

# Structural Analysis of Multistory Building of Differentshear Walls Location and Heights

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## Abstract

*Abstract: Shear walls are structural systems which provide stability to structures from lateral loads like wind, seismic loads. These structural systems are constructed by reinforced concrete, plywood/timber unreinforced masonry, reinforced masonry at which these systems are sub divided into coupled shear walls, shear wall frames, shear panels and staggered walls. The present paper work was made in the interest of studying and analysis of various research works involved in enhancement of shear walls and their behaviour towards lateral loads. As shear walls resists major portions of lateral loads in the lower portion of the buildings and the frame supports the lateral loads in the upper portions of building which is suited for soft storey high rise building, building which are similar in nature constructed in India, As in India base floors are used for parking and garages or officers and upper floors are used for residential purposes.*

**Keywords:** Multistory building (G + Structure), Shear wall, STAAD. Pro etc.

## 1. INTRODUCTION

In structural engineering, a shear wall is a structural system composed of braced panels (also known as shear panels) to counter the effects of lateral load acting on a structure. Wind and seismic loads are the most common loads that shear walls are designed to carry. Shear walls resist in-plane loads that are applied along its height. The applied load is generally transferred to the wall by a diaphragm or collector or drag member. They are built in wood, concrete, and CMU (masonry).

Shear walls must provide the necessary lateral strength to resist horizontal earthquake forces. When shear walls are strong enough, they will transfer these horizontal forces to the next element in the load path below them. These other components in the load path may be other shear walls, floors, foundation walls, slabs or footings.

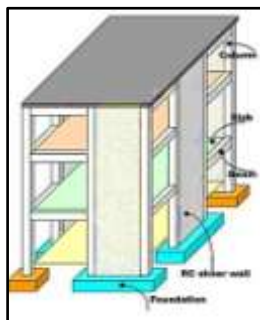


Fig 1.1: Shear wall

Shear walls also provide lateral stiffness to prevent the roof or floor above from excessive side-sway. When shear walls are stiff enough, they will prevent floor and roof framing members from moving off their supports. Also, buildings that are sufficiently stiff will usually suffer less nonstructural damage.

The strength of the shear wall depends on the combined strengths of its three components: lumber, sheathing and fasteners. Later in this section you will learn how each component affects the strength and how strength is lost by improper installations. When all of the components are properly in place, the shear wall can provide its intended strength. For shear wallsheathing, the 1994 Uniform Building Code (UBC) permits the use of gypsum wallboard, cements plaster, fiberboard, wood particleboard, plywood and oriented strand board. Previous editions of the UBC also allowed wood lath and plaster, horizontal and diagonal sheathing for shear walls. All of these sheathing materials provide different strengths. The UBC shows these strengths in pounds per foot of wall length. Fasteners for shear wall construction may bestaples, screws or nails. Denser lumber species provide stronger fastener strengths. Values for shear wall strengths assume a dense lumber species like douglas fir-larch or southern pine. Thicker framing members also increase wood structural panel sheathing strengths.

## 1.1 How Shear Walls Provide Stiffness

The stiffness of the shear wall, just like its strength, depends on the combined stiffness of its three components: lumber, sheathing and fasteners. The size and grade of end stud(s), thickness and grade of sheathing, and the sheathing fastener diameter determine how flexible a wood shear wall will be. When present, holddown devices also contribute to the overall stiffness of the shear wall. If holddown devices stretch or slip, the top of the shear wall will move horizontally. This horizontal movement adds to the movement allowed by the lumber, sheathing and fasteners. Any additional movement from the holddown will reduce the effective stiffness of the shear wall.

## 1.2 Stiffness and Aspect Ratios

Shear walls provide stiffness in large part by the ratio of their height to width. Long short walls are stiffer than tall narrow ones. For a wall of constant height, the stiffness will grow exponentially as the wall length increases. To help control stiffness, the UBC requires a minimum wall length for any given wall height. This allowable dimension ratio changes for each type of sheathing material and its construction. Wood structural panels can have smaller shear wall lengths than cement plaster or gypsum wallboard. When this sheathing is fastened at all of its edges.

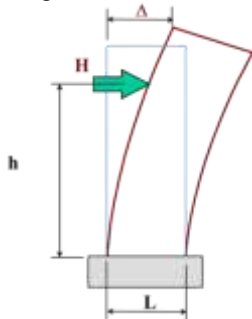


Fig 1.2: Lateral Stiffness of Shear wall

Advantages of shear wall:

**(1) Sound reducing:** Land for home building is becoming scarce and homes are being built closer together and near noise sources like highways, railways and airports. Concrete homes have attractive sound-reducing qualities to provide the kind of quiet comfort buyers look for in a home.

