# Use of Precast Hollow Core Slabs in High Rise Buildings

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***Abstract*** **- Precast prestressed hollow core flooring is used extensively around the world because of economical, light weight, faster assembling etc. This type of slabs is generally used in the construction of floors for high-rise apartments or multi-storey buildings in low-seismic regions.**

**The present study is on the analysis of seismic behaviour of precast hollow core slabs in high rise buildings using ETABS software. Comparision of behaviour of hollow core slab building and solid slab building for different seismic zones keeping the member size same for all models. Comparision of quantity of concrete and quantity of steel for hollow core slab building and solid slab building. A 33 storey commercial office building with precast hollow core slabs have been analyzed for seismic zone IV with type two medium soil. Structural system used for these buildings are taken as concrete special moment-resisting frame with ductile shear walls. Five different models of hollow core slab building with different member sizes have been performed. Static analysis has been carried out by equivalent static method and dynamic analysis has been carried out by response spectrum method as per recommendation of IS: 1893(Part 1):2002.Based on analysis results of five models it has been concluded that model 5member sizes shows better performance when compared to other four models member sizes. Keeping model 5 member sizes constant, 4 models of hollow core slab building and 4 models of solid slab building have been performed for different seismic zones and compared with various factors such as base shear, storey drift. Thus hollow core slab building shows better performance when compared to solid slab building. Hollow core slab building and solid slab building have been analyzed for seismic zone IV based on analysis and design results, quantity of steel and quantity of concrete required are calculated and compared. Based on the analysis results it can be concluded that hollow core slab building consumes less material when compared to solid slab building. Therefore hollow core slab building is best compared to solid slab building.**

**Keywords:** ***precast hollow core slab; high rise building; finite ETABS Software; seismic zones.***

## 1. INTRODUCTION

A hollow core slab refers to a precast slab that is prepared using prestressed concrete with tubular voids which run through the full length of the slab. Prestressing gives concrete longer spanning capacity, shallow depth and the ability to carry heavy loads. Precast hollow core slabs are typically 1200mm in width and about 20m in length. This type of slabs are cost-effective, quick to assemble and build, have lower self-weight, use less raw materials etc.

The prestressed hollow core slabs are tender, light weight products which help in construction of thinner floor. The thinner the flooring much is the space saved for construction which can be translated in to additional floors in the high rise structure that too with controlled costs and lesser joints. The precast prestressed hollow core units are very easy to install and offer an immediate working platform after completion of installment and can be implemented with lesser labour or workforce in lesser time. This greatly reduces the construction delay to a minimum thereby enabling for faster construction of the high rise projects.

With hollow core slabs, thermal activated flooring can be installed in the high rise constructions. In high rise building hollow core flooring offers better fire resistance and ensures better protection of inhabitants or people within building at the time of fire incidents. Costs of construction are greatly reduced with use of hollow core floors in high rise constructions. The presence of longitudinal voids leads to about 45% saving in concrete compared with normal in-situ reinforced slab flooring.



### *1.1 Definition of High Rise Building*

A building is an enclosed structure that has walls, floors, a roof, and usually windows. “A tall building is a multi-storey structure in which most occupants depends on elevators [lifts] to reach their destinations. The most prominent tall buildings are called high-rise buildings in most countries. The terms do not have internationally agreed definitions. ” However, a high rise building can be defined as follows:

“Generally, a high rise structure is considered to be one that extends higher than the maximum reach of available fire-fighting equipment. In absolute numbers, this has been set variously between 75 feet(23 meters) and 100 feet(30 meters)” or about seven to ten stories (depending on the slab-to-slab distance between floors).

The exact height above which a particular building is deemed to be a high rise is specified by fire and building codes for the country, region, state, or city where the building is located. When the building exceeds the specified height, then fire, an ever-present danger in such situation facilities, must be fought by fire personnel from inside the building rather than from outside using fire hoses and ladders.

*1.2 Definition of earthquake*

An earthquake is the series of vibration on the earth's surface caused by the generation of seismic waves due to sudden rupture within the earth.
Seismograph is used to find strength and location of earth quake.

