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# SEISMIC ANALYSIS AND DESIGN OF RESIDENTIAL BUILDING

**Eraboina Lalitha,**
Course:M.Tech ,
AVN Institute of Engineering &Technology
Mail: eraboinalalithace@gmail.com,

**Dr. MD.Subhan M.Tech,**
PhD professor & HOD ,
Civil Engineering Dept,
AVN Institute of Engineering &Technology

## ABSTRACT:

*Structural designing requires structural analysis and earthquake or seismic analysis of any structure prior to construction. Earthquake or seismic analysis is the calculation of the response of a structure subjected to earthquake excitation. Various seismic data are necessary to carry out the seismic analysis of the structures in this study the seismic response of the structures is investigated under earthquake excitation expressed in the form of member forces, joint displacement, support reaction and story drift. The response is investigated for g+7 building structures by using STAAD PRO designing software. We observed the response reduction of cases ordinary moment resisting frame. In this case we have taken earthquake zone 2, response factor 3 for ordinary moment resisting frame and importance factor 1.*

*Initially we started with the designing of simple 2dimensional frames and manually checked the accuracy of the software with our results. Then according to the specified criteria assigned it analyses the structure and designs the members with reinforcement details for G+7 residential building RCC frames. The minimum requirements pertaining(Be appropriate) to the structural safety of buildings are being covered by way of laying down minimum design loads which have to be assumed for dead loads, imposed loads, and other external loads.*

*In order to be able to prevent or to minimize occurrence of cracks, it is necessary to understand basic causes of cracking and to have knowledge about certain properties of building materials, specification for mortar and concrete, Architectural design of building, structural design, foundation design, construction practices & techniques and environments.*

***Keywords:*** *seismic analysis, earthquake excitation, ordinary moment resisting frame, member forces, joint displacement, support reaction, storey drift, STAAD PRO V8i.*

## 1.0 INTRODUCTION:

The earthquake causes vibratory ground motions at the base of the structure, and the structure actively responds to these motions. For the structure responding to a moving base, there is an equivalent system. The base is fixed and the structure is acted upon by forces that cause the same distributions that occur in the moving – base system. In design system it is customary to assume the structure as a fixed base system acted upon by inertia forces. Seismic design involves two distinct steps:

a) Determining or estimating the structure forces that will act on the structure
b) Designing the structure to provide adequate strength, stiffness, and energy dissipation capabilities to with stand these forces.

## BEHAVIOR OF THE STRUCTURE

The Building and other structure are composed of horizontal and vertical structural elements that resist lateral forces. The horizontal elements, diaphragms and horizontal bracings are used to distribute the lateral forces to vertical elements. The vertical elements that are used to transfer lateral forces to the ground are shear wall, braced frames and moment resisting frames. The structure must include complete lateral and vertical force resisting systems, capable of providing adequate energy dissipation capacity to withstand the design ground motions within the prescribed limits, deformations and strength demand.

**Motivation**

Day to day variations in the designing of the structures we were motivated to deal with this project. As civil engineering is much concerned with different designs to meet the necessity of human life we took this project.

**Problem definition**

As the land is con sized to meet the demands of all the growing population the adoption of multi storied had grown up to meet their demands. As it is cost effective. Many of Rc building constructed recent times have special feature of the ground is left open for the purpose of parking, i.e. columns in the ground story do not have any partition walls of either masonry or RC between them.

**OBJECTIVES OF PROJECT:**

Carrying out a complete design of the main structural elements of a multi – storied building including slabs, beams, columns and footing .Getting real life experience with the engineering practices.

Structure should be so arranged that it can transmit dead, wind and imposed loads in a direct manner to the foundations. The general arrangement should ensure a robust and stable structure that will not collapse progressively under the effects of misuse or accidental damage to any one element.

**Limitations of project**

- Depending on the site area the number of floors is limited.
- Designing is completely based on IRC codes.
- Once the structure is designed completely minor changes are accepted in site with cost consideration.