**(2) Cost saving:** Purchasers and developers will reap the benefits of concrete construction, including good acoustic performance, excellent fire resistance, high thermal mass and low maintenance, all achieved within budget. Conventional structural design

emphasizes rebar component with minimum concrete frame. This type of reinforce concrete structure emphasizes very heavy rebar design. Conventional design remains infilling with brick walls of which require a lot of skill workers for brick laying and plastering. That gives cost savings in material, time and money and eliminating waste etc Mortar, Timber form, Steel reinforcement, Bricks, Plastering, Sand, Cement...

**(3) Good appearance:** Wood will decay when there is too much moisture. That presents particularly when it is in contact with the ground. Meanwhile a carpenter uses a lot of nails to make the structural parts of wood built forms. Fasteners, including nails, are the weakest part of any construction joint. Meanwhile, the potential failures of wood formwork, it represents a great hazard to workers working around and on it. Unskilled workers always over secure the wood forms. Too many nails will weaken lumber, and increase difficulty of removing the forms, and reduce the usage of the plywood and timbers.

**(4) Greater control of accuracy and workmanship:** With the durable, each successive home built is as high quality as the first. When you build a house using pre-engineering, it offers greater control of accuracy and workmanship during construction. This result in a higher quality structure compared to the conventional method using a lot of timber formwork. The quality of timber formwork very much depends on the individual skills of workers of which made the quality of each home built different. With the shortage of available skill labors in today construction market, selecting the right forming equipment becomes even more important.

**(5) Superb concrete finish, quality improvement:** Have all the value and benefit of concrete. Quality is enhanced despite the speed of construction. The precise, even steel face of PCG SYSTEMS creates a smooth, high quality finish capable of receiving direct decoration with the minimum of preparation (a level of 1 to 10mm thick skim coat is required). This reduces the requirement for finishing trades, thus providing additional cost savings and speeding the entire process

**(6) Lesser water seepage problem:** Water seepage through external walls was found to be a common defect faced by homeowners. The survey findings also showed that the use of single layer brick wall is the most common cause of water seepage through external walls. Almost 90% of the water seepage

occurred through cracks in the plastered brick walls. In general, water seepage through external walls occurred within the first five years of building completion. Water seepage through the external walls is unacceptable to the occupants.

**(7) Fire resistance:** Fire can endanger the lives of everyone in the family and destroy those things that cannot be replaced. Insurance companies recognize concrete as being safer than any other method of construction when fire threatens a home. Living in a concrete home can ultimately bring peace of mind for homeowners concerned about fire.

**(8) Strong, solid, rigid, durable and low maintenance:** One of the key benefits of building with concrete is that it is durable and easy to maintain. Concrete and cement based products form a solid, durable that resists rot, pests and wild fires. Buying a home is typically the biggest investment we will ever make. If that home is constructed with concrete walls, our investment is naturally protected from the structural damage that can be caused by the effects of nature. As the owner of a concrete home, we will benefit from lowest annual maintenance and energy costs while living in a home that provides a secure haven for our family.

## 2. METHODOLOGY

In this chapter a multistory building has been modelled and analyze with considering all loads like Dead load, Live load, Wind Load as per as IS standard and Seismic load as per as IS standard.

The structure details takes from reference is given in table 2.1 is placed in below.

**Table 2.1:** The structure details takes from reference Case-I, II & III

Young's modulus of M20 concrete, E	$2.8 \times 10^7 \text{ kN/m}^2$
Grade of concrete	M20
Grade of steel	Fe 415
Density of Reinforced Concrete	$25 \text{ kN/m}^3$
Modulus of elasticity of brick masonry	$2100 \times 10^3 \text{ kN/m}^2$
Density of brick masonry	$20 \text{ kN/m}^3$
No of storey	G+10, G+20 & G+26
Beam size	0.3m x 0.3 m (G+10) 0.35m x 0.35m (G+20) 0.4m x 0.4m (G+26)
Column size	0.45 m x 0.45m (G+10)

