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# Analysis and Design of High Rise Residential Building with Shear Wall

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**ABSTRACT:-** Medium rise R.C. framed apartment buildings with storey ranges from 8 to 10 or 12 are becoming popular in metropolitan areas of India. These are provided with shear walls to improve the lateral load resistance. Frequently the shear walls are provided with openings. Therefore, in the present work analytical study on the effect of openings in shear walls has been undertaken. The parameters studied are column shear, moments, deflections and stresses within the shear wall. A 3-D analysis of the shear wall structure has been carried out using the ETAB2018 Software package. This study covers the effect of size, shape and locations of these openings. A 10 storeyed RCC building has been selected to study the effect of openings in shear wall. The building is assumed to be in seismic zone IV, V. The opening of sizes 10, 15, 20 and 25% of shear wall area has been provided in shear wall and studied the variation of shear, moment, and deflection in columns.

**KEY WORDS:-** Shear wall, replacement of masonry wall with RC wall, elimination of beam and column

## I. INTRODUCTION

The population of cities is increasing every day as people migrate to cities in pursuit of work or vocations that need the construction of high-rise structures to accommodate the influx of people. When it comes to tall structures, adequate consideration of wind and seismic performance is critical. Shear wall is one of the earthquake-resistant structural features that extends from the structure's foundation to its top. They are evenly placed such that when a structure is subjected to earthquake forces, no torsional force will occur in the whole shape of the building. Wind, earthquake, and uneven settlement loads, along with the weight of the structure and its inhabitants, produce severe twisting (torsion) forces. These forces are capable of tearing (shearing) a structure apart. The shape of a frame is maintained and rotation at the joints is prevented by connecting or installing a stiff wall inside it.

These walls are used to accommodate both stairwells and seismic-resistant features in a structure. Shear walls have been a common feature of mid- and high-rise residential structures in the last two decades. As part of an earthquake-resistant building design, these walls are included in building plans to prevent lateral displacements under seismic stresses. As a result, shear-wall frame constructions are created. Shear wall structures usually have a regular layout and elevation. Lower levels are employed for commercial purposes in some structures, which are distinguished by bigger plan measurements on those floors. Many structures have recently fallen throughout the world as a result of powerful earthquakes. During such earthquakes, even reinforced concrete (RC) structures with shear walls have seen a variety of collapse scenarios. The majority of the failures are still unknown, and several experts have pointed up flaws in the existing shear wall design Codal provisions

## II. LITERATURE REVIEW

Le Yee Mon-ETABS software is used to perform reaction spectrum analysis on a high-rise reinforced concrete building in seismic zone 4 for a comparative study on dynamic analysis of irregular buildings with shear walls. ETABS v 9.7.1 software is used in this work to analyse a fourteen-story Y-shaped high-rise reinforced concrete building in seismic zone 4 utilising response spectrum analysis. Each model is checked for stability after it has been analysed. The UBC – 97 Formula is used to check for storey drift and torsional irregularity.

Panay Roy Shear Walls' Effectiveness in Seismic Resistance of Multi-Storey Buildings in India As the height of the rc wall rises, the loading pattern in the wall is investigated. The axial forces in the columns were decreased by 10-15%



and the shear force in the columns was significantly reduced due to the presence of shear walls in the structure. With the addition of a shear wall to the structure, the maximum nodal displacement in the beam-column junction is reduced by 60.1 percent.

Axay thapa & sajal sarkar Comparative Study of a Multi-Story RCC Building with and Without Shear Wall - The displacement values will be determined by the earthquake frequency and the structure's natural frequency.

