Erudite Journal of Engineering Technology and Management Sciences

Vol. 4, No. 4, December 2024, pp. 14-20

Journal homepage: http://www.ejetms.com

Design and Analysis of Multi Storied G+2 Buildings using ETABS Software

Jajula Harideep[a], Jatavath Saicharan[a], Maragoni Manish[a], M. Anuradha[b]

[a] U.G. Student, Department of Civil Engineering, Guru Nanak Institutions Technical Campus, Ibrahimpatnam, Telangana, India.

[b] Assistant Professor, Department of Civil Engineering, Guru Nanak Institutions Technical Campus, Ibrahimpatnam, Telangana, India

https://doi.org/10.5281/zenodo.14288659

Received: 10 Octber 2024
Accepted: 05 December 2024

Keywords:
ETABS, Building, Analysis, Design.

ABSTRACT

Any building structure used by the industry to store raw materials or for manufacturing products of the industry is known as an industrial building. Industrial buildings may be categorized as Normal type industrial buildings and Special type industrial buildings. Normal types of industrial building are shed type buildings with simple roof structures on open frames. These buildings are used for workshop, warehouses etc. These building require large and clear areas unobstructed by the columns. The large floor area provides sufficient flexibility and facility for later change in the production layout without major building alterations. The industrial buildings are constructed with adequate headroom for the use of an overhead traveling crane. Special types of industrial buildings are steel mill buildings used for manufacture of heavy machines, production of power, shopping malls etc. The function of the industrial building dictates the degree of sophistication.

1. INTRODUCTION

Recently, most of the high-rise buildings may have basement used as parking lots or shopping malls etc. In general, it is commonly assumed that the building is fixed at the ground level in the analysis and the basement is not included in the analytical model. Using this assumption, the lateral stiffness of the structure may be overestimated since the flexibility introduced by the basement is ignored. Therefore, the natural periods may be shortened and the dynamic response of a building structure may be misestimated due to this inaccurate prediction of the lateral stiffness

In general, only gravity loads are considered in designing the basement structure without the effect of lateral forces as earthquake loads applied to the super structure such. But the seismic loads applied to the super structure will affect the member forces in the basement structure. The previous researches on buildings with basement were only focused on the dynamic behavior of a structure using a simplified model and could not cover the effect of seismic loads on basement structural members. The effect of the basement on the seismic response of high-rise buildings and the effect of the seismic loads on the member force of the basement were investigated in this study. Especially in seismic analysis of high-rise building structures with basement, it is of practical importance to obtain an accurate estimation of the high shear force acting on the basement structure. Therefore the shear force in the basement is carefully investigated in this study. And an efficient method is proposed for the analysis of high-rise buildings considering the effects of basement by using partial or full rigid diaphragm and matrix condensation procedure.

Earthquake has always been a threat to human civilization from the day of its existence, devastating human lives, property and man-made structures. The very recent earthquake that we faced in our neighboring country Indian has again shown nature’s fury, causing such a massive destruction to the country and its people. It is such an unpredictable calamity that it is very necessary for survival to ensure the strength of the structures against seismic forces. Therefore there is continuous research work going on around the globe, revolving around development of new and better techniques that can be incorporated in structures for better seismic performance. Obviously, buildings designed with special techniques to resist damages during seismic activity have much higher cost of construction than normal buildings, but for safety against failures under seismic forces it is a prerequisite.

Reinforced Concrete frames are the most common construction practices in India, with increasing numbers of high-rise structures adding up to the landscape. There are many important Indian cities that fall in highly active seismic zones. Such high-rise structures, constructed especially in highly prone seismic zones, should be analyzed and designed for ductility and should be designed with extra lateral stiffening system to improve their seismic performance and reduce damages. Two of the most commonly used lateral stiffening systems that can be used in buildings to keep the deflections under limits are bracing system and shear walls.

2. LITERATURE

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 et al. (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.

Yamada et al.(2002) studied, experimentally as well as analytically, deformation and fracture characteristics of lateral load resisting systems-shear wall for RC frame- and –steel bracing for steel multi-storey frame- under earthquake, considering models having 3 different spans and 3, 6 and 9 storeys. Deformations and facture results for all the three cases are compared and differences are clarified by normalization of proposed horizontal resisting ratios.