	0.5m x 0.5m (G+20) 0.6m x 0.6m (G+26)
Shear wall thickness	0.2 m
Height of all storey	33m (G+10) 63m (G+20) 81m (G+26)
Height of each floor	3.5m
Earthquake Zone	II
Damping Ratio	5%
Importance factor	1
Type of Soil	Medium
Type of structure	Special Moment Resisting Frame
Response reduction Factor	5

### 2.1 Finite Element Method (FEM)

The finite element method (FEM) (its practical application often known as finite element analysis (FEA)) is a numerical technique for finding approximate solutions to partial differential equations (PDE) and their systems, as well as (less often) integral equations. In simple terms, FEM has an in built algorithm which divides very large problems (in terms of complexity) into small elements which can be solved in relation to each other. FEM solves the equations using the Galerkin method with polynomial approximation functions. The solution is obtained by eliminating the spatial derivatives from the partial differential equation. This approximates the PDE with

- A system of algebraic equations for steady state problems
- A system of ordinary differential equations for transient problems.

These equation systems are linear if the corresponding PDE is linear and vice versa. Algebraic equation systems are solved using numerical linear algebra methods. The ordinary differential equations that arise in transient problems are numerically integrated using techniques such as Euler's method or the Runge-Kutta method.

In solving PDE's, the major problem is to create an equation that approximates the equation to be analyzed, but is numerically stable, meaning that errors in the input and intermediate calculations do not accumulate and cause the resulting output to be meaningless. There are many ways of doing this, which have their respective pros and cons.

### 2.2 STAAD.Pro

STAAD or (STAAD.Pro® V8i) is a structural analysis and design computer program originally developed by Research Engineers International in

Yorba Linda, CA. In late 2005, Research Engineers International was bought by Bentley Systems. It is the World's #1 Structural Analysis and Design Software. The analysis is done in a numerical way by the STAAD.PRO program, a finite element package, which enables us to solve the linear and the nonlinear PDE's and thus the modulus of elasticity of the beam material is obtained. STAAD.PRO is modeling and analysis software which helps in the modeling and analysis of required models, a FEM tool. It is used to analyze complex problems in mechanical structures, thermal processes, electrical fields, magnetics, and computational fluid dynamics. STAAD.PRO provides a rich graphics environment, which is used to display results of analysis that re performed.

STAAD.Pro is a comprehensive and integrated finite element analysis and design offering, including a state-of-the-art user interface, visualization tools, and international design codes. It is capable of analyzing any structure exposed to static loading, a dynamic response, soil-structure interaction, wind, earthquake, and moving loads. STAAD.Pro V8i is the premier FEM analysis and design tool for any type of project including towers, culverts, plants, bridges, stadiums, and marine structures. Advanced Analysis and Design .With an array of advanced analysis capabilities including linear static, response spectra, time history, cable, and pushover and non-linear analyses, STAAD.Pro V8i provides your engineering team with a scalable solution that will meet the demands of your project every time. STAAD.Pro V8i will eliminate the countless man-hours required to properly load your structure by automating the forces caused by wind, earthquakes, snow, or vehicles. In addition, no matter what material you are using or what country you are designing your structure for, STAAD.Pro V8i can easily accommodate your design and loading requirements, including U.S., European (including the Euro codes), and Nordic, Indian, and Asian codes. Even special codes like AASHTO, ASCE 52, IBC, and the U.S. aluminum code can be catered to.

### 2.3 STAAD Pro Solution Steps

Methods of Analysis:

- A. Edit Commands Lines Method
- B. Graphical Method
  1. Modeling
  2. Loading
  3. Analyzing
    - Elastic Analysis
    - P-Delta Analysis
    - Buckling Analysis
    - Cable Analysis
  4. Reading Results

- Tables results
- Graphical results

### 3. MODELLING AND ANALYSIS IN STAAD.PRO

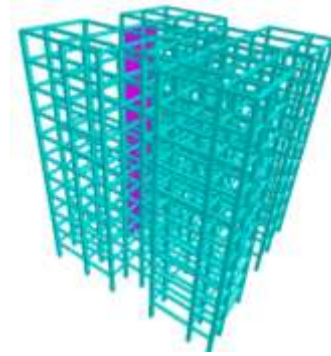


Fig 3.1: G+10 RCC Shear Wall Structure with different shear wall location

The above figure 3.1 has been shows that multistory building structure frame G+10 has been modelled in STAAD.Pro design and analysis software with given material properties and specifications.



