International Journal of Research
Available at https://edupediapublications.org/journals

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 10
September 2017

Study On Optimum Location Of Shear Walls In U-Shaped Building

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ABSTRACT:- *Shear walls are structural members used to augment the strength of RCC structures. These shear walls will be built in each level of the structure, to form an effective box structure. Equal length shear walls are placed symmetrically on opposite sides of exterior walls of the building. Shear walls are added to the building interior to provide extra strength and stiffness to the building when the exterior walls cannot provide sufficient strength and stiffness. It is necessary to provide these shear walls when the allowable span-width ratio for the floor or roof diaphragm is exceeded. The present work deals with a study on the optimum location of shear walls in U shape building. In this work a high rise building with different locations of shear walls is considered for analysis. The high rise building is analyzed for its torsion, strength and stability. The shear walls are placed such that there is no torsion in the second mode shape. The results of the analysis on the shear force, bending moment and torsion are compared. The results are presented in tabular and graphical form. The results on the drift and displacement are checked with service ability condition and are compared and presented in tabular form.*

INTRODUCTION

Shear Walls

Reinforced concrete framed buildings are adequate for resisting both the vertical and the horizontal loads acting on them. However, when the buildings are tall, say, more than twelve storey's or so, beam and column sizes work out large and reinforcement at the beam-column junctions works out quite heavy, so that, there is a lot of congestion at these joints and it is difficult to place and vibrate concrete at these places, which fact, does not contribute to the safety of buildings. These practical difficulties call for introduction of shear walls in tall buildings. There will be no architectural difficulty in extending them thought the height of the building; care shall be taken to have symmetrical configuration of walls in plan so that torsional effect in plan could be avoided. Further, shear walls should get enough vertical load from floors, for which reason, nearby columns should be omitted and load taken to the shear walls by means of long span beams if required.

Development of Structural System

Structural development of tall buildings has been a continuously evolving process. There is a distinct structural history of tall buildings similar to the history of their architectural styles in terms of skyscraper ages. These stages range from the rigid frame, tube, core-outrigger to dia grid systems. Structural systems for tall buildings have, undergone dramatic changes since the demise of the conventional rigid frames in the 1960s as the predominant type of structural system for steel or concrete tall buildings. With the emergence of the tubular forms still conforming to the international style, such changes in the structural form and organization-of tall building swere necessitated by the emerging architectural trends in design in conjunction with the economic, demands and technological developments in the realms of rational structural analysis and design made possible by the advent ‹) of high-speed digital computers. Beginning in the 1980s, once-prevalent Miesian tall buildings were then largely replaced by the facade characteristics of postmodern, historical, diagrid and deconstructive expressions. This was not undesirable because the new generation of tall buildings broke the monotony of the exterior tower form and gave rise to novel high-rise expressions. Innovative structural systems involving tubes, ‹mega frames, core-and-outrigger systems, artificially damped structures, and mixed steel-concrete systems are some of the new developments since the 1960s.

Structural Systems

In the early structures at the beginning of the 20th century, structural members were assumed to carry primarily the gravity loads. Today, however, by the advances in structural design/systems and high-strength materials, building weight is reduced, and slenderness is increased, which necessitates taking into consideration mainly the lateral loads such as

e-ISSN: 2348-6848
p-ISSN: 2348-795X
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wind and earthquake. Understandably, especially for the tall buildings, as the slenderness, and so the flexibility increases, buildings suffer from the lateral loads resulting from wind and earthquake more and more. As a general rule, when other things being equal, the taller the building, the more necessary it is to identify the proper structural system for resisting the lateral loads. Currently, there are many structural systems that can be used for the lateral resistance of tall buildings. In this context, authors classify these systems based on the basic reaction mechanism/structural behavior for resisting the lateral loads.

Structural systems for tall buildings

i. Rigid frame systems
ii. Braced frame and shear-walled frame systems
iii. Braced frame systems
iv. Shear-walled frame systems
v. Outrigger systems
vi. Framed-tube systems
vii. Braced-tube systems
viii. Bundled-tube systems

Structural systems of tall buildings can be divided into two broad categories: interior structures and exterior structures. This classification is based on the distribution of the components of the primary lateral load-resisting system over the building. A system is categorized as an interior structure when the major part of the lateral load resisting system is located within the interior of the building. Likewise, if the major part of the lateral load-resisting system is located at the building perimeter, a system is categorized as an exterior structure. It should be noted, however, that any interior structure is likely to have some minor components of the lateral load-resisting system at the building perimeter, and any exterior structure may have some minor components within the interior of the building.

The Role of Floor Diaphragm in Framed Buildings

The role of floor diaphragm is as important as it is in the case of framed buildings. The floor diaphragm forces all the vertical elements like frames and shear walls to share the incumbent horizontal shear in the ratio of their rigidities or stiffness. To calculate the share of the total horizontal shear of each shear wall element is a major task and it may be called 'allocation analysis', while each shear wall under the assigned horizontal shears at floor levels acts as a vertical cantilever beam fixed at base and its analysis and design will be given later under the head' shear wall analysis and design.