Amit Barde A global view on the minimum wall thickness requirement: load bearing rcc shear wall system for tall residential structures in India: In general, a 160 mm minimum wall thickness is acceptable for both structural and fire resistant rating requirements for structures less than 70 m tall. In recent years, the residential construction industry has favoured RCC Load Bearing Shear Wall (LBSW) construction over traditional beam/column or local shear wall construction. A crucial feature of the RCC LBSW system is the inclusion of far more shear walls, which results in great redundancy in the system's ability to redistribute loads in the case of natural disasters. However, the RCC LBSW system is not officially addressed in the present edition of IS 456 and is frequently likened to the Framed System with a Few Shear Walls system. In addition to the redundancy provided by the RCC LBSW system, the overall structural design demand for the LBSW system's Load Bearing Walls is lower than for the framed system's Shear Walls.

M.Pavani, G.Nagesh Kumar, Dr. Sandeep Pingale In the case of high-rise buildings, shear wall analysis and design optimization using Etabs (software)- Shear walls are both compression and shear resisting elements, whereas columns are both compression and shear resisting elements. Because of the presence of shear walls at all potential deflection points, damage caused by wind and seismic forces can be controlled in this article.

S. Krishnachandran Revisiting the Seismic Design Basis for Lightly Reinforced Concrete Wall Systems in India- As a result, the goal of this article is to figure out where this structural system should be positioned in terms of expected seismic behaviour. From a purely economic standpoint, design conservatism was a factor that had a negative impact on structural design. In the current situation, however, maintaining a balance between design conservatism and energy impact is critical for environmental sustainability as well.

U.H. Varyani ,To simulate the boundary elements, the experimental investigations were conducted on thirteen shear walls, four of which were rectangular in cross-section with a width of 1905 mm (75 in) and a thickness of 101.6 mm (4 in), and the remaining nine were bar bell in cross-section with a thickness of 304.8 mm (12 in) at the ends. The purpose of this study was to see how cross-sectional form, as well as the quantity of reinforcement, affected shear walls that were subjected to lateral stress at the top.

S.K. Duggal, Based on his deep interest in structures, he characterised a wall in a building that resists lateral stresses coming from wind or earthquakes as shear walls in his book " Structures built to survive earthquakes." Based on which design of structure to be carried out in tall shear walls, he believed flexural strength in the wall to be the dominant factor. He discussed the various types of shear walls and their load-bearing capacity in accordance with code requirements.

Mr.N.B.Baraskar Structural Performance of RC Structural Wall System vs. Conventional Beam Column System in a G+15 Storey Building- High-rise building construction is highly difficult and necessitates the use of advanced construction technology and equipment. The latest developments in formwork are Mivan technologies, climbing formwork, and Aluform technologies. The difference in both system time periods for various modes ranges from 72.88 to 81.42 percent. Mode 1 provides the longest time duration. The RC structural wall system's inherent frequency is higher than the natural frequency of the beam column system. For various modes, the natural frequency for RC structural wall systems ranges from 72.88 to 81.44 percent. The maximum storey displacement in the event of a beam column system is 87.5 percent more than in the case of an RC structural wall system at the top storey.

V. R. Kale Analysis and Design of Shear Wall with Various Openings Criteria It is highly economical. It is better replacement of many columns in a single plane.

Swetha K S, Akhil P The Impact of Shear Wall Openings The shear wall with vertically placed apertures sees a 1.5 percent higher displacement.

S.H.Jagadale Analysis of Shear Wall Thicknesses with and without Openings, as well as Percentage Reinforcement Small-scale damage, such as cracked dry wall and shattered tile, should be avoided.



**Methodology:-** Study of literature review, Study of structure design, Building description, Analysis and design of super structure using E-tab, Analysis results, The material is homogeneous, isotropic, All columns supports are considered as fixed at the foundation.