3. METHODOLOGY AND EXPERIMENTAL RESULT

To achieve the objectives about this study that is to analyze and design commercial building using ETABS and by manual method, which meets the basic requirements such as safety, durability, economy, aesthetic appearance, feasibility, practicability and acceptability. It have been proposed to follow the following methodology.

- Site survey
- Soil investigation
- Structural planning
- Analysis and design in ETABS
- Verification by manual method
- Detailing

Surveying is a basic tool for a Civil engineering science. Before any civil engineering work has to start, surveying has to be done and then the we must prepare a plan of this area showing topographical details related to the design of structure etc. Good planning and management of a geotechnical site investigation is the key to obtaining sufficient site information for designing a structure in a timely manner and with minimum cost for the effort needed. The engineering properties of soil like water content, density and SBC are calculated by conducting tests in laboratory. The structural plan is prepared using auto cad.

3.1. Methodology Adopted:

As discussed in the scope of the work, the entire work is divided into three parts:

- Analysis of bare frame in all the above three mentioned ground motions
- Analysis of the braced frames.
- Analysis of the frame with shear wall

For analysis a 12 stories high building is modeled in Staad Pro as a space frame. The building is does not represent any real existing building. The building is unsymmetrical with the span more along Z direction than along X direction. The building rises up to 42m along Y direction and spans 15m along X direction and 20 m along Z direction.

3.2. Data Collection:

The present study is to analyze and design a g+3 storey commercial building of 6336.6976sq.ft floor area located at nalgonda (2km from jm gouds complex, dvk road).

3.3. Seismic Design Force

Earthquake shaking is random and time variant. But, most design codes represent the earthquake-induced inertia forces as the net effect of such random shaking in the form of design equivalent static lateral force. This force is called as the Seismic Design Base Shear VB and remains the primary quantity involved in force-based earthquake-resistant design of buildings. This force depends on the seismic hazard at the site of the building represented by the Seismic Zone Factor Z. Also, in keeping with the philosophy of increasing design forces to increase the elastic range of the building and thereby reduce the damage in it, codes tend to adopt the Importance Factor I for effecting such decisions (Figure 1.12). Further, the net shaking of a building is a combined effect of the energy carried by the earthquake at different frequencies and the natural periods of the building. Codes reflect this by the introduction of a Structural Flexibility Factor Sa/g. Finally, asdiscussed in section 1.2 of Chapter 1, to make normal buildings economical, design codes allow some damage for reducing cost of construction. This philosophy is introduced with the help of Response Reduction Factor R, which is larger for ductile buildings and smaller for brittle ones. Each of these factors is discussed in this and subsequent chapters. In view of the uncertainties involved in parameters, like Z and Sa/g, the upper limit of the imposed deformation demand on the building is not known as a deterministic upper bound value. Thus, design of earthquake effects is not termed as earthquake-proof design. Instead, the earthquake demand is estimated only based on concepts of probability of exceedance, and the design of earthquake effects is termed as earthquake-resistantdesignagainst the probable value of the demand.

As per the Indian Seismic Code IS: 1893 (Part 1) - 2007, Design Base Shear VB is given by:

$$V_B = A_h W = \frac{ZI}{2R}\left(\frac{S_a}{g}\right)W, \qquad (2.1)$$

where *Z* is the *Seismic Zone Factor* (Table 2.1), *I* the *Importance Factor* (Table 2.2), *R* the *Response Reduction Factor* (Table 2.3), and S_a/g the *Design Acceleration Spectrum Value* (Figure 2.2) given by:

$$\frac{S_a}{g} = \begin{cases} \begin{cases} 2.5 & 0.00 < T < 0.40 \\ \frac{1.00}{T} & 0.40 < T < 4.00 \end{cases} & \text{for Soil Type I : rocky or hard soil sites} \\ \begin{cases} 2.5 & 0.00 < T < 0.55 \\ \frac{1.36}{T} & 0.55 < T < 4.00 \end{cases} & \text{for Soil Type II : medium soil sites} \\ \begin{cases} 2.5 & 0.00 < T < 0.67 \\ \frac{1.67}{T} & 0.67 < T < 4.00 \end{cases} & \text{for Soil Type III : soft soil sites} \end{cases} \qquad (2.2)$$

in which *T* is the fundamental translational natural period of the building in the considered direction of shaking.