If once the structure is designed for one purpose it cannot be used for other purpose if the load acting on it is increased than the designed.

**Design strength**

| s. no. | Type of stress | Design strength in N/mm$^2$ |
|---|---|---|
| 1 | Design strength in tension and bending compression | o.87$f_y$ |
| 2 | Design strength in axial compression | o.67$f_y$ |

**Modulus of elasticity of steel**

The module of elasticity of steel of all grades is taken as 2 x $10^5$ N/mm$^2$ (200KN/mm$^2$).

**Unit weight of steel**

The unit weight of steel is 78.5 KN/m$^3$ (7850 kg/m$^3$). A quicker method to find the weight of bar of circular section is given by the following equation.

Weight of bar in kg/m = $Ø^2$ /162.2

Where Ø = diameter of the bar in mm.

**2.0.LITERATURE REVIEW:**

**Chandurkar, Pajgade (2013)** evaluated the response of a 10 storey building with seismic shear wall using Staad Pro V8i Main focus was to compare the change in response by changing the location of shear wall in the multi-storey building. Four models were studied- one being a bare frame structural system and rest three were of dual type structural system. The results were excellent for shear wall in short span at corners. Larger dimension of shear wall was found to be ineffective in 10 or below 10 stories. Shear wall is an effective and economical option for high-rise structures. It was observed that changing positions of shear wall was found to attract forces, hence proper positioning of shear wall is vital. Major amount of horizontal forces were taken by shear wall when the dimension is large. It was also observed that shear walls at substantial locations reduced displacements due to earthquake.

**Viswanath K.G (2010)** investigated the seismic performance of reinforced concrete buildings using concentric steel bracing. Analysis of a four, eight, twelve and sixteen storied building in seismic zone IV was done using Staad Pro software, as per IS 1893: 2002 (Part-I). The bracing was provided for peripheral columns, and the effectiveness of steel bracing distribution along the height of the building, on the seismic performance of the building was studied. It was found that lateral displacements of the buildings reduced after using X-type bracings. Steel bracings were found to reduce flexure and shear demand on the beams and columns and transfer lateral load by axial load mechanism. Building frames with X- type bracing were found to have minimum bending as compared to other types of bracing. Steel bracing system was found to be a better alternative for seismic retrofitting as they do not increase the total weight of the building significantly.

**Chavan, Jadhav (2014)** studied seismic analysis of reinforced concrete with different bracing arrangements by equivalent static method using Staad Pro. Software. The arrangements considered were diagonal, V-type, inverted V-type and X-type. It was observed that lateral displacement reduced by 50% to 60% and maximum displacement reduced by using X-type bracing. Base shear of the building was also found to increase from the bare frame, by use of X-type bracing, indicating increase in stiffness.

**Esmaili et al. (2008)** studied the structural aspect of a 56 stories high tower, located in a high seismic zone in Tehran. Seismic evaluation of the building was done by non-linear dynamic analysis. The existing building had main walls and its side walls as shear walls, connected to the main wall by coupling of beams. The conclusion was to consider the time-dependency of concrete. Steel bracing system should be provided for energy absorption for ductility, but axial load can have adverse effect on their performance. It is both conceptually and economically unacceptable to use shear wall as both gravity and bracing system. Confinement of concrete in shear walls is good option for providing ductility and stability.

**Akbari et al. (2015)** assessed seismic vulnerability of steel X-braced and chevron-braced Reinforced Concrete by developing analytical fragility curve. Investigation of various parameters like height of the frame, the p-delta effect and the fraction of base shear for the bracing system was done. For a specific designed base shear, steel-braced RC dual systems have low damage probability and larger capacity than unbraced system. Combination of stronger bracing and weaker frame reduces the damage probability on the entire system. Irrespective of height of the frame, Chevron braces are more effective than X-type bracing. In case of X-type bracing system, it is better to distribute base shear evenly between the braces and the RC frame, whereas in case of Chevron braced system it is appropriate to allocate higher value of share of base shear to the braces. Including p-delta effect increases damage probability by 20% for shorter dual system and by 100% for taller dual systems. The p-delta effect is more dominant for smaller PGA values.