In **a** building with rigid floor diaphragm, the following three situations may arise with respect to the Centre of mass and Centre of rigidity.

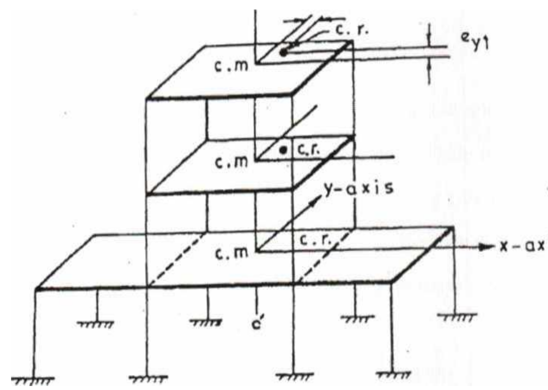

Figure 1.1 shows that the Centre of mass of all the floors lies on the same vertical axis passing through the center of gravity of the floors.

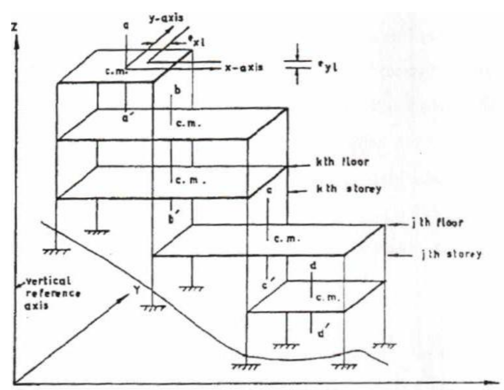

Figure 1.2 shows that the Centre of mass and center of stiffness of all the floors lies on the different vertical axis

Effect of Earthquakes on High Rise Buildings.

When a building exposure to the earthquake vibrations its foundation will move back and forth with the ground. These vibrations can be quite intense, creating stresses and deformation throughout the structure making the upper edges of the building swing from a few mm to many inches dependent on their height size and mass. This is uniformly applicable for buildings of all heights, whether single storied or multi-storied in high-risk earthquake zones.A building needs to be slightly flexible and also have components, which can withstand or counter the stresses caused in various parts of the building due to horizontal movements caused by earthquakes. It was observed that buildings of different sizes and heights vibrated with different frequencies. Where these were made next to each other they created stresses in both the structures and thus weakened each other and in many cases caused the failure of both the structures. Bureau Of Indian Standards clearly gives in its code IS 4326 that a Separation Section is to be provided between buildings. Separation Section is defined as "

Geo-Technical Considerations

Site Selection: The seismic motion that reaches a structure on the surface of the earth is influenced by local soil conditions. The subsurface soil layers underlying the building foundation may amplify the response of the building to earthquake motions originating in the bedrock.

For soft soils the earthquake vibrations can be significantly amplified and hence the shaking of structures sited on soft soils can be much greater than for structures sited on hard soils. Hence appropriate soil investigation should be carried out to establish the allowable bearing capacity and nature of soil. The choice of site for a building from the failure prevention point of view is mainly concerned with the stability of the ground. The very loose sands or sensitive clays are liable to be destroyed by the earthquake so much as to lose their original structure and thereby undergo compaction.

Bearing capacity of foundation soil three soil types are considered here

Hard- Those soils, which have an allowable bearing capacity of more than 10t/m2. **Medium -** Those soils, which have allowable bearing capacity less than or equal to 10t/m2

Soft - Those soils, which are liable to large differential settlement or liquefaction during earthquake.

Soils must be avoided or compacted to improve them so as to qualify them either as firm or stiff. The allowable bearing pressure shall be determined in accordance with iS: 1888-1982 load test (Revision 1992). It is a common practice to increase the allowable bearing pressure by one-third, i.e. 33%, while performing seismic analysis for the materials like massive crystalline bedrock sedimentary rock, dense to very dense soil and heavily over consolidated cohesive soils, such as a stiff to hard clays.For the structure to react to the motion, it needs to overcome its own inertia, which results in an interaction between the structure and the soil. The extent to which the structural response may alter the characteristics of earthquake motions observed at the foundation level depends on the relative mass and stiffness properties of the soil and the structure. Thus the physical property of the foundation medium is an important factor in the earthquake response of structures supported on it.