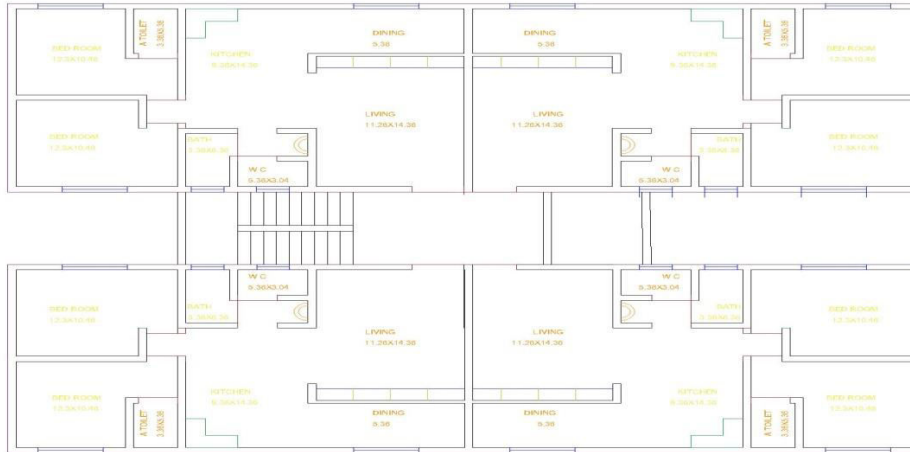
**Shear Walls:-** Shear walls, also known as structural walls, are used in building constructions to withstand lateral forces produced in the plane of the wall by wind, earthquakes, and other lateral forces. For large aspect ratios, the name Shear Wall (SW) is deceptive since such walls act more like flexural members. They are commonly seen in tall structures and have been proved to be quite useful in preventing total building collapse due to seismic pressures. When designing shear walls, strive to limit bending stresses on columns caused by lateral loads by shifting the lateral loads to shear walls with a high stiffness.

Wind, earthquake, and uneven settlement loads, along with the weight of the structure and its inhabitants, produce severe twisting (torsion) forces. These forces are capable of tearing (shearing) a structure apart. By connecting or installing a stiff wall inside a frame, the contour of the frame is maintained and rotation at the joints is prevented. Shear walls are highly important in high-rise buildings that are subject to lateral wind and seismic pressures.

**Construction of a Shear Wall:-**

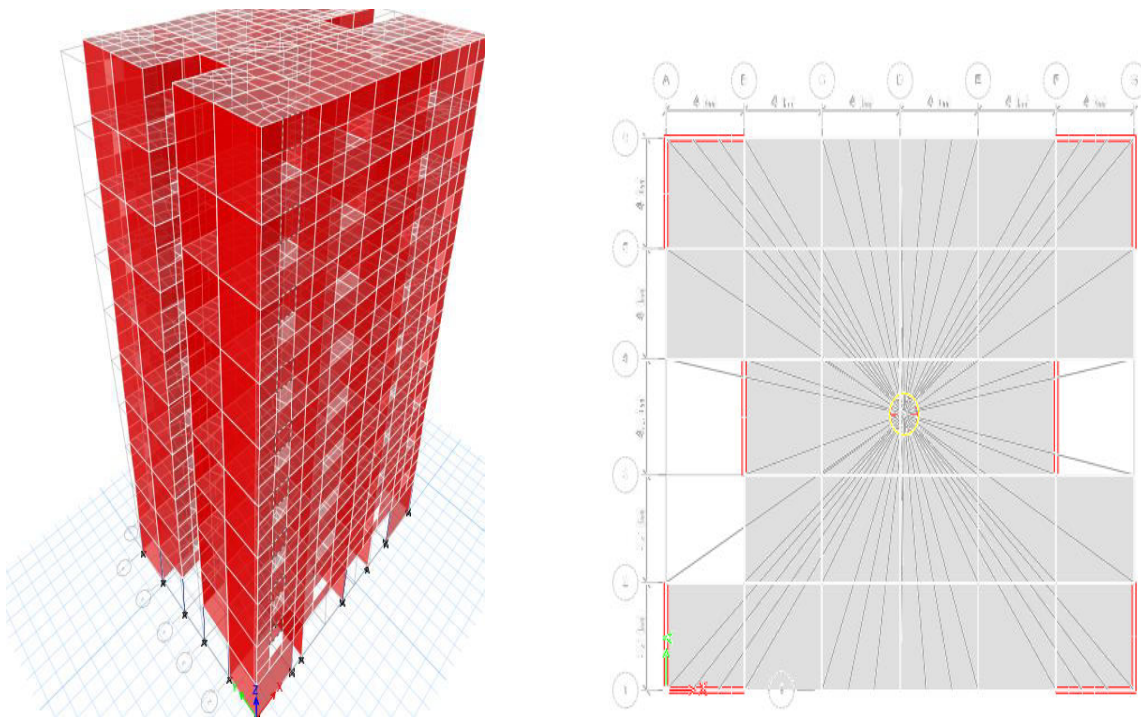
Because shear walls are frequently cast in a single piece and inside the walls, the beams and columns are installed, there are no beams within any of the floors in this kind of construction. After the horizontal reinforcement has been put according to the design, the vertical reinforcement is installed. According to the design specifications, 10mm central reinforcement with 30mm spacing is erected in the middle of a  $0.8 \times 25 = 200$  m long wall, and In the remaining 0.2 area, 20 mm P 20 bars are inserted as edge reinforcement. The horizontal bars of the vertical reinforcement have a diameter of 10 mm and are placed 300 mm apart. This horizontal reinforcement is usually tied with GI wire in a double strand single tie, although it can also be done with a rebar machine.