**Kappos, Manafpour (2000)** presented new methodology for seismic design of RC building based on feasible partial inelastic model of the structure and performance criteria for two distinct limit states. The procedure is developed in a format that can be incorporated in design codes like Eurocode 8. Time-History (Non-linear dynamic) analysis and Pushover analysis (Non-linear Static analysis) were explored. The adopted method showed better seismic performance than standard code procedure; at least in case of regular RC frame building. It was found that behaviour under "life-safety" was easier to control than under serviceability earthquake because of the adoption of performance criteria involving ductility requirements of members for "life-safety" earthquake.

**MATERIAL USED IN CONSTRUCTION**

Following are the materials used for the construction of a building.

- Bricks.
- Sand.
- Cement.
- Stone.
- Coarse aggregate.
- Fine aggregate.
- Timber.
- Metal.
- Floor tiles.
- Roof tiles.
- Reinforcement.
- Plastic materials.
- Doors & windows.
- Asphalt bitumen.
- Coloring material.
- White cement.
- Paints & varnishes.
- Brick ballast.
- Sanitary materials.
- Water.

**3.0ANALYSIS OF G+7 BUILDING**

**Dynamic Analysis**

Dynamic analysis is performed to obtain the design seismic force, and its distribution to different levels along the height of the building and to the various lateral load resisting elements, for the following buildings

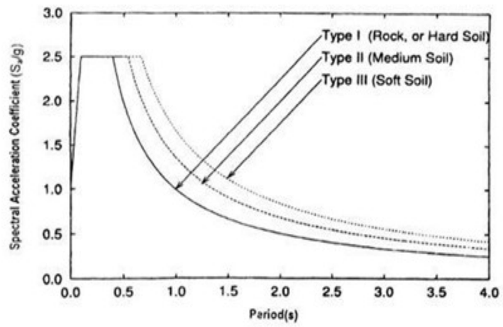


**Fig. 3.0 Response Spectra for rock and soil sites for 5% damping**

**STATEMENT OF THE PROJECT**

- Live Load: 2.0 KN/Sq.m
- Thickness of slab: 120 mm
- Location of the site: Hyderabad in Seismic Zone-II
- Type of Soil: Medium Soil, (Type-II as per IS: 1893 (Part-1))
- Allowable bearing pressure: 150 KN/Sq.m
- Each Storey Height: 3 m
- No of Floors: Ground+7
- External Wall Thickness: 230 mm
- Internal Wall Thickness: 120 mm
- Column Size: 300x420 mm
- Beam Size: 300x450 mm
- Wind Load: As per IS: 875-1987 (Part-3)
- Earthquake Load: As Per IS: 1893-2002 (Part-1)