Need and Objectives of the Study

Now a day's earthquake is frequency occurrence in many areas .The magnitude of disaster caused due to calamities by way of loss of life and property is shocking. Now the areas which were coming in safe zone are not safe for earthquake loads, therefore code has updated the seismological maps of the terrains in a hurry. Therefore, some areas are considered to be safe against earth quake are no longer safe. All these factors put an additional burden and great responsibility to search safe methods of construction on the shoulders of the structural engineer presently with the task of awarding safe certification to the structures active areas. Apart from these, any new structures to be taken up in these areas have to be designed to withstand the earth quake forces. In my present work

a)The study behavior of multistoried U –shaped RCC framed structure and dual system for various locations of shear walls with seismic & wind loading has been done.

b) The variation of lateral loads to diaphragms of the models has been studied.

c) To examine the effect of different types of soil (Hard, medium and Soft) on the overall interactive behavior of the shear wall foundation soil system.

d) The variation of maximum storey axial force, storey shear, storey moment and storey torsion of the models has been studied.

e) The variation of storey drifts of the models has been studied

f) The variation of displacement of the models has been studied

g) The variation of maximum column axial force,maximum column shearforce, maximum

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column moment and maximum column torsion of the models has been studied.

h) And the variation of time period has been studied.

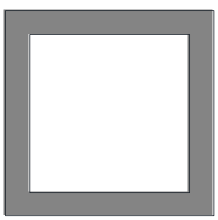
SHEAR WALL AND LATERAL LOAD

Shear Wall

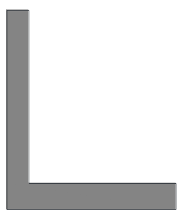
Shear wall is a concrete wall made to resist lateral forces acting on multistorey buildings. It is provided, when the centre of gravity of building area & loads acted on it differs by more than 30%. In order to bring the center of gravity in range of 30% concrete wall is provided i.e. lateral forces may not increase much.

The Shear Wall sections are classified as six types.

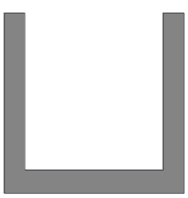
(a) Box Section
(b) L – Section
(c) U - Section
(d) W – Section



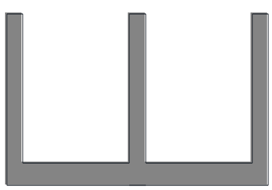
(a) Box Section



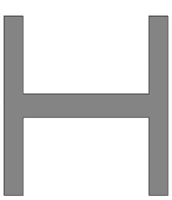
(b) L – Section



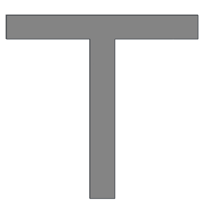
(c) U – Section



(d) W – Section



(e) H - Section



(f) T – Section

The shape and location of shear wall have significant effect on their structural behavior under lateral loads. Lateral loads are distributed through the structure acting as a horizontal diaphragm, to the shear walls, parallel to the force of action. These shear wall resist horizontal forces because their high rigidity as deep beams, reacting to shear and flexure against overturning. A core eccentrically located with respect to the building shapes has to carry torsion as well as bending and direct shear. However torsion may also develop in building symmetrical featuring of shear wall arrangements when wind acts on the facades of direct surface textures (i.e. roughness) or when wind does not act through the centre of building's mass.

Shear Wall Components

Reinforced concrete and reinforced masonry shear walls are seldom-simple walls. Whenever a wall has doors, windows, or other openings, the wall must be considered as an assemblage of relatively flexible components like column segments and wall piers and relatively stiff elements like wall segments

1. Column segments: A column segment is a vertical member whose height exceeds three times its thickness and whose width is less than two and one-half times its thickness. Its load is usually predominantly axial. Although it may contribute little to the lateral force resistance of the shear wall is rigidity must be considered. When a column is built integral with a wall, the portion of the column that project from the face the wall is called a pilaster. Column segments shall be designed according to ACI 318 for concrete.

2 Wall piers: A wall pier is a segment of a wall whose horizontal length is between two and one-half and six times its thickness whose clear height is at least two times its horizontal length.

3. Wall segments: Wall segments are components that are longer than wall piers. They are the primary resisting components in the shear wall.

Advantages of Shear Wall In R.C. Building

• They are very rigid in their own plane and hence are effective in limiting deflections.

• Properly designed and detailed building with shear wall has shown very good performance in past earthquake.

• Shear walls in high-seismic regions require special detailing. However, during earthquakes, even buildings with sufficient amount of walls that were not specially detailed for seismic performance (but had enough well-distributed reinforcement) were saved from collapse.

Lateral Forces

The two types of lateral loads considerably vary and at times the requirements may be conflicting. For example one strategy to reduce vibration of multistorey structures due to wind load is to increase its mass whereas increase in mass usually causes increase in the lateral load due to earthquake. It is therefore very important to understand the relative importance of wind and earthquake on a structure located at a particular site.

Wind loads

The most common types of wind flow around multistorey buildings that need to be accounted for during and after construction are categorized as:

a) Down-draughts
b) Separation
c) Vortices
d) Funneling
e) Wakes

Earthquake Loads

Severity of ground shaking at a given location during an earthquake can be minor, moderate and strong. Relatively speaking, minor shaking occurs frequently; moderate shaking occasionally and strong shaking rarely.