*1.2.1 Definitions in earthquake resistant structures:*

**1. Design Basis Earthquake (DBE):** It is the earthquake which can reasonably be expected to occur at least once during the design life of the structure.
**2. Design Horizontal Acceleration Coefficient ($A_h$):** It is a horizontal acceleration coefficient that shall be used for design of structures.
**3. Design Lateral Force:** It is the horizontal seismic force prescribed by this standard that shall be used to design a structure.
**4. Design Seismic Base Shear ($V_B$):** It is the total design lateral force at the base of a structure.
**5. Height of Structure (h):** It is the difference in levels, in metres, between its base and its highest level.
**6. Importance Factor (I):** It is a factor used to obtain the design seismic force depending on the functional use of the structure, characterized by hazardous consequences of its failure, its post-earthquake functional need, historic value, or economic importance.
**7. Natural Period (T):** Natural period of a structure is its time period of undamped free vibration.
**8. Response Reduction Factor (R):** It is the factor by which the actual base shears force that would be generated if the structure were to remain elastic during its response to the Design Basis Earthquake (DBE) shaking, shall be reduced to obtain the design lateral force.
**9. Seismic Weight (W):** It is the total dead load plus appropriate amount of specified imposed load.
**10. Shear Wall:** It is a wall designed to resist lateral forces acting in its own plane.
**11. Special Moment-Resisting Frame:** It is a moment resisting frame specially detailed to provide ductile behaviour and comply with the requirements given in IS 4326 or IS 13920 or SP 6 (6).
**12. Storey Drift:** It is the displacement of one level relative to the other level above or below.
**13. Storey Shear ($V_i$):** It is the sum of design lateral forces at all levels above the storey under consideration.
**14. Structural Response Factors (Sa/g):** It is a factor denoting the acceleration response spectrum of the structure subjected to earthquake ground vibrations, and depends on natural period of vibration and damping of the structure.
**15. Zone Factor (Z):** It is a factor to obtain the design spectrum depending on the perceived maximum seismic risk characterized by Maximum Considered Earthquake (MCE) in the zone in which the structure is located. The basic zone factors included in this standard are reasonable estimate of effective peak ground acceleration.



## 2. DESCRIPTION OF ANALYZING MODELS

*2.1 Modeling*

A commercial office building of 33 storeys with precast hollow core slabs of plan dimension 24mx18m is considered for analysis. Height of each storey is 3m and total height of the building is 99m. Structural system used for these building is taken as concrete special moment-resisting frame with ductile shear walls and type-II medium soil has been considered.

*2.2 preliminary data*

Plan of the building are shown in figure 2.1. Five models of hollow core slab buildings of different member sizes have been analyzed. For all models beam dimensions have been assumed as 230x260mm, 300x600mm, 300x750mm, and hollow core slab thickness have been assumed as 260mm and column dimensions and shear wall thickness have been shown in table 2.1.

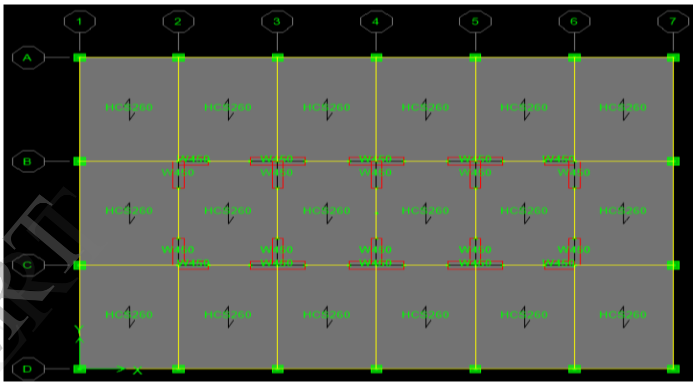

Figure 2.1-Plan of the commercial office building with precast hollow core slabs

Table 2.1: Schedule of Member Sizes

| Name | Column Dimensions | | | Shear Wall Thickness | |
|---|---|---|---|---|---|
| | Storey 1-10 | Storey 11-20 | Storey 21-33 | Storey 1-10 | Storey 11-33 |
| | C1 | C2 | C3 | Sw1 | Sw2 |
| Model 1 | 450x900 | 450x750 | 450x600 | 400 | 300 |
| Model 2 | 450x1000 | 450x750 | 450x600 | 400 | 300 |
| Model 3 | 600x1200 | 400x800 | 300x600 | 400 | 300 |
| Model 4 | 600x900 | 450x750 | 300x600 | 500 | 450 |
| Model 5 | 450x1200 | 450x750 | 450x600 | 500 | 450 |

Note: All dimensions are in mm.

Model 1-Column dimensions and shear wall thickness have been changed.
Model 2-Column dimensions have been changed.
Model 3-Column dimension have been changed and shear wall length has been increased.
Model 4-Column dimensions and shear wall thickness have been changed.
Model 5-Column dimensions have been changed.

**2.3 Material properties**

The strength of a structure depends on the strength of the materials from which it is made for this purpose material strength is specified in standardized ways as a step to proceed the design of a structure.