Fig 3.2: G+20 RCC Shear Wall Structure with different shear wall location

The above figure 3.2 has been shows that multistory building structure frame G+20 has been modelled in STAAD. Pro design and analysis software with given material properties and specifications.



Fig 3.3: G+26 RCC Shear Wall Structure with different shear wall location

The above figure 3.3 has been shows that multistorey building structure frame G+26 has been modelled in STAAD.Pro design and analysis software with given material properties and specifications.

### 3.1 Support and Load cases in STAAD.Pro

In this topic all structure member are configure respective cases like support, load cases etc. The below figure 3.4 has been shows that multistorey building structure frame of G+10, G+20 and G+26 with considering fixed support at ground as foundation of column structure.

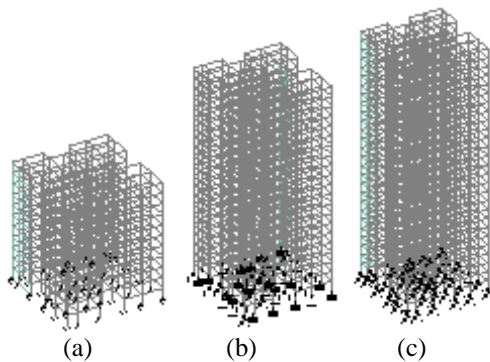


Fig 3.4: (a), (b) & (c) G+10, G+20 & G+26 RCC Shear Wall Structure with fixed support (Let us assumed as foundation of column)

- Load Case-I: Dead Load
- Load Case-II: Live Load (3 kN/m<sup>2</sup>)
- Load Case-III: Wind Load (As per as SI Indian Standard)

### 3.2 Various Result obtained in STAAD.Pro

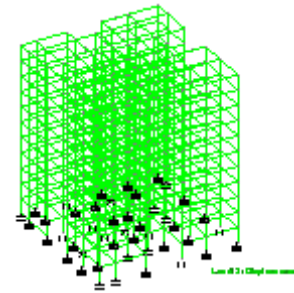


Fig 3.5: Nodal Displacement in G+10 RCC Structure with shear wall

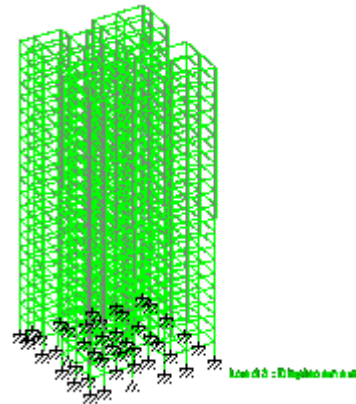


Fig 3.6: Nodal Displacement in G+20 RCC Structure with shear wall

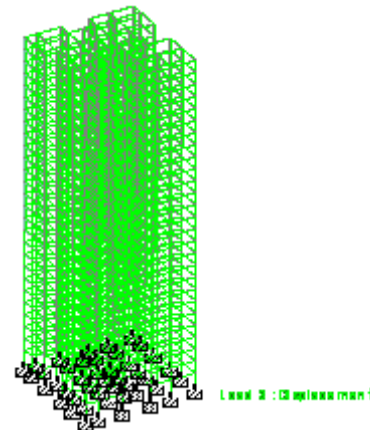


Fig 3.7: Nodal Displacement in G+26 RCC Structure with shear wall

The above figure 3.7 has been shows that the nodel displacement of the beam and column at each nodes in multi storey building.

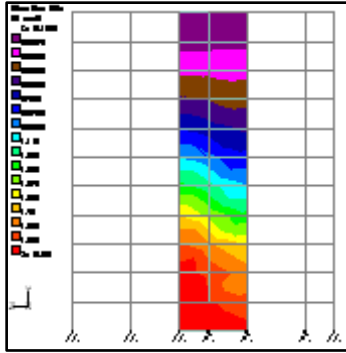


Fig 3.7: Stress generated in Shear wall in G+10 RCC Structure

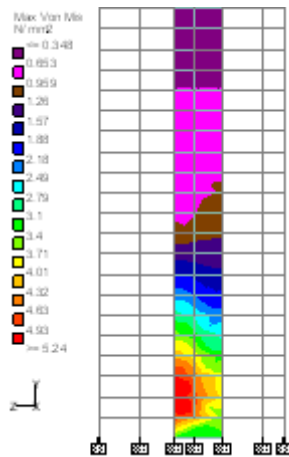


Fig 3.9: Stress generated in Shear wall in G+20 RCC Structure

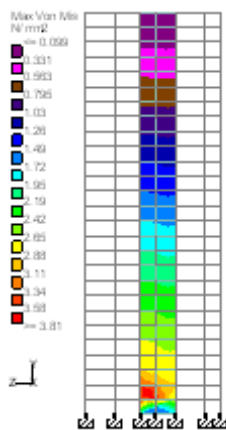


Fig 3.10: Stress generated in Shear wall in G+26 RCC Structure

The above figure 3.8, 3.9 & 3.10 indicates that the Maximum Von miss stress generated in shear wall at different load condition.