ARECHITECTURAL FEATURES

A desire to create an aesthetic and functionally efficient structure drives architects to conceive wonderful and imaginative structures. Sometimes the *shape* of the building catches the eye of the visitor, sometimes the structural system of work together to make the structure a marvel. However, each of these choices of shapes and structure has significant bearing on the performance of the building during past earthquake across the world is very educative in identifying structural configurations that are desirable versus those which must be avoided.

A) Size of buildings

In tall buildings with large height- to-base size ratio, the horizontal movement of the floors during ground shaking is large. In short but very long buildings, the damaging effect during earthquake shaking are many. And, in buildings with large plan area like warehouses, the horizontal seismic forces can be excessive to be carried by columns and walls.

B) Horizontal layout of buildings

In general, buildings with simple geometry in plan have performed well during strong earthquakes. Buildings with reentrant corners, like those U.V.H and + shaped in plan, have sustained significant damage. Many times, the bad effects of these interior corners in the plan of buildings are avoided by making the buildings into two parts. For example, an L-Shaped plan can be broken up into two rectangular plan shapes using a separation joint at the junction. Often the plan is sample but the columns/ walls are not equally distributed in plan. Buildings with such features tend to twist during earthquake shaking.

C) Vertical layout of buildings

The earthquake forces developed at different floor levels in a buildings need to be bought down along the height to the ground by the shortest path; any deviation or discontinuity in this load transfer path results in poor performance of the buildings with a few stores wider than the rest cause a sudden jump in earthquake forces at the level f discontinuity. Buildings that have fewer columns or walls in a particular storey or with unusually tall storey tend to damage or collapse which is initiated in that storey.

D) Adjacent buildings

When two buildings are too close to each other, they may pound on each during strong shaking. With increase in building height, this collision can be greater problem. When building heights do not match the roof of the shorter building may pound at the mid - height of the column of the taller one; this can be very dangerous.

Shear Wall Analysis

Each shear wall acts like a column under vertical load (P) from the supported floors and its self-weight. The wall shall be designed as a column, taking into account joint moments and additional moment due to slenderness. The horizontal shears at each floor level on a wall element produce shear (H) and overturning moment (M) in wall, with the wall being regarded as a vertical cantilever beam fixed at base. Each section of wall has to be designed for P,M and H, taking advantage of increased stresses or lowered load factors as the overturning moment M and the horizontal shear H are both the result of either wind or earthquake forces.

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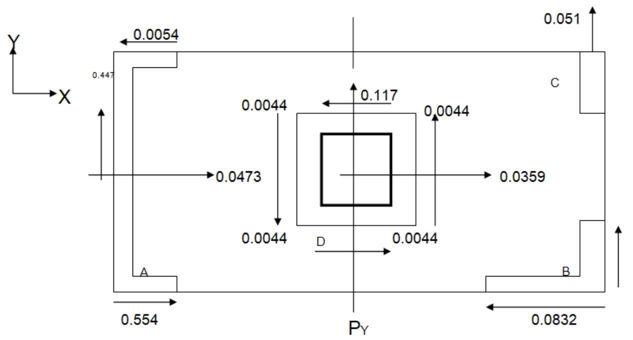

Critical issues for the design of high rise buildings in regions prone to significant wind and seismic effects typically include:

1- High base overturning moment and foundation design (wind, Seismic).
2- High shear capacity requirements near base (seismic).
3- High gravity stresses in the vertical elements (and use of high strength materials) to minimize structural design and to maximize net floor area.
4- Development of ductility in elements at the base of a structure under high compressive gravity stress (Seismic).
5- Controlling lateral accelerations (wind).
6- Controlling storey drift (wind and seismic).
7- Controlling damage so as to permit repair (seismic).
8- Ensuring ductile energy dissipation mechanisms and preventing brittle failures (seismic).

METHODOLOGY

Design Aspect:-When a structure is subjected to an earthquake, it responds by vibrating. An earthquake can be resolved in any three mutually perpendicular directions-the two horizontal directions (longitudinal and transverse displacement) and the vertical direction (rotation).This motion causes the structure to vibrate or shake in all three directions; the predominant direction of shaking is horizontal. All the structures are designed for the combined effects of gravity loads and seismic loads to verify that adequate vertical and lateral strength and stiffness are achieved to satisfy the structural performance and acceptable deformation levels prescribed in the governing building code. Because of the inherent factor of safety used in the design specifications, most structures tend to be adequately protected against vertical shaking. Vertical acceleration should also be considered in structures with large spans, those in which stability for design, or for overall stability analysis of structures.
In general, most earthquake code provisions implicitly require that structures be able to resist:

1. Minor earthquakes without any damage.
2. Moderate earthquakes with negligible structural damage and some non-structural damage.
3. Major earthquakes with some structural and non-structural damage but without collapse.