**2.3.1 Analysis property data**

Material name - Concrete

Grade of concrete-M25 has been considered for beams and slabs.

Grade of concrete-M40 has been considered for columns and shear walls.

Type of material - Isotropic

Mass per unit volume-2.4 kN/m$^3$

Modulus of elasticity-25 kN/mm$^2$

Poisson's ratio- 0.2

**2.3.2 Design property data**

Concrete cube compressive strength for M25 grade of concrete, fck-25 N/mm$^2$

Concrete cube compressive strength for M40 grade of concrete, fck-40 N/mm$^2$

Bending reinforcement yield stress for steel reinforcement, fy 415 N/mm$^2$

These are the material properties which have been considered for all the models.

**2.4 Load considerations**

Dead load, live load and earthquake load are considered in the design as per Indian standard codes.

Table 2.2 represents dead load and live load data considered for analysis.

Table 2.2: Dead load and live load data

| | |
|---|---|
| Wall load | 12kN/m$^2$ |
| Super imposed dead load | 2.5 kN/m$^2$ |
| Super imposed live load | 4 kN/m$^2$ |

Table 2.3 represents earthquake load data for seismic zone-IV considered for analysis of five models.

Table 2.3: Earthquake load data

| | |
|---|---|
| Seismic zone | Zone –IV |
| Soil type | Medium(Type-2) |
| Each storey height | 3m |
| Zone factor, Z | 0.24 |
| Importance factor, I | 1.0 |
| Response reduction factor, R | 5.0 |
| Analysis type | Dynamic analysis |

**2.5 Methods of static analysis**

The method of static analysis used here is equivalent static method.

**2.5.1 Equivalent static analysis**

All design against earthquake effects must consider the dynamic nature of the load. However, for simple regular structures, analysis by equivalent linear static methods is often sufficient. This is permitted in most codes of practice for regular, low to medium-rise buildings and begins with an estimate of peak earthquake load calculated as a function of the parameters given in the code. Equivalent static analysis can therefore work well for low to medium-rise buildings without significant coupled lateral-torsion modes, in which only the first mode in each direction is of significance. Tall buildings (say, over, 75 m), where second and higher modes can be important, or buildings with torsion effects, are much less suitable for the method, and require more complex methods to be used in these circumstances.

**2.5.2 Manual equivalent static analysis design procedure as per IS 1893(PART 1):2002**

The total design lateral force or design base shear along any principal direction is given in terms of design horizontal seismic coefficient and seismic weight of the structure. Design horizontal seismic coefficient depends on the zone factor of the site, importance factor of the structure, response reduction factor of the lateral load resisting elements and the fundamental period of the structure. The procedure generally used for the equivalent static analysis is explained below:

**1. Determination of fundamental natural period (Ta) of the buildings.**

For moment resisting RC frame building without brick infill wall.

$$T_a = 0.075h^{0.75}$$

For moment resisting steel frame building without brick infill wall.

$$T_a = 0.085h^{0.75}$$

For all other buildings including moment resisting RC frame building with brick infill walls.

$$T_a = 0.09h/\sqrt{d}$$

Where,

h- The height of building in m.

d- The base dimension of building at plinth level in m, along the considered direction of lateral force.

**2. Determination of base shear ($V_B$) of the building.**

$$V_B = A_h \times W$$

Where,

$$A_h = \frac{Z}{2}\frac{I}{R}\frac{Sa}{g}$$

$A_h$ = Design horizontal seismic coefficient.

Z = Zone factor.

I = Importance factor.

R = Response reduction factor.

Sa/g = Average response acceleration coefficients.

Sa/g in turn depends on the nature of foundation soil (rock, medium or soft soil sites), natural period and the damping of the structure.

**3. Distribution of design base shear.**

The design base shear $V_B$ thus obtained shall be distributed along the height of the building as per the following expression:

$$Q_i = V_B \frac{W_i h_i^2}{\sum_{i=1}^{n} W_i h_i^2}$$

Where,
$Q_i$ = The design lateral force.
$W_i$ = The seismic weight.
$h_i$ = The height of the $i^{th}$ floor measured from base.
n = The number of stories in the building.

### 2.6 Methods of dynamic analysis

IS: 1893(Part 1):2002 presents two methods of dynamic analysis. They are:

1. Time-history analysis.
2. Response spectrum analysis.

Out of these two methods, response spectrum analysis is more convenient than time history analysis.

### 2.6.1 Response spectrum analysis

A response spectrum is the graphic representation of maximum response i.e. displacements, velocity and acceleration of a damped single-degree-of-freedom system to a specified ground motion, plotted against the frequency or modal periods.