Table 2.1: Seismic Zone Factor *Z* as per IS:1893 (Part 1) - 2007 of the site where the building to be designed is located

Seismic Zone	V	IV	III	II
Z	*0.36*	*0.24*	*0.16*	*0.10*
Note: *The zone in which a building is located can be identified from the Seismic Zone Map of India given in IS:1893-2007, sketched in Figure 2.1.*				

Table 2.2: Importance Factor Z of buildings as per IS:1893 (Part 1) - 2007

Building	*Importance Factor I*
Normal Buildings	*1.0*
Important Buildings (*e.g.*, Critical buildings required to be functional after an earthquake, Lifeline buildings associated with utilities, like water, power & transportation)	*1.5*

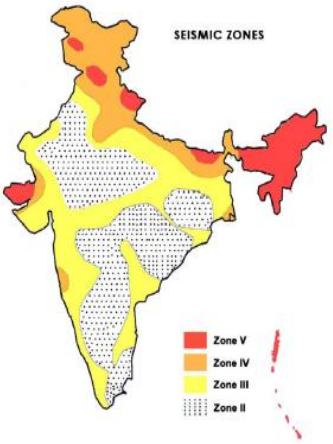


Figure 1. seismic zone

W is the seismic weight of the building. For the purpose of estimating the seismicweight of the building, full dead load and part live load are to be included. The proportion of live load to be considered is given by IS:1893 (Part 1) as per Table 2.4; live load need not be considered on the roofs of buildings in the calculation of design earthquake force. While there is lesser control on design acceleration spectrum value Ah, designers can consciously reduce seismic weight W though the mass of the building. Choosing light materials and efficiently using the materials together help reducing the source of design earthquake force on the building. Also, the distribution of this mass in plan and elevation of the building rendersearthquake-induced inertia forces to be uniformly distributed throughout the building, instead of being localized at a few parts of the building. Proportion of Live Load to be considered in the estimate of Seismic Weight of buildings as per IS: 1893-2004.

DESIGN & ANALYSIS OF RC MEMBERS

Types of Soil:

According to the 1893 code guidelines the following type of soil were considered:

- For rocky or hard soil- It is well graded gravel and sand gravel mixtures with or without clay binder, and clayey sands poorly graded or sand clay mixtures (GB, CW, SB, SW, and SC) having N above 30, where N is the standard penetration value.
- For medium soil- All soils with N between 10 and 30, and poorly graded sands or gravelly sands with little or no fines (SP), with N > 15.
- For soft soil- All soils other than SP with N<10.

These provisions were not sufficient for designing structure as the response spectra generated according to IS code is based upon three types of soil rock or hard soil, mediumsoil and soft soil, which is taken as the average values for all the respective zones. But the local soil condition is different for the various places and the peak ground acceleration and the response spectra generated will be different for different cases, for the strong ground motion is dependent to the geometry and material properties of the subsurface materials, on site topography and on the characteristics of the input motion like shear wave velocities, shear modulus, etc.

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+2
- ➢ 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)