**a) Load calculations**

**Self - weight of Slab load:**

Floor loads for 120mm thick slab

Thickness of slab -120mm

Unit weight of reinforced concrete - 25.00kn/m3

= 0.12 x 1x 25

= 3.0 KN/$m^2$

Dead load of slab = 3.0kn/$m^2$

Floor finishes = 1.50kn/ $m^2$

= 3.0 x 1. 5

= 4.5KN/$m^2$
Roof Finishing: 1.0 KN/Sq.m
**Total load of slab** = 8.5kn/ $m^2$
**Wall loads**
**External Wall**
230mm thick wall for 3.0 heights
Thickness of wall 'b' - 0.23m
Height of walls 'h' - 3.0mm
Unit weight of brick masonry γ - 19.2kN/m3
= 0.23 x 3.0 x 19.2
Total load h*b* γ = -13.248 kN/$m^3$
**Internal or Partition Walls**
150mm thick wall for height 3.0m
Thickness of wall 'b' - 0.12m
Height of walls 'h' - 3.0m
Unit weight of brick masonry 'γ' - 19.2kN/$m^3$
= 0.12 x 3.0 x 19.2
Total load h*b* γ = -6.912 kN/$m^3$
**Parapet & Balcony wall load**
Thickness of wall 'b' - 0.115m
Parapet wall 'h' - 1.00m
Unit weight of brick masonry 'γ' - 19.20kn/m3
= 0.115 x 1 x 19.2
Total load h*b* γ = 2.208 kn/$m^3$

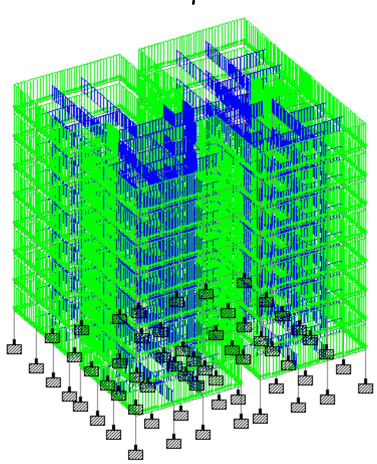

**Fig.3.4: Dead Load of G+7 Building**
Reinforcement cement concrete
Steel reinforcing bars shall be of mild steel or deformed steel of standard specifications and shall be free from corrosion, loose rust scales, oil, grease, paint etc
Centering and shuttering
Centering and shuttering shall be made with timber or steel plate close and tight to prevent leakage or mortar with necessary props, bracing and wedges, sufficiently strong and stable.

## 4.0 DESIGN OF SLABS

Slabs are plane members whose thickness is small as compared to its length and breadth. Slabs are most frequently used as roof coverings and floors in various shapes such as square, rectangle, circular, triangular etc in buildings. Slabs supports mainly transverse loads and transfers them to the supports by bending action in one or more directions. Beams or walls are the common supports for the slabs.

**Classification of slabs**:
Slabs are classified based on many aspects;
**Based on shape**:
Square, rectangular, polygonal, triangular etc
**Based on type of support**:
Slab supported on beams, slab supported on walls, slab supported on columns.
**Based on support or boundary conditions**:
Simply supported, cantilever, overhanging, fixed or continuous slab.
**Based on use:**
Roof slab, floor slab, water tank slab, foundation slab
**Basis of cross section or sectional configuration**:
Ribbed slab/grid slab, solid slab, filler slab, and folded slab.

**Fig.4.1: Grid slab (mostly used when load acting is more)**

**Table 4.1:Types of support (values)**

| Type of support | Fe-250 | Fe-415 |
|---|---|---|
| Simply supported | $\frac{1}{35}$ | $\frac{1}{28}$ |
| Continuous | $\frac{1}{40}$ | $\frac{1}{32}$ |

**Designing of continuous slab on site**

**Trail depth and effective span:**

Consider 1m width of slab and effective span shall be taken equal to c/c beams

Assume trail depth d=$\frac{l}{30}$, $\frac{3600}{30}$=120mm

OR

Assume $P_t$=0.3%, modification factor $k_1$=1.2

Basic ( $\frac{l}{d}$ ) ratio for continuous slab =26

Trail depth d= $\frac{3600}{26 X 1.2}$=115mm

However, assume total depth =150mm, dia of bar 10mm and nominal cover 15mm

Effective depth d=150-15-$\frac{10}{2}$=130mm

**Load on slab:**

Total dead load

Self -weight of slab=0.12x25=3.0KN/$m^2$

Floor finish=1KN/$m^2$

Partition load=1KN/$m^2$

Total=5.0 KN/$m^2$

Factored dead load $W_D$ =1.5x5.0=7.5KN/$m^2$

Factored live load $W_L$=1.5x3=4.5KN/$m^2$

**Bending moment**

The bending moments and shear forces are calculated at different sections using bending moment coefficients given in table 12 and 13 of IS 456-2000