Five models of different member sizes have been done considering above member sizes, material properties, and load Consideration and they have been analyzed for seismic zone IV. By considering gravity loads such as dead load, live load data shown in table 2.2 static analysis has been carried out by equivalent Static method and by considering earthquake load data shown in table 2.3 dynamic analysis has been carried out by response spectrum method as per recommendation of IS 1893(Part 1):2002.The results of base shear, time period and storey drift have been collected and compared with different models.

### 2.7 Comparision of hollow core slab building with solid slab building for different seismic zones

By varying member sizes seismic analysis have been carried out by response spectrum method on Model 1, Model 2, Model 3, Model 4, and Model 5.Thus based on analysis results it can be concluded that Model 5 member size perform better when compared to other 4 Models member sizes.

A 33 storey commercial office building of plan dimension 24mx18m is considered for analysis. Keeping the Model 5 member size constant, different hollow core slab buildings and solid slab buildings have been performed for seismic zone II, seismic zone III, seismic zone IV and seismic zone V. Table 2.4 represent schedule of member sizes for hollow core slab buildings and solid slab buildings. Structural system used for these building is taken as concrete special moment-resisting frame with ductile shear walls and type-II medium soil is considered.

By considering gravity loads such as dead load, live load data shown in table 2.2 static analysis has been carried out by equivalent static method and by considering earthquake load data for different seismic zones shown in table 2.5. Dynamic analysis has been carried out by response spectrum method as per recommendation of IS 1893(Part 1):2002.The results of base shear and maximum storey drift have been collected and compared with different models.

**Table 2.4: Schedule of member sizes**

| Name | | Type of buildings | | | |
|---|---|---|---|---|---|
| | | Hollow core slab building | | Solid Slab building | |
| Beam Dimensions | | B1 | 230 x 260 | B1 | 230 x 600 |
| | | B2 | 300 x 600 | B2 | 300 x 600 |
| | | B3 | 300 x 750 | B3 | 300 x 750 |
| Column Dimensions | Storey 1-10 | C1 | 450x 1200 | C1 | 450 x 1200 |
| | Storey 11-20 | C2 | 450 x 750 | C2 | 450 x 750 |
| | Storey 21-33 | C3 | 450 x 600 | C3 | 450 x 600 |
| Slab Thickness | | | 260 | | 150 |
| Shear Wall Thickness | Storey 1-10 | SW1 | 500 | SW1 | 500 |
| | Storey 11-33 | SW2 | 450 | SW2 | 450 |

Note: All dimensions are in mm.

Table 2.5: Shows earthquake load data for different seismic zone

| Type of buildings | Type of model | Seismic zone | Zone factor, Z | Importance factor, I | Response reduction factor, R |
|---|---|---|---|---|---|
| Hollow core slab buildings | Model A | Zone –II | 0.10 | 1.0 | 5.0 |
| | Model B | Zone –III | 0.16 | 1.0 | 5.0 |
| | Model C | Zone –IV | 0.24 | 1.0 | 5.0 |
| | Model D | Zone –V | 0.36 | 1.0 | 5.0 |
| Solid slab buildings | Model A1 | Zone –II | 0.10 | 1.0 | 5.0 |
| | Model B1 | Zone –III | 0.16 | 1.0 | 5.0 |
| | Model C1 | Zone –IV | 0.24 | 1.0 | 5.0 |
| | Model D1 | Zone -V | 0.36 | 1.0 | 5.0 |

### 2.8 Comparision of total quantity of concrete and total quantity of steel in hollow core slab building and solid slab building

Model C hollow core slab building and Model C1 solid slab building have been considered for the determination of total quantity of concrete and total quantity of steel. Model C hollow core slab building and Model C1 solid slab building have been analyzed and designed for seismic zone IV. Design details such as longitudinal reinforcement details and shear reinforcement details of Model C and Model C1 have been collected. Detail calculation of quantity of steel and quantity of concrete have been done in excel sheet and the total quantity have been compared by graphical representation.

## 3. RESULTS AND DISCUSSIONS

The results of each building models have been presented. The analysis carried out is static analysis by equivalent static method and dynamic analysis by response spectrum method.

The result of Base shear, storey drifts and time period for different models were presented. Comparision of hollow core slab building and solid slab building results have been presented. Comparision results of total quantity of concrete and total quantity of steel in hollow core slab building and solid slab building have been presented.

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### 3.1 Analysis results of five hollow core slab building models of different member sizes

The results of five models such as base shear, time period, and maximum storey drift are represented in table 3.1.