**Floor plan**



**III. DESIGN OF RESIDENTIAL BUILDING USING E-TABS**

To begin, click the ETABS icon. Every time you launch the software, a popup appears with a different tip. We have three alternatives in this window. You can go back and forth between tips by clicking previous or next, or you can continue on by clicking ok. Change the units to KN-m or any other unit you like in the bottom right corner.



**Momentum / Force**

When it comes to allocated loads, ETABS is quite trustworthy. loads on the surface, whether it's a uniform or a non-uniform situation, It's possible to use it in any direction, Uniform or trapezoidal loads can be specified on any line in any direction, not simply in the direction of gravity. The Force Load is used to deliver forces to specific locations and moments along the frame members and at the joints.

**SHEAR STRENGTH**

The shear strength requirements for RCC beams are roughly equal. It is also conceivable to consider boosting shear strength. In this scenario, however, only 80% of the predicted axial force is deemed effective. This 20% cut is intended to account for the potential of vertical acceleration.

The nominal shear stress is  $t_v = v_u / t_w \times d_w$

The height between floors is 3.15m

The dead load per unit area of the floor which consists of floor slab finishes is 4 KN/+m<sup>2</sup>

Weight of partitions on floors is 2 KN/m

The intensity of live load acting is 3 KN/m<sup>2</sup> on floor and on terrace 1.5 KN/m<sup>2</sup>

Loads are considered as per IS: 875, part 1 and part 2.

The concrete grade that was utilised M-30.

Steel grade used: is Fe 415.

Reinforced concrete unit weight is 25 KN/m<sup>3</sup>

Hence the effective weight of each floor = 4+2+0.25x4 = 7 kn/m<sup>2</sup>

And equivalent load at roof level = 4x1820+2362.5+1440=16087.5 KN

Seismic weight of building = 10363.5+(16087.5x4)=74713.5KN that of roof= 4kn/m<sup>2</sup>

For a 5% damping rate and type I soil

Bending moment and shear force:

Two shear walls are provided as given in the problem to resist the seismic forces in each direction the shear wall is assumed to be cantilever in calculations.

Maximum shear force at base (V) = 1013.82 KN

Along the wall's vertical edges, It will function similarly to the flanges of a steel beam, There is an equal quantity of reinforcement.