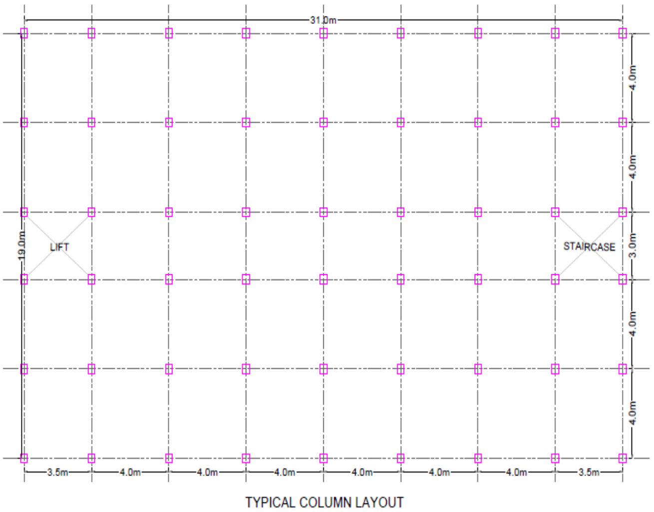


Figure 2. column layout of G+2 Building

LOADS

The reinforced concrete structures are designed to resist the following types of loads.

1. Dead load:

Dead loads are permanent or stationary loads which are transferred to the structure throughout their life span. Dead loads mainly cause due to self-weight of structural members, permanent partitions, fixed equipment's and fittings. These loads shall be calculated by estimating the quantity of each material and them multiplying it with the unit weight. The unit weights of various materials used in building construction are given in the code IS 875 (part -1) -1987. The unit weight of commonly used building materials are given below:

RC PROPERY:

- Column Size: 300x420 mm
- Beam Size: 300x450 mm

Table 1. Unit weight of common building materials

s.no.	Material	Unit weight KN/m^3
1	Plain concrete	24
2	Reinforced concrete	25
3	Brick masonry, cement plaster	20
4	Stone masonry	24
5	Wood	8
6	Steel	78.5
7	Floor finish	0.6-1.2

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

= 4.5 KN/m^2

Roof Finishing: =1.0 KN/Sq.m

Total load of slab = 8.5kn/ m^2

b) Self-weight of Beam Load:

Beam Size- 300x450mm

Unit weight of reinforced concrete - 25.00kn/m3

= 0.3 x 0.45 x 25

= 3.375Kn/m^3

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

2. Live loads (or) imposed loads:

These are the loads that changes with time. Live loads or imposed loads include loads due to the people occupying the floor, weight of movable partitions, weight of furniture and materials. The live loads to be taken in design of buildings have been given in IS: 875 (part-2) -1987. Some of the common live loads used in the design of buildings are given below:

Live loads are either movable or moving loads without any acceleration or impact. There are assumed to be produced by the intended use or occupancy of the building including weights of movable partitions or furniture etc. The floor slabs have to be designed to carry either uniformly distributed loads or concentrated loads whichever produce greater stresses in the part under consideration.

Since it is unlikely that any one particular time all floors will not be simultaneously carrying maximum loading, the code permits some reduction in imposed loads in designing columns, load bearing walls, piers supports and foundations.

Live load as per Code IS: 875 (Part-2)

Patient rooms =4.000kn/ m^2

Stair case, corridor =3.000kn/ m^2

Terrace, portico =2.000kn/ m^2

3. Wind loads:

The horizontal load caused by the wind is called as wind loads. It depends up on the velocity of wind and shape and size of the building. Complete details of calculating wind loads on structures are given in IS 875(part -3)-1987.

Wind load is primarily horizontal load caused by the movement of air relative to earth. Wind load is required to be considered in design especially when the heath of the building exceeds two times the dimensions transverse to the exposed wind surface. For low rise building say up to four to five storeys, the wind load is not critical because the moment of resistance provided by the continuity of floor system to column connection and walls provided between columns are sufficient to accommodate the effect of these forces. Further in limit state method the factor for design load is reduced to 1.2 (DL+LL+WL) when wind is considered as against the factor of 1.5(DL+LL) when wind is not considered. IS 1893 (part 3) code book is to be used for design purpose.

Design Wind Speed $V_z = V_b \times K_1 \times K_2 \times K_3$

Where

V_b- Design Wind speed

K_1- Probability factor

K_2 – Terrain factor

K_3- Topography Factor

Exposure factor is -1.0 (As per code)

4. Earth quake forces:

Earth quake forces are horizontal forces caused by earth quake and shall be computed in accordance with IS 1893-1984.