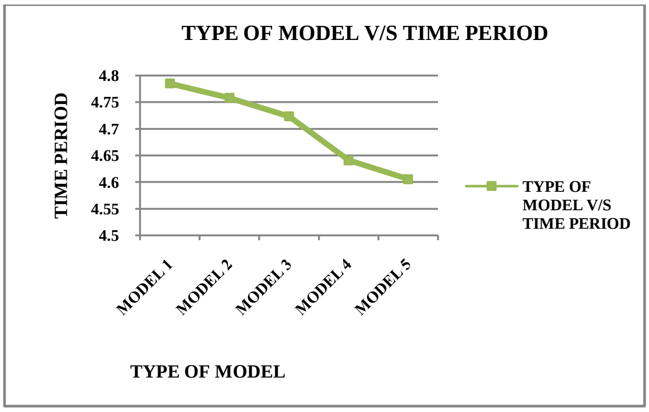
Table 3.1: Results of five hollow core slab building models of different member sizes

| Name | Base Shear,(kN) | | Time period, (Sec) | Max Storey Drift,(mm) | |
|---|---|---|---|---|---|
| | EQX | EQY | | Drift x | Drift y |
| Model 1 | 3664.12 | 3664.12 | 4.785067 | 0.000754 | 0.0022 |
| Model 2 | 3671.55 | 3671.55 | 4.757858 | 0.000745 | 0.002245 |
| Model 3 | 3709.72 | 3709.72 | 4.723347 | 0.000699 | 0.002239 |
| Model 4 | 3819.93 | 3819.93 | 4.64381 | 0.00068 | 0.002135 |
| Model 5 | 3839.71 | 3839.71 | 4.60538 | 0.000656 | 0.00207 |

Based on analysis results of five hollow core slab building models presented in table 3.1 graphs have been drawn as shown below.

### 3.1.1 Comparision of type of model v/s time period

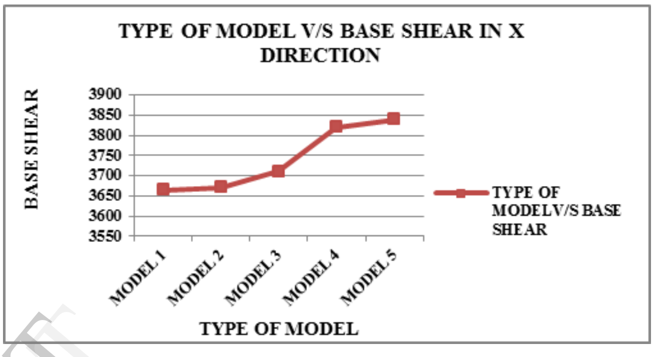
**Figure 3.1: Graph of type of model v/s time period**




The comparative study of maximum time period values for different type of models are represented in figure 3.1. In comparison of time period at different storey levels, it is observed that the time period are steadily increased i.e., minimum at top storey and maximum time period at bottom storey. The maximum time period value of Model (1) is 1.005 times greater than that of Model (2), 1.013 times greater than that of Model (3), 1.031 times greater than that of Model (4), 1.039 times greater than that of Model (5) at storey 1.Thus maximum time period in building have been steadily decreased as the member size increases.

### 3.1.2 Comparision of type of model v/s base shear in x direction

**Figure 3.2: Graph of type of model v/s base shear in x direction**

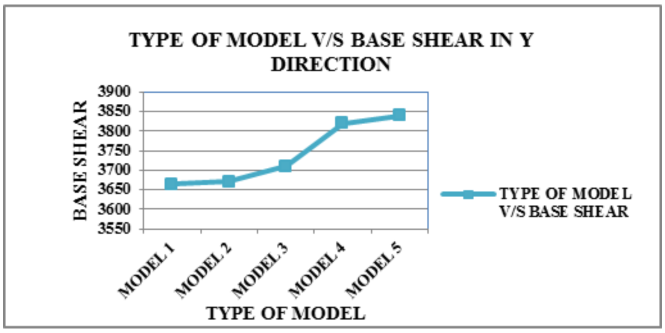





The comparative study of base shear values in x direction for different type of models are represented in figure 3.2.The base shear values of Model (1) is 1.002 times less than that of Model (2), 1.012 times less than that of Model (3), 1.042 times less than that of Model (4), 1.047 times less than that of Model (5) in x direction. Thus base shear in building steadily increased as the member size increases.