M= (21.4x4) + (87.95) (197.75x12) + (3510.95x16) (354.27x20) =15878 KN m

Taking partial safety factor=1.5

Factored shear force=1.5x1013.82=1520.73



Factored bending moment =  $15878.8 \times 1.5 = 23818.2$

Considering axial load acting = 16000 KN

Factored axial load =  $1.5 \times 16000 = 24000$  KN

Must provide a total of 20 numbers. At each end of the wall, there are 20 P bars in two tiers.  $ast \ 314.15 \times 20 = 6283 \text{ mm}^2$  provided at ends

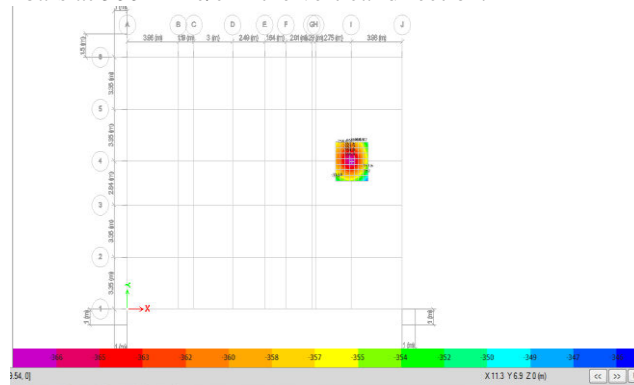
For a wall's length, The vertical reinforcement is kept to a bare minimum.

The shear wall must have a minimum amount of steel =  $0.0025 \times 24400 \times 300 = 18300 \text{ mm}^2$

$0.0025 \times 1000 \times 300 = 750 \text{ mm}^2$  of minimum reinforcement per metre length of wall

As a result, the distance between reinforcements is important. = 450 mm c/c.

In two layers, provide 10mm P bars at 300 mm c/c in the vertical direction.



**Footing**

Vertical load: 1334 kn , Moment= 133 knm, pressure of soil =  $300 \text{ kn/m}^2$  , M 30 grade of concrete steel is 500

**Determining size of footing:**

Load = 1334kn, Weight of soil =  $1334 \times 10\% = 133 \text{ kn}$ , Total load P = 1467kn, The length of the footing = L

The width of the footing = B, Required footing area =  $P/SBC = 1467/300 = 4.8 \text{ M}^2$

Providing length and width of footing = 2.25M Area of footing =  $2.25 \times 2.25 = 5.06 \text{ M}^2$

Pressure on isolated footing  $(P/A) + (M /Zy) + (Mz/Zz)$

When calculated  $p_{max} = 289.9 \text{ kn/M}^2 < 300 \text{ kn/m}^2$  hence okay

Factored upward soil pressure =  $p_{max} = 375.315 \text{ kn/m}^2$

**Two way shear**

Thickness of footing D = 500mm, Assuming 16mm diameter bars for main steel

Effective depth of footing d is  $d = 500 - 50 - 8 = 452 \text{ mm}$

Punching shear , Punching area of footing =  $(a+d)^2 = (0.45+0.452)^2 = 0.813 \text{ m}^2$

Punching shear force =  $1500 - (289 \times 0.813) \text{ TV} = 0.802 \text{ n/mm}^2$

Permissible shear stress

$t_c = 0.25 \sqrt{FCK} = 1.369 \text{ N/mm}^2$   $f_{ck} = 30 \text{ N/mm}^2$

$K_s = (0.5 + B_c) = 0.5 + 0.45/0.45 = 1$  Allowable shear stress =  $1 \times 1.369 = 1.369 \text{ N/mm}^2$  safe

Factored upward soil pressure  $p_{u \ max} = 375.315 \text{ KN/m}^2$



Considering uniform soil pressure of 375.315 , $M_u = 180 \text{ KN/m}^2$

$p_t = 0.265$  SP 16

Ast reqrd =  $p_t \times b \times d = b=2250\text{mm } d=2250\text{mm} = 13415 \text{ mm}^2$

spacing of bars =  $13415 / (\frac{\pi}{4} \times 16^2)$

Providing 16 dia bar @ 140mm c/c

Story ID	Spandrel ID	Centroid X (mm)	Centroid Y (mm)	Depth (mm)	Width (mm)	LLRF
Story1	S1	1333.3	0	1000	200	1

