

Analysis and Design of Multistoried Building With Shear Wall

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ABSTRACT: In structural engineering, a shear wall is a wall composed of braced panels to counter the effects of lateral load like wind and seismic acting on a structure. Under several building codes including the International Building Code and Uniform Building Code all exterior wall lines in Wood or steel frame construction is braced. Plywood is the conventional material used in the Construction of shear walls, but with advances in technology and modern building methods, there are other prefabricated options which have made it possible to inject shear assemblies into narrow walls that fall at either side of an opening in a shear wall. Sheet steel and steel-backed Shear panels in the place of structural plywood in shear walls have proved to be far stronger in Seismic resistance. Walls have to resist the lateral force of the wind that tries to push the walls in and pull them away from the building. Shear walls are quick in construction, and in a country like India where shelter is very important in a short lapse of time shear walls can be built very quickly. The precision to which they are built is also very high compared to normally built brick structures. Hence the key objective of shear wall is to build a safe, tall, aesthetic building.

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. When shear walls are designed and constructed properly, and they will have the strength and stiffness to resist the horizontal forces.

Now a day, shear walls are the most common structures built inside the structures in order to counteract severe earthquake forces. Earthquake is a major concern for the engineers to give stability to the buildings. Properly designed and detailed buildings with shear walls have shown very good performance in past earthquakes. 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.

II. LITERATURE REVIEW

Varian U.H et al (2002) described about shear walled buildings under horizontal loads. Considering in his design "Reinforced concrete framed buildings are adequate for resisting both the vertical and the horizontal loads acting on shear walls of a building". In his 2nd edition 2002 of "Design of structures". He gave rigidity of shear wall, tensional rigidity and shear center of a building in detailed description.

Duggal S.K et al on his profound interest on structures gave a detailed description about reinforced concrete buildings in his book "Earth quake resistant design of structures "describing a wall in a building which resist lateral loads originating from wind or earthquakes are known as shear walls". He considered flexural strength in the wall to be dominant force based on which design of structure to be carried out in tall shear walls. He described in detail about various types of shear walls with their load bearing capacities as per code requirements.

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Jadhav.A.P et al Associate Professor Rajarambapu Institute of technology rajaramnagar, Illampu has given a detailed report on the form work used for the construction of shear walls. Mr.A.P.Jadhav highlighted the importance of quickness in construction and the need for earthquake resistant building for better sustainability of life.

III. STUDY METHODOLOGY

Function of shear wall

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. Shear walls also provide lateral stiffness to prevent the roof or floor above from excessive sideway. 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

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. Bearing walls have less uplift than non-bearing walls because gravity Loads on shear walls help them resist uplift. Shear walls need hold down devices at each end when the gravity loads cannot resist all of the uplift. The hold down device then provides the Necessary uplift resistance.

Shear walls should be located on each level of the structure including the crawl space. To form

An effective box structure, equal length shear walls should be placed symmetrically on all four exterior walls of the building. Shear walls should be added to the building interior when the exterior walls cannot provide sufficient strength and stiffness. Shear walls are most efficient when they are aligned vertically and are supported on foundation Walls or footings. When exterior shear walls do not provide sufficient strength, other parts of the Building will need additional strengthening. Consider the common case of an interior wall supported by a sub floor over a crawl space and there is no continuous footing beneath the wall.

For this wall to be used as shear wall, the sub floor and its connections will have to be Strength need near the wall. For Retrofit work, existing floor construction is not easily changed. That's the reason why most retrofit work uses walls with continuous footings underneath them as Shear walls.

Classification of shear walls

- Simple rectangular types and flanged walls (bar bell type)
- Coupled shear walls
- Rigid frame shear walls
- Framed walls with in filled frames
- Column supported shear walls
- Core type shear walls

Types of shear walls

1. RC Shear Wall
2. Plywood Shear Wall
3. Mid ply Shear Wall

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IV. ANALYSIS AND RESULTS

Building plan with shear wall

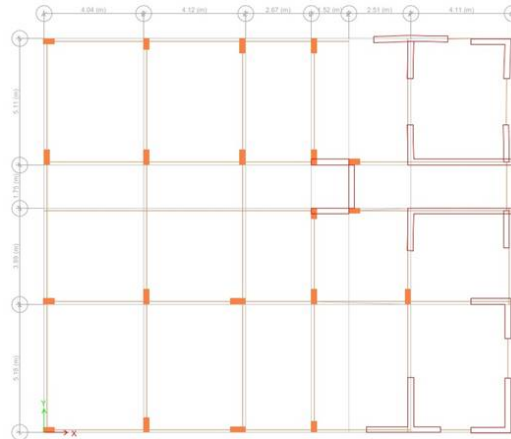


Fig 1: view of Building plan with shear wall

Shear Wall Design

GIVEN,

Length of shear wall = 4.16m
Thickness of shear wall = 250mm

Assume,

F_{ck} = 25
 F_y = 415 N/mm²

STEP1:

Determine design loads

Note: load factor 0.8 for instead of IS value 1.2 for gravity loads

$$P_1 = 0.8 * 1950 + (1.2 * 250) = 1860$$

$$P_2 = 1.2 (1950 + 250) = 2640$$

$$\text{Moment} = 1.2 (600 + 4800) = 6840 \text{ KNm}$$

$$\text{Shear} = 1.2 (20 + 700) = 864 \text{ KN.}$$

STEP2:

Check whether boundary elements are required

NOTE: (extreme stress are more than 0.2 F_{ck})

$$= 0.2 * 25 = 5 \text{ N/mm}^2$$

$$F_c = P/A + M/I * Y$$

$$I = \frac{BD^3}{12} = \frac{4160 * 250^3}{12} = 1.5 * 10^{12} \text{ mm}^4$$

$$A = b d = 4160 * 250 = 1.04 * 10^6 \text{ mm}^2$$

$$F/y = M/I$$

$$I = M/I * Y$$

(normal stress + permeable stress)

$$F_c = 11.52, -6.45$$

- Boundary elements are required

STEP 3 :

Dimensions of boundary elements

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 11, November 2016

Bar bells type $3400 + 2 (380) = 4160$ mm

STEP 4 :

Check two layer steel IS required

- Shear stress is more than $0.25\sqrt{F_{ck}}$
- The thickness of section is more than 200mm

$$\begin{aligned} \text{Depth} &= 3780\text{mm} \\ V &= V_u/bd \\ &= 864 * 10^3 / 250 * 3780 \\ &= 0.9 \\ 0.25\sqrt{20} &= 1.11 \text{ N/mm}^2 \end{aligned}$$

Thickness is 250 more than 200mm so two layer is required

STEP 5 :

Design steel is required

Minimum steel is 0.0025 (0.25 %)

Assume for 1 m

$$\begin{aligned} &= 0.0025 * 250 * 1000 \\ &= 625\text{mm}^2 = \text{two layers} \end{aligned}$$

Provide T 10 @ 250

$$\begin{aligned} \Pi d^2/4 &= \Pi * 10^2/4 \\ &= 314\text{mm}^2 \end{aligned}$$

For one layer

If ,

$$\begin{aligned} \text{Two layer} &= 628\text{mm}^2 \\ \text{Required} &= 625\text{mm}^2 \\ \text{Provided} &= 628\text{mm}^2 \end{aligned}$$

STEP 6 :

Calculate V_s taken by steel

$$V = 0.92 \text{ N/mm}^2$$

$$V_s = V_u - V_c$$

$$V_c = V_u - T_c * d$$

So,

$$V_s = (0.92 - 0.36) * 250 * 3780$$

$$\begin{aligned} \tau_{c\text{Fol}} \text{ 0.25 \% steel and } F_{ck} &= 20 \\ &= 0.36 \text{ N/mm}^2 \end{aligned}$$

$$V_s = 529.2 \text{ KN}$$

STEP 7 :

Calculate steel necessary to take V_s

$$V_s/d = 0.87 f_y A * S_v/S_v$$

$$\begin{aligned} A_{sv}/s_v &= 529.2 * 10^3 / 0.87 * 415 * 3720 \\ &= 0.388 \end{aligned}$$

Consider 1m in height = S_v

$$A_{sv} = 628\text{mm}^2 \text{ (for layer)}$$

$$\begin{aligned} A_{sv} / S_v &= 628/1000 \\ &= 0.628\text{mm}^2 \end{aligned}$$

Flexural strength 1 web parts

$$P_w = 1860 * 3400 * 250 / (3400*250)+2(380*760)$$

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 11, November 2016

$$= 1107\text{KN}$$

STEP 8:

x/l & \dot{x}/l

$$x/l = \lambda + \phi/0.36 + 2\phi$$

$$\lambda = Pw / Fck + 1$$

$$= 1107 * 10^3 / 20 * 250 * 5400$$

$$= 0.065$$

$$\text{Like } \phi = 0.87 f_y / f_{ck}$$

$$= 0.045$$

$$\beta = 0.516 \text{ for 415 grade}$$

$$x/l = 0.24$$

$$\dot{x}/l = 0.5 \text{ for 415}$$

$$x/l < \dot{x}/l$$

$$\mu / f_{ck} * f_l^2 = \phi (1 + \lambda / \phi) (0.52 - 0.42 * 0.20)$$

$$= 0.041$$

$$M_u = 0.04 * 20 * 250 * 3400^2$$

$$M_u = 2370\text{KNm}$$

STEP 9 :

$$\text{Moment from BE} = 6480 - 2370$$

$$= 4110 \text{ KNm}$$

STEP 10:

C & T in BE

$$= 3400 + 380$$

$$= 3780\text{mm}$$

$$= 3.78\text{m}$$

$$\text{Axial loads} = m/c$$

$$= 4110 / 3.86$$

$$= 1065\text{KN}$$

STEP 11:

Calculation compression at one end and tension at another end

$$\text{Extraction area} = 0.2025$$

In compression

$$P_2 = (0.2025 * 2640)$$

$$= 535$$

In tension

$$= 0.2025 * 1860$$

$$= 377 \text{ KN}$$

$$\text{Compression end} = 1065 + 535$$

$$= 1600 \text{ KN}$$

$$\text{Tension end} = -1065 + 377$$

$$= -688 \text{ KN}$$

STEP 12 :

Reinforcement around opening site as 1200*1200

Area of reinforcement cut off by the opening

$$= 1200 * t * 0.0025$$

$$= 1200 * 250 * 0.0025$$

$$= 750\text{mm}^2$$

$$4\text{NO. bars } 16\text{mm dia} = 804 \text{ mm}^2$$

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V. CONCLUSION

Thus shear walls are one of the most effective building elements in resisting lateral forces during Earthquake. By constructing shear walls 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 structure and its contents. Not only has its strength, in order to accommodate huge number of population in a small area tall structured with shear walls are considered to be most useful. Hence for a developing nation like India shear wall construction is considered to be a back bone for construction industry.

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- (3) Mr A.P. Jadhav Associate Professor Rajarambapu Institute of technology rajaramnagar, Illampu Has given a detailed report on the form work used for the construction of shear walls.
- (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) I.S 456:2000. 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.
- (7) In IS: 13920:1993 it gives the ductile detailing of shear wall as per clause 9, where 9.1 gives General requirements.