### 3.1.3 Comparision of type of model v/s base shear in y direction

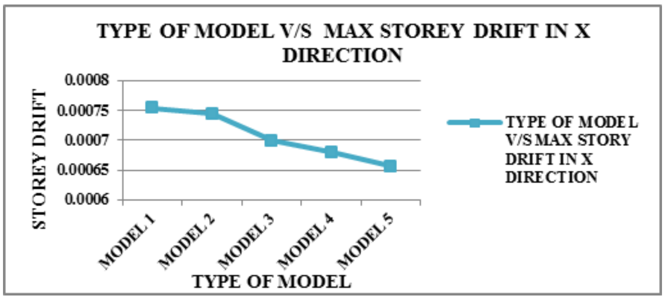
**Figure 3.3: Graph of type of model v/s base shear in y direction**




The comparative study of base shear values in y direction for different type of models are represented in figure 3.3. The base shear value of Model (1) is 1.002 times less than that of Model (2), 1.012 times less than that of Model (3), 1.042 times less than that of Model (4),1.047 times less than that of Model (5) in y direction. Thus base shear in structure will be steadily increased as the member size increases.

### 3.1.4 Comparision of type of model v/s max storey drift in x direction

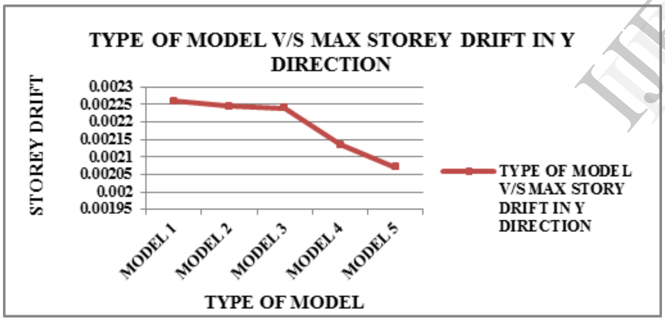
Figure 3.4: Graph of type of model v/s max storey drift in x direction




The comparative study of maximum storey drift values in x directions for five different models is represented in figure 3.4.The maximum storey drift value of Model (1) is 1.012 times greater than that of Model (2), 1.072 times greater than that of Model (3), 1.078 times greater than that of Model (4),1.108 times greater than that of Model (5).Thus maximum storey drift will decreases as the member size increases and storey drift values of all models lies within the limits as per IS:1893(Part 1):2002 (clause-7.11.1).

### 3.1.5 Comparision of type of model v/s max storey drift in y direction

Figure 3.5: Graph of type of model v/s max storey drift in y direction




The comparative study of maximum storey drift values in y direction for five different models is represented in figure 3.5. The maximum storey drift value of Model (1) is 1.006 times greater than that of Model (2), 1.009 times greater than that of Model (3), 1.058 times greater than that of Model (4), 1.091 times greater than that of Model (5) in y direction. Thus maximum storey drift will decreases as the member size increases and storey drift values of all models lies within the limits as per IS:1893(Part 1):2002 (clause-7.11.1).

### 3.2 Comparision of hollow core slab building with solid slab building for different seismic zones

Analysis results of hollow core slab building and solid slab building for different seismic zones are shown in table 3.2 and 3.3. The results of models such as base shear and maximum storey drift are given below.

**Table 3.2: Represents results of hollow core slab building for different seismic zones**

| Seismic Zone | Name | Base Shear,(kN) | | Max Storey Drift,(mm) | |
|---|---|---|---|---|---|
| | | EQX | EQY | Drift X | Drift Y |
| Zone II | Model A | 1599.88 | 1599.88 | 0.000273 | 0.000862 |
| Zone III | Model B | 2559.80 | 2559.80 | 0.000437 | 0.001380 |
| Zone IV | Model C | 3839.71 | 3839.71 | 0.000656 | 0.002070 |
| Zone V | Model D | 5759.56 | 5759.56 | 0.000984 | 0.003105 |

Table 3.3: Represents results of solid slab building for different seismic zones

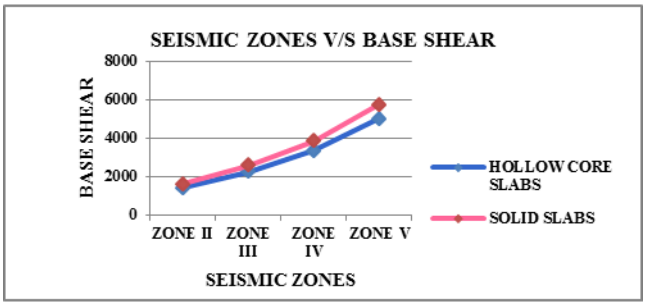
| Seismic Zone | Name | Base Shear,(kN) | | Max Storey Drift,(mm) | |
|---|---|---|---|---|---|
| | | EQX | EQY | Drift X | Drift Y |
| Zone II | Model A1 | 1394.19 | 1394.19 | 0.000238 | 0.000750 |
| Zone III | Model B1 | 2230.71 | 2230.71 | 0.000381 | 0.001201 |
| Zone IV | Model C1 | 3346.06 | 3346.06 | 0.000571 | 0.001801 |
| Zone V | Model D1 | 5019.10 | 5019.10 | 0.000856 | 0.002702 |