Equivalent Lateral Force (Seismic Coefficient) Method:

This method of finding lateral forces is also known as the static method or the equivalent static method or the seismic coefficient method. The static method is the simplest one and it requires less computational effort and is based on formulae given in the code of practice.

Seismic Weight:

The seismic weight of building is the sum of seismic weight of all the floors. The seismic weight of each floor is its full dead load plus appropriate amount of imposed load, the latter being that part of the imposed loads that may reasonably be expected to be attached to the structure at the time of earthquake shaking. It includes the weight of permanent and movable partitions, permanent equipment, a part of the live load, etc. While computing the seismic weight of columns and walls in any storey shall be equally distributed to the floors above and below the storey.

Time Period:

The approximate fundamental natural period of vibration T_a in seconds, of a moment resisting frame building without brick infill panels may be estimated by the following empirical formula

$T_a = 0.075h^{0.75}$ for RC frame building
$T_a = 0.085h^{0.75}$ for steel frame building

The approximate fundamental natural period of vibration in seconds of all other, buildings including moment resisting frame buildings with brick infill panels may be estimated by the following expression.

$$T = \frac{0.09\ \mathrm{H}}{\sqrt{\mathrm{d}}}$$

Where H = Height of building in meters (This excludes the basement storey's, where basement walls are connected with the ground floor deck or fitted between the columns. But, it includes the basement storeys, when they are not connected).
d = Base dimensions of the building at the plinth level, in m, along the considered direction of the lateral force.

Lateral Distribution of Base Shear:
The computed base shear is now distributed along the height of the building, the shear force, at any level depends on the mass at that level and deforms shape of the structure. Earth quake forces deflect a structure into number of shapes known as the natural mode shapes. Number of natural mode shapes depends up on the degree of freedom of the system. Generally a structure has continuous system with infinite degree of freedom the magnitude of the lateral force at a particular floor (node) depends on the mass of the node, the distribution of stiffness over the height of the structure, and the nodal displacement in the given mode. The actual distribution of base share over the height of the building is obtained as the superposition of all the mode of vibration of the multi - degree of freedom system.
As per IS 1893: 2002 in clause 7.7.1, the design base shear thus obtained from Eq. 3.1 shall be distributed along the height of the building as per the following expression:

$$Q_i = V_B \frac{W_i h_i^2}{\sum_{j=1}^{n} W_j h_j^2}$$

Where Q_i = Design lateral force at floor i.
W_i= Seismic weight of floor i.
H_i= Height of floor i measured from base, and
n = Number of stores in the building i.e., the number of levels at which the masses are located.
The distribution suggested in the code gives parabolic distribution of seismic forces such that seismic shears are higher near top storeys for the same base shear. The assumptions involved in the static procedure reflected in the expression are

a) fundamental mode of the building makes the most significant contribution to base shear, and
b) The total building mass is considered as against the modal mass that would be used in a dynamic procedure.
c) The mass and stiffness are evenly distributed in the building.

Dynamic Analysis:
Dynamic analysis shall be performed to obtain the design seismic force, and its distribution in different levels along the height of the building, and in the various lateral loads resisting element, for the following buildings:
Regular buildings:Those greater than 40m in height in zones IV and V, those greater than 90m in height in zone II and III.
Irregular buildings:All framed buildings higher than 12m in zones IV and V, and those greater than 40m in height in zones II and III.
The analysis of model for dynamic analysis of buildings with unusual configuration should be such that it adequately models the types of irregularities present in the building configuration. Buildings with plan irregularities, as defined in Table 4 of IS code: 1893-2002 cannot be modeled for dynamic analysis.
Dynamic analysis may be performed either by the TIME HISTORY METHOD or by the RESPONSE SPECTRUM METHOD,

a) Time history method:
The usage of this method shall be on an appropriate ground motion and shall be performed using accepted principles of dynamics. In this method, the mathematical model of the building is subjected to accelerations from earthquake records that represent the expected earthquake at the base of the structure.

b) Response spectrum method:
The word spectrum in engineering conveys the idea that the response of buildings having a broad range of periods is summarized in a single graph. This method shall be performed using the design spectrum specified in code or by a site-specific design spectrum for a structure prepared at a project site. The values of damping for building may be taken as 2 and 5 percent of the critical, for the purposes of dynamic of steel and reinforce concrete buildings, respectively. For most buildings, inelastic response can be expected to occur during a major earthquake, implying that an inelastic analysis is more proper for design. However, in spite of the availability of nonlinear inelastic programs, they are not used in typical design practice because:

1- Their proper use requires knowledge of their inner workings and theories. design criteria, and

2- Result produced are difficult to interpret and apply totraditional design criteria , and

1- The necessary computations are expensive.