Material Properties

$E_c$ (MPa)	$f_{ck}$ (MPa)	Lt.Wt (Unitless)	Factor	$f_y$ (MPa)	$f_{ys}$ (MPa)
27386.13	30	1		413.69	413.69

Design Code Parameters

$\Gamma_s$	$\Gamma_c$	MinEcc Major	MinEcc Minor
1.15	1.5	Yes	Yes

Spandrel Flexural Design—Top Reinforcement

Station	Reinf Area	Reinf	Reinf	Moment, $M_u$
Location	$\text{mm}^2$	Percentage	Combo	kN-m
Left	0.000	0.0000	N/A	N/A
Right	0.000	0.0000	N/A	N/A

Station	Reinf Area	Reinf	Reinf	Moment, $M_u$
Location	$\text{mm}^2$	Percentage	Combo	kN-m
Left	636	0.32	DWAl2	4.8385
Right	636	0.32	DWAl2	5.074

Providing 10mm dia bar 8 nos

Spandrel Shear Design

Station	$A_{vert}$	$A_{horiz}$	ShearCombo	$V_u$	$V_c$	$V_s$	$V_n$
Location	$\text{mm}^2/\text{m}$	$\text{mm}^2/\text{m}$		kN	kN	kN	kN
Left	222.39	0	DWAl1	6.1009	77.8126	72	149.8126
Right	222.39	0	DWAl1	6.5986	77.8263	72	149.8263

ETABS Shear Wall Design

IS 456:2000 Spandrel Design



IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
Story2	P1	12000	0	10666.7	200	0.526

Material Properties

$E_c$ (MPa)	$f_{ck}$ (MPa)	Lt. Wt (Unitless)	Factor	$f_y$ (MPa)	$f_{ys}$ (MPa)
27386.13	30	1		413.69	413.69

$\Gamma_s$	$\Gamma_c$	$IP_{MAX}$	$IP_{MIN}$	$P_{MAX}$	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left $X_1$ mm	Left $Y_1$ mm	Right $X_2$ mm	Right $Y_2$ mm	Length mm	Thickness mm
Top	Leg 1	2666.7	0	4000	0	1333.3	200
Top	Leg 2	0	0	1333.3	0	1333.3	200
Top	Leg 3	8000	0	9333.3	0	1333.3	200
Top	Leg 4	10666.7	0	13333.3	0	2666.7	200
Top	Leg 5	14666.7	0	16000	0	1333.3	200
Top	Leg 6	20000	0	21333.3	0	1333.3	200
Top	Leg 7	22666.7	0	24000	0	1333.3	200
Bottom	Leg 1	2666.7	0	4000	0	1333.3	200

IV. SCOPE FOR FUTURE WORK

Shear walls are thought to be a boon to the construction sector in the future. Shear walls have a wide range of applications in the building industry. Since its introduction to the market, their theme has always piqued people's interest. Shear walls are frequently used to resist lateral loads on a structure. Wind and earthquakes are the primary causes of lateral loads. And earthquake loads have a greater impact on building structures than other types of loads. Earthquakes are growing increasingly powerful as a result of ground water displacement, which is the primary cause. As a result, it is always essential to safeguard ourselves from future calamities in order to overcome the various repercussions of earthquakes. Shear walls are easy to construct because they don't require any particular brick arrangements or plastering. It only necessitates efficient form work and a small number of competent labourers. It is estimated that a 20-story structure may be constructed in six months, which is incredible

V. CONCLUSION

Shear walls are as a result lateral stress resistance during an earthquake is one of the most useful structural qualities. Damages caused by lateral forces caused by earthquakes and severe winds can be reduced by erecting shear walls. Shear walls increase the stiffness of a building, reducing damage to the structure and its contents. Tall constructions with shear walls are thought to be the best at cramming a large number of people into a small space, not only because of their strength, but also because they are the most useful for accommodating a large number of people in a small space. As a result, in a developing country like India, shear wall construction is regarded as a backbone for the construction industry.





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