Based on analysis result values presented in table 3.2 and table 3.3 graphs have been represented as shown below. Base shear, maximum storey drift have been compared for different zones between hollow core building and solid slab building.



### 3.2.1 Comparision of seismic zone v/s base shear for hollow core slab building and solid slab building

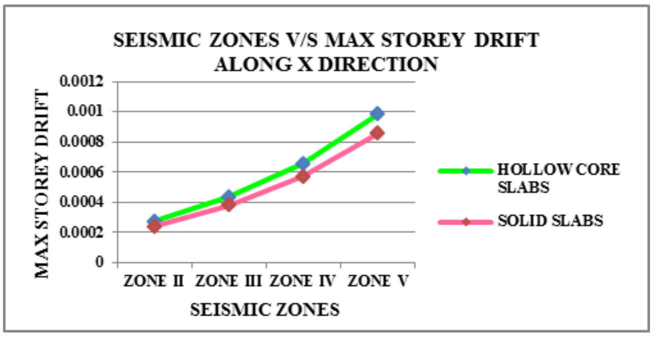
**Figure 3.6: Graph of seismic zones v/s base shear**




The comparative study of base shear values for different seismic zones is represented in figure 3.6. In comparision of base shear values for different seismic zones, base shear value are increased steadily and maximum base shear are found in seismic zone V. The base shear values of hollow core slab building in seismic zone II, zone III, zone IV and zone V is 1.147 times less than that of solid slab building in seismic zone II, zone III, zone IV, and zone V. Thus hollow core slab building produce less base shear compared to solid slab building.

### 3.2.2 Comparision of seismic zone v/s max storey drift along x direction for hollow core slab building and solid slab building

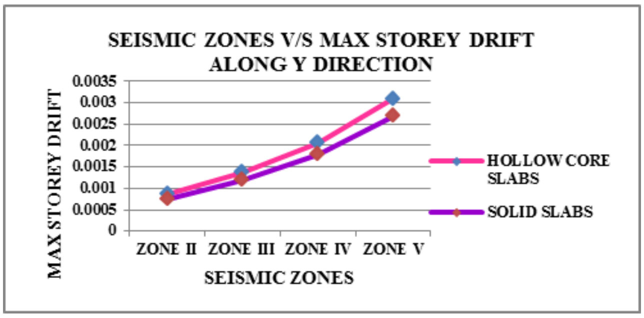
Figure 3.7: Graph of seismic zones v/s maximum storey drift along x direction




The comparative study of max storey drift values in x direction for different seismic zones is represented in figure 3.7. In comparision of max storey drift values for different seismic zones, storey drift value are increased steadily and maximum storey drift are found in seismic zone V. The maximum storey drift values of hollow core slab building in seismic zone II is 1.1470 times greater than that of solid slab building in seismic zone II, 1.1469 times greater than that of solid slab building in seismic zone III, 1.1488 times greater than that of solid slab building in seismic zone IV, 1.1495 times greater than that of solid slab building in seismic zone V. Thus hollow core slab building produce greater storey drift values in x direction compared to solid slab building.

### 3.2.3 Comparision of seismic zone v/s max storey drift along y direction for hollow core slab building and solid slab building

Figure 3.8: Graph of seismic zones v/s max storey drift along y direction




The comparative study of max storey drift values in y direction for different seismic zones is represented in figure 3.8. In comparision of max storey drift values for different seismic zones, storey drift value are increased steadily and maximum storey drift are found in seismic zone V. The maximum storey drift values of hollow core slab building in seismic zone II is 1.1490 times greater than that of solid slab building in seismic zone II, 1.1490 times greater than that of solid slab building in seismic zone III, 1.1493 times greater than that of solid slab building in seismic zone IV, 1.1491 times greater than that of solid slab building in seismic zone V. Thus hollow core slab building produce greater storey drift values in y direction compared to solid slab building.