## 4. RESULT & DISCUSSION

The structure analysis of all the frames models that includes different location of shear walls has been done by using software STAAD.Pro and the results are shown below. The parameters which are to be studied are inter-storey drift, base shear and lateral displacement.

### 4.1 Location of shear wall

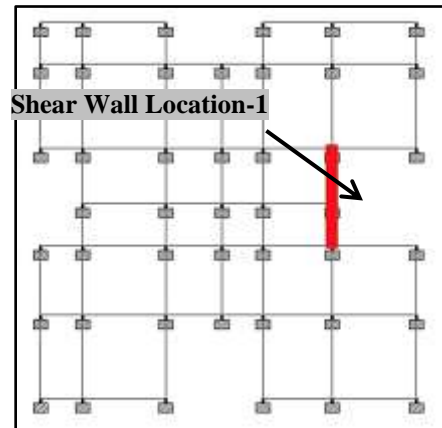


Fig 4.1: Location-1 of shear wall

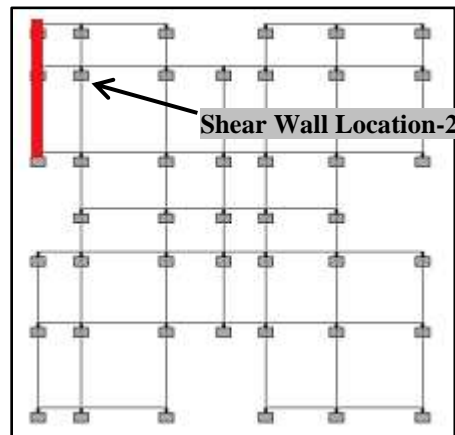


Fig 4.2: Location-2 of shear wall

The above fig 4.1 & 4.2 has been shows that the different shear wall location in different multistory building structure (G+10, G+20 & G+26).

The structure analysis of all the frames models that includes different location of shear walls has been done by using software STAAD.Pro and the results are shown below. The parameters which are to be studied are inter-storey drift, base shear and lateral displacement.

Table 4.1: Maximum Von Miss Stress in shear wall at location 1 & 2 due Load case 1

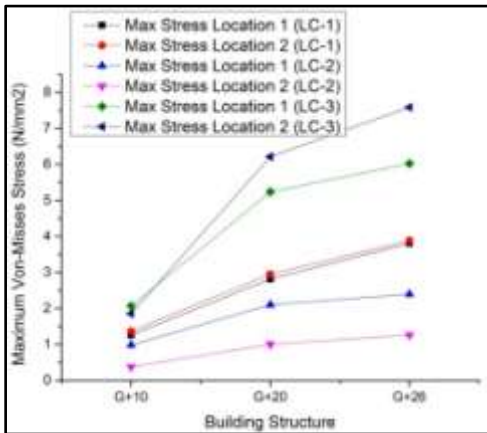
Load Case	Building Structure	Maximum $\left(\frac{N}{mm^2}\right)$ Location 1	Maximum $\left(\frac{N}{mm^2}\right)$ Location 2
LC 1	G+10	1.25742	1.36362
LC 1	G+20	2.81632	2.94763
LC 1	G+26	3.80801	3.88496

Table 4.2: Maximum Von Miss Stress in shear wall at location 1 & 2 due Load case 2

Load Case	Building Structure	Maximum $\left(\frac{N}{mm^2}\right)$ Location 1	Maximum $\left(\frac{N}{mm^2}\right)$ Location 2
LC 2	G+10	0.981865	0.372493
LC 2	G+20	2.09846	1.00182
LC 2	G+26	2.39742	1.25766

Table 4.3: Maximum Von Miss Stress in shear wall at location 1 & 2 due Load case 3