Therefore, analysis in practice typically use linear elastic procedures based on the response spectrum method. The response spectrum analysis is the *preferred* method because it is easier to use.

Response Spectrum Analysis

This method is also known as modal method or mode superposition method. It is based on the idea that the response of a building is the superposition of the responses of individual modes of vibration, each mode responding with its own particular deformed shape, its own frequency, and with its own modal damping.

According to IS-1893(Part-l):2002, high rise and irregular buildings must be analyzed by response spectrum method using design spectra shown in Figure 4.1. There are significant computational advantages using response spectra method of seismic analysis for prediction of displacements and member forces in structural systems.

Modal Combination:

Modal Response quantities (member forces, displacements, storey forces, storey shears and base reactions) for each mode of response may be combined by the complete quadratic combination (CQC) technique or by taking the square root of the sum of the squares (SRSS) of each mode of the modal values or absolute sum (ABS) method.

(i) CQC Method :

The peak response quantities shall be combined as per the complete quadratic combination (CQC) method.

$$\lambda = \sqrt{\sum_{i=1}^{r}\sum_{j=1}^{r}\lambda_i\rho_{ij}\lambda_j}$$

Where

r= Number of modes being considered

ρ_{ij} = *Cross – modal coefficient*

λ_i =*Response quantity in mode I (including sign)*

λ_j =*Response quantity in mode j (including sign)*

$$\boldsymbol{\rho_{ij}} = \frac{8\zeta^2(1+\beta)\beta^{1.5}}{(1+\beta)^2+4\zeta^2\beta(1+\beta)^2}$$

β= Modal damping ratio (in fraction) as specified in 7.8.2.1

ζ=Frequency ratio $=\frac{\omega_j}{\omega_i}$

(ii) SRSS Method

If the building does not have closely spaced modes than the peak response quantity due to all modes considered shall be obtained as

$$\lambda=\sqrt{\sum_{k=1}^{r}(\lambda_k)^2}$$

Where

λ_k = Absolute value of quantity in mode k, and

r= Number of modes being considered.

(iii) ABS Method

If the building has a few closely spaced modes, then the peak response quantity due to all modes considered shall be obtained as:

$$\lambda^* = \sqrt{\sum_c^r \lambda_c}$$

Where the summation is for the closely-spaced modes only. This peak response quantity due to the closely spaced modes (λ^*) is then combined with those of the remaining well-separated modes by the method described above.

Modal Analysis

Building with regular, or nominally irregular, plan configuration may be modeled as a system of masses lumped at the floor levels with each mass having one degree of freedom, that of lateral displacement in the direction under consideration. In the modal analysis, the variability in masses and stiffness is accounted for in the computation of lateral force coefficients. The following expressions are used for the computation of various quantities:

(a)Modal mass:The modal mass (M_K) of mode 'k' is given by

$$M_k = \frac{(\sum_{i=1}^{n} W_i \emptyset_{ik})^2}{g\sum_{i=1}^{n} W_i(\emptyset_{ik}^2)}$$

Where

International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
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Volume 04 Issue 10
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g=Acceleration due to gravity, and
ϕ_{ik}=Mode shape coefficient at floor (i) in mode 'k' and
W_i= Seismic weight of floor (i)

(b)Modal participation factor: The modal participation factor (p_k) of mode k is given by

$$p_k = \frac{\sum_{i=1}^{n} W_i \varnothing_{ik}}{\sum_{i=1}^{n} W_i (\varnothing_{ik}^2)}$$

(c) Design lateral force at each floor in each mode: The peak lateral force ϕ_i at floor I in mode k^t is given by

$$\varnothing_{ik} = A_k \varnothing_{ik} p_k W_i$$

WhereA_k= Design horizontal acceleration spectrum value as per Eq. (3.2). Using the natural period of vibration (Tk)of mode 'k'
(d) Storey shear forces in each mode:
The peak shear force (V_{ik}) acting in storey 'i' in mode 'k' is given by

$$V_{ik} = \sum_{j=i+1}^{n} \varnothing_{ik}$$

(e) Storey Shear forces due to all modes considered: The peak storey shear force (V_i) in storey i due to all modes considered is obtained by combining those due to each mode in accordance with
(f) Lateral force at each storey due to all modes considered: The design lateral forces F roof and F_i at roof and floor i.