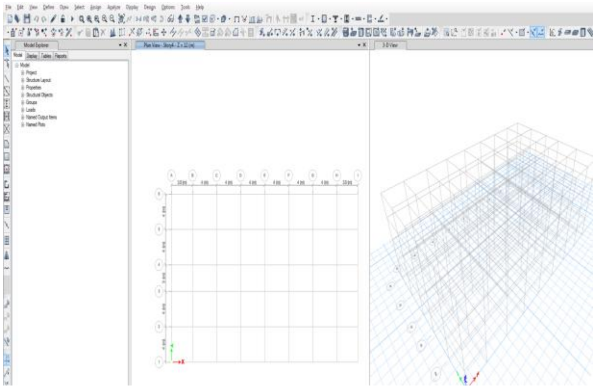
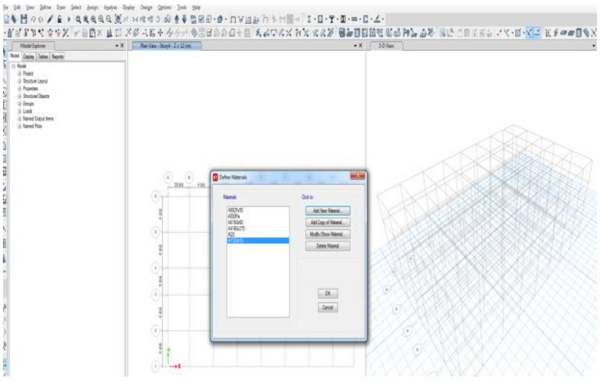
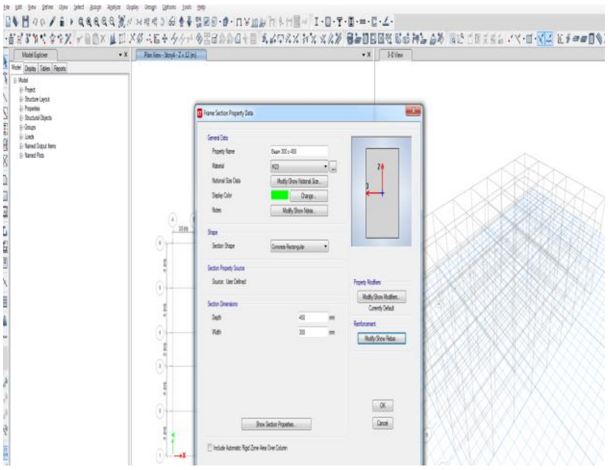