Load Case	Building Structure	Maximum $\left(\frac{N}{mm^2}\right)$ Location 1	Maximum $\left(\frac{N}{mm^2}\right)$ Location 2
LC 3	G+10	2.06473	1.85379
LC 3	G+20	5.23674	6.21295
LC 3	G+26	6.02281	7.58716

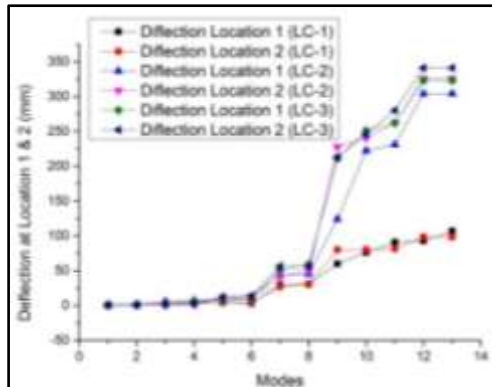


Graph 4.1: Maximum Von-Mises Stress generated in multistory building structure (G+10, G+20 & G+26) shear wall in different locations

- The above figure 5.1 and (also in figure 4.14, 4.15 & 4.16 ) has been indicate that the stress development and stress distribution in shear wall

due to different load conditions in different location of shear wall.

- In above figure 5.1 indicating that the maximum stress generated in shear wall in different height or locations in form of color.
- The color red and blue is shows that the maximum stress of shear wall at location 1 & 2. In location 1 at load case 1 the stress is decreases while increasing building height and at location 2 is also as same location 1 but location 2 stress is more than the location 1 as shown in figure 5.1.
- Also remain results are same. Hence the location 1 of shear wall is more efficient.



Graph 4.2: Graph plotted between deflections on building structure due to load considerations at different modes.

- Also in graph 5.2 we have discussed that the deflection, drift generated in building structure (G+10, G+20 & G+26) are plotted between modes.
- In this graph indicates that deflection on structure is increased at location 2 at increasing the height of structure but deflection of location 1 structure is also increases when height is increased but location 2 deflection is more as compare to location 1 structure.
- In above and after analysis have done we discussed or concluded that the location 1 of shear wall is best because in this wall the stress distribution and deflection in wall is less as compare to location 2.

## 5. CONCLUSION & FUTURE SCOPE

- In this project it is concluded that the G+10 structure shear wall is generated less value of von-misses stress and deformation on structure at location 1 as compare to location 2.
- Also it is concluded that in the G+20 structure shear wall is generated less value of von-misses

stress and less deformation on structure at location 2 as compare to location 1.

- Also it is concluded that the G+26 structure shear wall is generated less value of von-misses stress and less deformation on structure at location 1 as compare to location 2.
- In result and discussion section it is concluded that if height of structure is simultaneously increases of location 1 & 2. The deformation of structure G+10 at location 1 is less approx. 8.03% as compare to location 2.
- Also it is concluded that if height of structure is simultaneously increases of location 1 & 2. The deformation of structure G+20 at location 1 is less approx. 6.56% as compare to location 2.
- Also it is concluded that if height of structure is simultaneously increases of location 1 & 2. The deformation of structure G+26 at location 1 is less approx. 5.335% as compare to location 2.
- Overall conclusions is that deflection of the multi-story building structure of location 2 is more as compare to location 1 for G+10,G+20 and G+26 (approx. 6% less in overall deflection in location 2). Hence the location 1 shear wall is best for future construction.
- Also as above the result is that the stress and deflection or deformation of shear wall structure is increasing but also to see the only shear wall location 2 is more as compare to location 1. It is decreased the efficiency of the structure.
- From finally at above results or conclusion is that the location 1 is more efficient and in future we adopt the location of shear wall (location 1).
- We have also find out the manually calculation of all cases is more time consumable as see in reference paper both manually and software based are calculated but we have concluded and obtained results approximately. So used of software is affordable.

## **FUTURE SCOPE**

- As per analysis, it is concluded that displacement as well as its stress also at different level in multistoried building with shear wall is comparatively lesser as compared to R.C.C. building Without Shear Wall. So now a day we can adopt with shear wall at analyzed and optimized location.
- Less obstruction will be there because of reduced size of column and provision of shear wall.
- It is concluded that building with shear wall is constructed in lower cost as compared to structure without shear wall.

- STAAD.Pro becomes more and more critical in the analysis of engineering & scientific problems.
- These facilities for the implementations of more effective & professional engineering software so we can adopt software as compare to manual. It should be affordable to promote their wide spread usage amongst civil

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