall structures with shear walls considered to be most useful.
5) ETABS is the advanced software which is used for analysing any kind of building structures. By its fast and accuracy it can easily analyse buildings up to 40 floors. Shear wall design is separately done in this software with different combination of loads.
6) ETABS can analyse any building structure with pre-determined load conditions and load combinations for shear walls regarding IS codes.
7) So, for designing of building shear wall structure if we use ETABS software then it analyse the building easilyand give the fast resultswith accurate data.
8) In India the rate of population growth is very high so most of them are suffered with lack of shelter. By this shear wall design for a building in a small area we can increase the no.of floors and increasing the rate of living.
9) Hence for a developing nation like India shear wall construction is considered to be a back bone for construction industry.

VI. FUTURE SCOPE

Shear walls are considered to be a gift to the future construction industry. Scope of shear walls in construction field is immense. It's since their arrival in market there topic was always a topic of interest. Shear walls are the structures usually build to balance lateral loads acting on the structure. Where the lateral loads are most predominantly wind and earth quake loads. And predominantly earthquake loads are more intense in their effect on the building structures. Earthquakes are becoming more intense due to the key reason that is ground water depleshement. Hence in order to overcome the diverse effects of earthquake it is always best to save ourselves from future disasters.

Shear walls are quick in construction, as the walls doesn't need any special brick arrangement or plastering they are very quick in their construction. It just requires an effective form work and very few skilled labours. It was estimated that a 20 floors building can be built within six months which is most astonishing. At the same time ETABS software which gives the speed analysis and results will helpful to compare the manual design.

Not only for the quickness in its work and resistance to earthquakes, shear walls are also build for defence purpose. Presently The Hindustan Prefab Limited (HPL) is executing various locatable prefab structures for paramilitary forces especially for the CRPF in Karnataka, Uttar Pradesh, Chhattisgarh and Bihar among others. We are using "Shear Wall" technology with thermal curing –a fast track technology– for KMDA for construction of houses in Kolkata, chairman and managing director HPL JaiveerSrivastava said.

REFERENCES

[1] S.K. Duggal in his "Earthquake resistant design of structures" Page no: 301, 8.12 about Shear walls.
[2] S.K. Duggal in his "Earthquake resistant design of structures "pg.no:305 on flexural strength 8.14.1 case:1, case:2.
[3] S.K. Duggal in his "Earthquake resistant design of structures" 8.16 Design of Shear walls which is also given in Is code 13920:1993
[4] A report on effects of openings in shear walls on seismic response of structure by Sharminriza Chowdhary, department of civil engineering dhake-1208, Bangladesh mostly focused on the design of shear walls with openings on seismic response using E- Tabs.
[5] 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.
[6] I.S:1893 Criteria of Earth Quake resistant Buildings Part (3) page 23, clause 4.2 gives the estimation of earth quake loads.