### 3.3 Comparision of total quantity of concrete and total quantity of steel in hollow core slab building and solid slab building

Model C hollow core slab building and Model C1 solid slab building design details such as longitudinal reinforcement details and shear reinforcement details of beams, columns and slabs have been collected. Detail calculation of quantity of steel and quantity of concrete of all storeys have been done in excel sheet and the results of total quantity of steel and total quantity of concrete for beams, columns, slabs in solid slab building and in hollow core slab building are represented in table 3.4.

**Table 3.4: Total Quantity of concrete and steel in Hollow core Slab building and Solid Slab building**

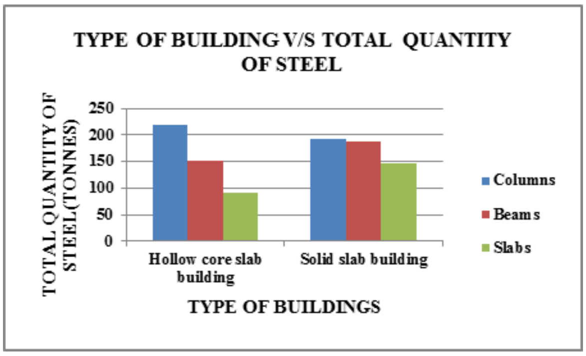
| Sl. No. | Hollow core Slab building | | Solid Slab building | |
|---|---|---|---|---|
| | Total Quantity of Concrete, ($m^3$) | Total Quantity of Steel, (Tonnes) | Total Quantity of Concrete, ($m^3$) | Total Quantity of steel, (Tonnes) |
| Beams | 976.734 | 151.403 | 1131.57 | 187.461 |
| Columns | 2204.265 | 217.776 | 2204.265 | 191.109 |
| Slabs | 1612.05 | 91.424 | 2138.40 | 146.239 |
| Total | 4793.30 | 460.603 | 5474.23 | 524.809 |



Total quantity of concrete and total quantity of steel in hollow core slab building and solid slab building have been compared in graph as shown below based on results presented in table 3.4.

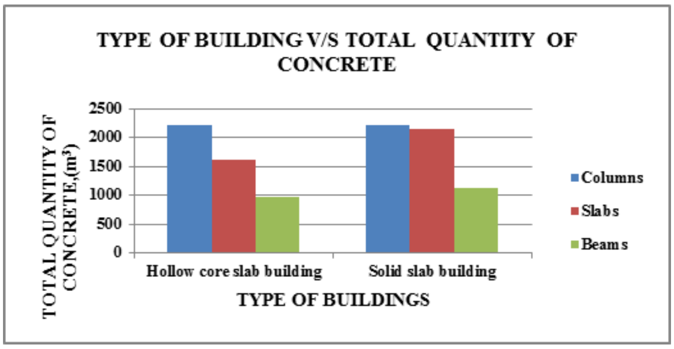
### 3.3.1 Comparision of type of buildings v/s total quantity of steel

**Figure 3.9: Graph of type of building v/s total quantity of steel**



### 3.3.2 Comparision of type of buildings v/s total quantity of concrete

Figure 3.10: Graph of type of building v/s total quantity of concrete




The comparative study of total quantity of concrete and total quantity of steel for different type of building are represented in figure 3.9 and 3.10. Hollow core slab building consume less material when compared to solid slab building because of the presence of longitudinal voids in the cross section of hollow core slabs leads to saving in concrete as compared to solid slabs and at the same time cuts the amount of prestressing steel because of lower self-weight. Therefore hollow core slab building is best compared to solid slab building.

## 4. CONCLUSION

The thesis attempts to study the behaviour of precast hollow core slabs in high rise buildings.Five models of hollow core slab buildings of different member sizes is analyzed using equivalent static method and Response spectrum method for seismic zone IV. From the above analysis results following conclusions can be made in this respect:

- Maximum storey drift, storey drifts in X and Y direction of model 5 is less than that of other four models.
- Time period of model 5 is less than that of other four models.
- Storey shear in X and Y direction of model 5 is greater than that of model 1, 2, 3, 4.

From the above study it has been conclude that model 5 shows better performance when compared to other models.

Keeping model 5 member size constant Hollow core slab building and solid slab building have been performed for different seismic zones and it has been analyzed using equivalent static method and Response spectrum method according to code provisions, considering the effect of base shear, storey drift the results obtained by hollow core slab building and solid slab building for different seismic zone has been compared. Following broad conclusions can be made in this respect:

- Base shear is less for hollow core slab building compared to solid slab building for different seismic zones.
- Storey drift is higher for hollow core slab building as compared solid slab building.
- Thus hollow core slab building consumes less material when compared to solid slab building. Therefore hollow core slab building is best compared to solid slab building.

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