B.M at any section $M_u=\alpha_d w_d l^2+\alpha_l w_l l^2$

B.M at middle of end span=15.15KN-m

B.M at middle of interior span=11.85KN-m

B.M at support next to end support=17.66KN-m

B.M at other intermediate support=15.8KN-m

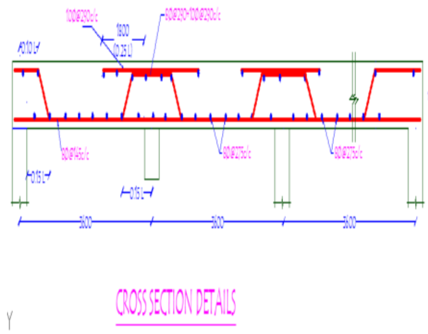


**Fig 4.2 Reinforcement detail of continuous one way slab**

**Assumptions:**

i. Plane sections normal to the axis remains plane after bending.
ii. The maximum strain in concrete at outermost compression fiber is taken as 0.0035 in bending regardless strength of concrete.
iii. The tensile strength of concrete is ignored.

## 5.0DESIGN & RESULTS

A vertical member whose effective length is greater than 3 times its least lateral dimension carrying compressive loads is called as column.

Fig.5.1:On site execution for column

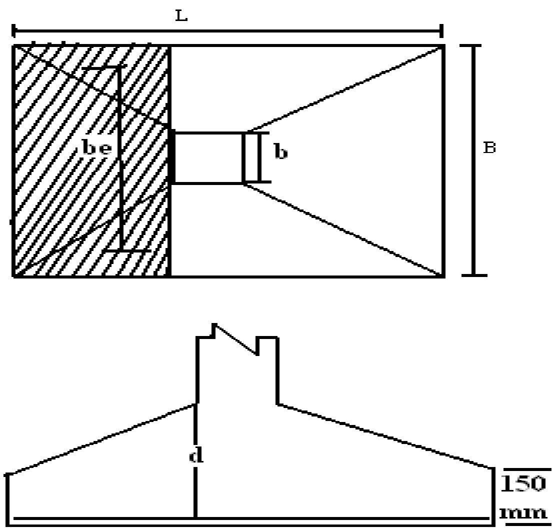


**Fig 5.20:Critical section for bending in sloped footing.**

**Fig.5.12:On site provision of mat.**

**Fig.5.21:On site fixing of Dowel bars.**

**Size of the footing:**

P=946KN

Self-weight of the footing =10% of column load

=946/10 = 94.6KN

Total load on the soil =1040.6KN

Area of footing = Total load/SBC = 4.387mm2

Provide 2.25 * 1.95 m footing

**Reinforcement along longer side:**

- $M_{uL} = 0.87f_y\, A_{st}\, d\, (1-((f_yA_{st})/(f_{ck}bd))$
- $A_{st}$= 1066.66$mm^2$
- Using 16mm diameter bars,
- $S = a_{st} * B/A_{st}$ =310mm
- Hence, provide 16mm bars at 300mm c/c in longer direction

## 6.0 CONCLUSIONS:

In the earthquake resistant design of G+7 RC framed building the steel quantity increased by 1.517% to the convention concrete design. The steel quantity increased in the structure ground floor to higher floor i.e G+7 level of the structure.

In this study of G+7 building, seismic load dominates the wind load under the seismic zone –II. Basically the wind pressure is high for high rise building based on weather conditions such as coastal areas, hillystations. For Building prominently seismic forces create the major cause of damage to the structure.

The Storey drift condition for considered G+7 building, the base drift=0.0 at every storey. This says that the structure is safe under drift condition. Hence shear walls, braced columns are not necessary to be provided. Hence storey drift condition is checked for the G+7 building.

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