$$F_{roof} = V_{roof}$$
$$F_i = V_i - V_{i+1}$$

RESULTS AND DISCUSSIONS

A 15 storied shear wall & rigid frame structure with different location of shear walls in plan was analyzed in ETABv9.6.0 and results are obtained and compared as follows':-
Structure 1: In this model building with 15 floors is modeled as a "'Rigid frame" with only, beams, columns & slabs. The dead loads of other elements (slabs, stairs and walls) are taken as member loads on the respective beams. The wall load is considered as uniformly distributed load on beams. In this case the effect of rigid floor diaphragm is taken into consideration.
Structure 2: In this model building with 15 floors is modeled as (Dual frame system with shear wall as shown in plan 2). Shear wall act as vertical cantilever .The loads are taken as same in structure1.
Structure 3: In this model building with 15 floors is modeled as (Dual frame system with shear wall (I-shaped) at middle span of the building as shown in plan 3). Shear wall act as vertical cantilever .The loads are taken as same in structure1.
Structure 4: In this model building with 15 floors is modeled as (Dual frame system with shear wall as shown in plan 4). Shear wall act as vertical cantilever .The loads are taken as same in structure1.
Structure 5: In this model building with 15 floors is modeled as (Dual frame system with shear wall (L-shaped) as shown in plan 5). Shear wall act as vertical cantilever. The loads are taken as same in structure1.
The dynamic analysis is carried out for all models with different type of soil (hard , medium and soft) and the time period , storey masses ,base shear , displacement , storey drift , column axial force , column shear force in both direction (x,y) , column torsion , column moment in both direction (x,y) , storey axial force , storey shear force , storey moment in both direction (x,y) are presented in table and figures form.

Table 6.1 Time Period For All Structure In Hard, Medium And Soft Soil

Mode	Time Period , Tk (sec)				
	Structure-1	Structure-2	Structure-3	Structure-4	Structure-5
1	1.413185	1.076808	1.018958	0.847353	1.014567
2	1.351922	0.903551	0.907869	0.823547	0.972968

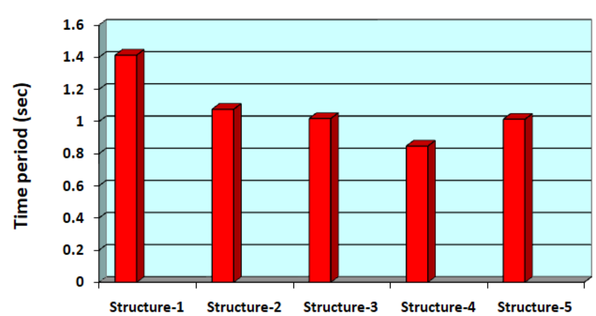

Figure 6.1 Modal natural time period for all stucture in hard , medium and soft soil

From the above table (6.1) and Fig 6.1 it is observed that the time period is

1- 1.413 sec for structure1 and it is same for different type of soil.
2- 1.076 sec for structure2 and it is same for different type of soil.
3- 1.018 sec for structure3 and it is same for different type of soil.
4- 0.847 sec for structure4 and it is same for different type of soil.
5- 1.014 sec for structure5 and it is same for different type of soil.

The percentage of time period decreased by adding shear wall as shown below:-

1- 24.3% for structure2 compared with structure1.
2- 28% for structure3 compared with structure1.
3- 40% for structure4 compared with structure1.
4- 28.2% for structure5 compared with structure1.

Table 6.2: Center Of Mass And Rigidity For All Structure In Hard, Medium And Soft Soil

Structure	Center of mass		Center of rigidity	
	XCM	YCM	XCR	YCR
Structure-1	30	24.163	30	22.588
Structure-2	30	24.205	30	23.456
Structure-3	30	24.157	30	23.806
Structure-4	30	24.335	30	24.65
Structure-5	30	24.252	30	23.263

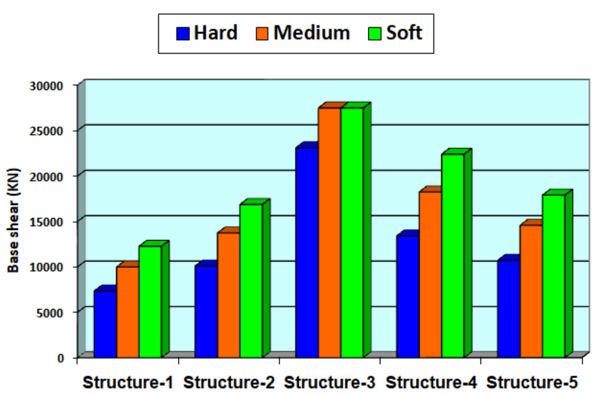

Figure 6.2 Variations in base shear for all structure with load combination 1.2 (LL+DL+EQXNE)

Table 6.3 Diaphragm CM displacement, maximum Ux (m) for all structures with load combination (DL+LL+EQXNE)

Type of soil	Maximum Displacement (m)				
	Structure-1	Structure-2	Structure-3	Structure-4	Structure-5
Hard	0.0226	0.0203	0.0083	0.0172	0.0195
Medium	0.0307	0.0276	0.0099	0.0234	0.0266
Soft	0.0377	0.0339	0.0099	0.0287	0.0326

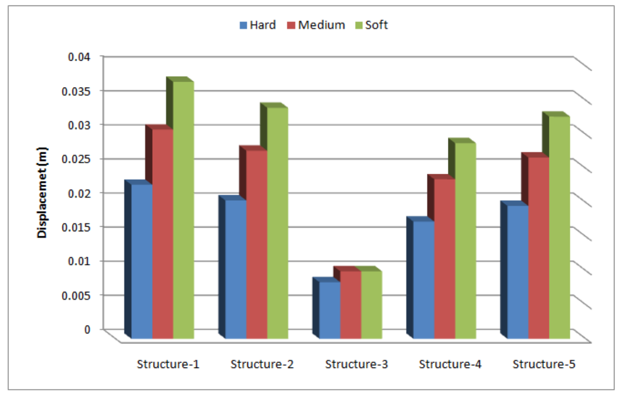

Figure 6.3 Variations in maximum displacement for all structure with load combination (LL+DL+EQXNE)

From above table (6.3) and Fig 6.3 it is observed that

1- The percentage of displacement in x-direction is more by 40% for all structures in soft soil and 26.4% for all structures in medium soil compared with structures in hard soil.
2- The percentage of displacement in x-direction is decreased by placing shear wall as shown below :-
   a- 10 % for structure2 compared with structure1.
   b- 68.23 % for structure3 compared with structure1.
   c- 23.8 % for structure4 compared with structure1.
   d- 13.4 % for structure5 compared with structure1.

Table 6.4 Diaphragm CM displacement, maximum Ux (m) for all structures with load combination (DL+LL+WLX)

Type of soil	Maximum Displacement (m)				
	Structure-1	Structure-2	Structure-3	Structure-4	Structure-5
Hard	0.0111	0.0055	0.001	0.0034	0.005
Medium	0.0111	0.0068	0.0013	0.0042	0.0061
Soft	0.0489	0.0407	0.0112	0.033	0.0388

International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 10
September 2017

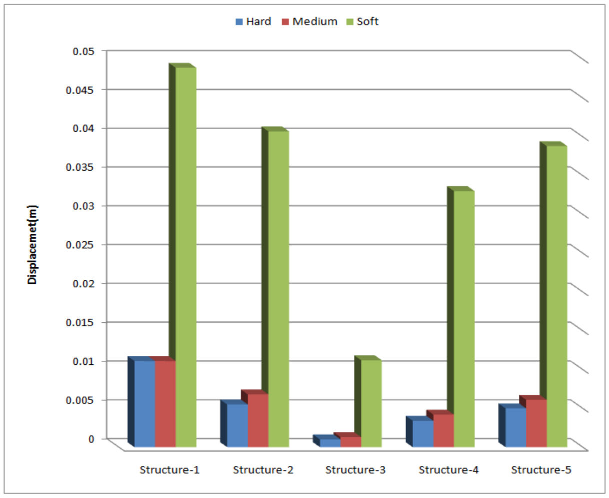

Figure 6.4 Variations in maximum displacement for all structure with load combination (LL+DL+WLX)

CONCLUSIONS

The following conclusions are made from the present study:-

1- The shear wall and it is position has a significant influenced on the time period. Time period is not influenced by type of soil and the better performance for structure 4 because it has low time period.
2- The center of mass and center of rigidity is influenced by adding and positioning of shear wall but is not depended on type of soil. It can be concluded that all structure is symmetric in x-direction and there is no effect of torsion due to center of mass and center of rigidity is same in x-direction. The performance of structure with shear wall is better than structure without shear wall because center of mass and center of rigidity become close.
3- Base shear is affected marginally with placing of shear wall, grouping of shear wall and type of soil. The base shear is increasing by adding shear wall due to increase in seismic weight of the building.
4- Provision of shear wall generally results in reducing the displacement because the shear wall increases the stiffness of building. The better performance for structure 3 because it has low displacement.
5- As per code, the actual drift is less than permissible drift. Parallel arrangement of shear wall in the center core and outer periphery is giving very good result in controlling drift in both the direction. The better performance for structure 3 because it has low storey drift..
6- The shear force resisted by the column frame is decreasing by placing the shear wall and the shear force resisted by the shear wall is increasing. This can be concluded indirectly by observing the maximum column shear force and moment in both directions.
7- The moment resisting frame with shear walls are very good in lateral force such as earthquake and wind force. The shear walls provide lateral load distribution by transferring the wind and earthquake loads to the foundation. And also impact on the lateral stiffness of system and also carry gravity loads.
8- It is evident that shear walls which are provided from foundation to the roof top, are one of the excellent mean for providing earthquake resistant to multistory reinforced building with different type of soil. These are little expensive by (5.4 % for structure 2, 6.7 % for structure 3, 10.8 % for structure 4, 5.4 % for structure 5 of overall cost) but desirable.
9- For the columns located away from the shear wall the Bending Moment ishigh and shear force is less when compared with the columns connected to the shear wall.

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