Figure 3. Developing the Model in ETABS



Fingure 4. Defining the Material Properties



Frame Section Property Data

Property Name: Beam 300 x 450

Material: M20

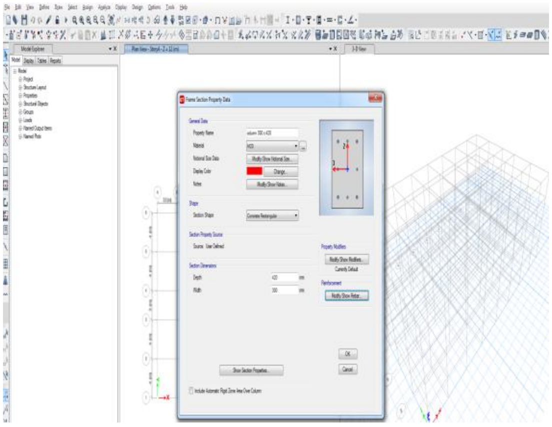
Section Shape: Concrete Rectangular

Source: User Defined

Depth: 450 mm

Width: 300 mm

Figure 5. Defining the Beam Section



Frame Section Property Data

Property Name: column 300 x 420

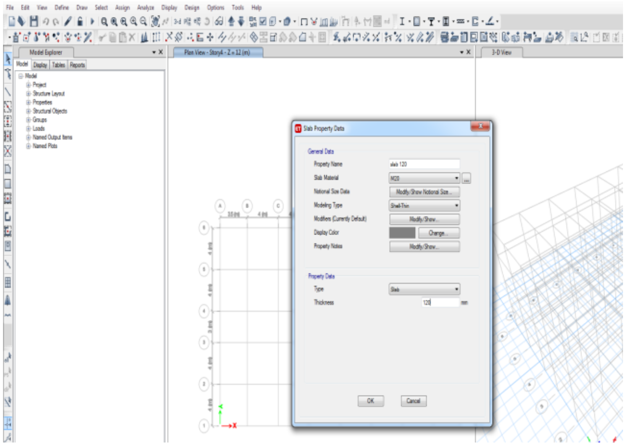
Section Shape: Concrete Rectangular

Source: User Defined

Depth: 420 mm

Width: 300 mm

Figure 6. Defining the Column Section



Slab Property Data

Property Name: slab 120

Slab Material: M20

Modeling Type: Shell-Thin

Type: Slab

Thickness: 120 mm

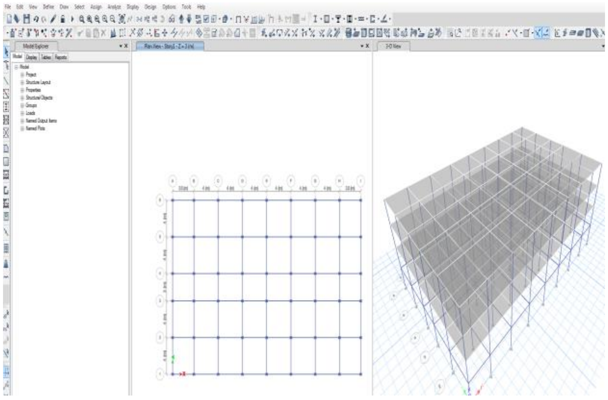


Figure 7. Defining the Slab Section

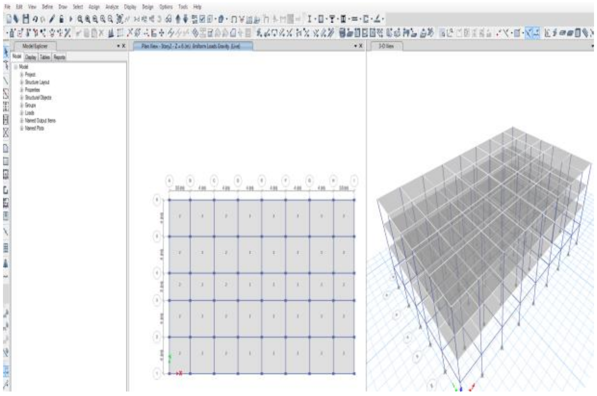


Figure 8. Assigning the Live Loads

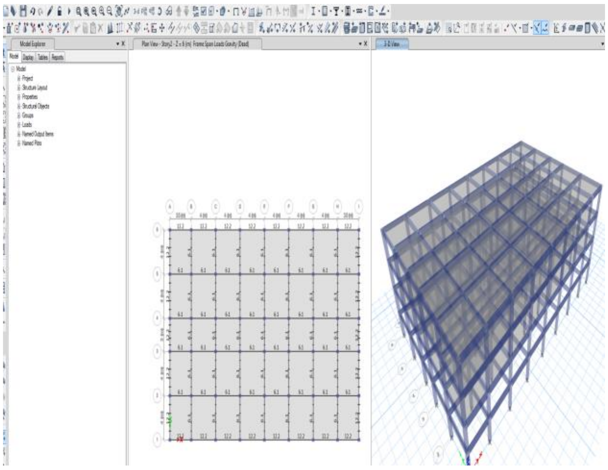


Figure 9. Assigning the Dead Loads

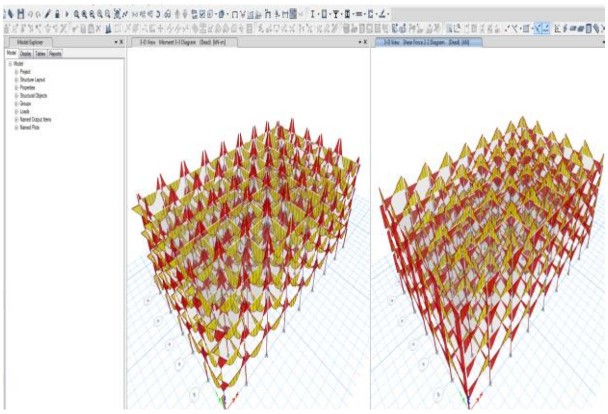
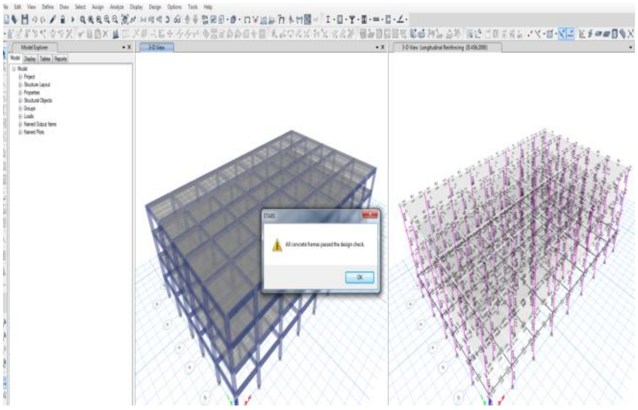


Figure 10. Bending Moment and Shear Force



All concrete frames passed the design check.

Figure 11. Design of Structural Members

DESIGN RESULTS AND DISCUSSUIONS

PURPOSE:

The purpose of the regional commercial zone (RC) is to

A. Allow for a wide range of commercial and retail trades and uses, as well as offices, business and personal services, that contribute to the positive character of the city, buffer adjacent residential neighborhoods, and maintain pedestrian access with links to neighborhoods, and other commercial developments;

B. Allow for new commercial development that is compatible with and contributes to the character of Midvale, through use of appropriate building materials, architectural detail, color range, massing, lighting, and landscaping criteria to soften the visual impact of commercial building sites and parking areas and to accentuate the relationship to streets and pedestrian ways; and

C. Encourage commercial development that incorporates design elements related to public outdoor space including pedestrian circulation and trails, transit facilities, plazas, pocket parks.

Architectural standards:

All new development must present an attractive, coordinated streetscape, incorporate architectural and site design elements appropriate to a pedestrian scale and provide for the safety and convenience of pedestrians. All new development shall comply with the following architectural standards:

A. Walls. No more than three materials shall be used for primary wall surfaces. Exterior finishes shall be of traditional, time- and weather-tested techniques. Retaining walls shall be of materials complementary to the building's materials. Wall colors may range from earth tones to colors with some white and gray. Trim around openings may be accent colors. No other wall colors are allowed.

B. Roofs. All the roofs and dormer roofs of a building shall be constructed of the same material. Slopes of roofs shall be of equal pitch if a gable or hip roof is employed. All metal roofs must be of a subdued color. Painted roof shingles are prohibited.

C. Fences, Hedges, and Walls. The following standards apply to new development of fences, hedges and walls:

1. Required Setbacks. A fence, hedge, wall, column, pier, post, or any similar structure or any combination of such structures is permitted in the required setback of a zone district if it meets the following conditions:

a. All fences and walls meet the requirements of this code, Buildings and Construction.

b. No fence, hedge, or wall extends beyond or across a property line without a recorded agreement with the abutting property owner.

c. *Reserved*.

d. Only one fence or wall shall be allowed per property line. Double fences, walls or combination thereof are prohibited.

e. No barbed wire or other sharp, pointed, or electrically charged fence may be erected or maintained, except a temporary fence on a construction site to protect the property during the period of construction may be topped with barbed wire where the barbed wire is not less than eight feet above the ground and does not extend more than two feet above the temporary fence.

2. Height. No fence or wall may exceed seven feet in height, four feet in height from the front of the primary structure forward, or three feet in the sight distance triangle, measured as follows:

a. In a required yard abutting a street, the total effective height above the finished grade measured on the side nearest the street;

b. In any other required yard, the total effective height above the finished grade measured on the side nearest the abutting property;

c. On a property line, measured from the finished grade of either side when the abutting property owners are in agreement; and

d. A temporary fence on a construction site may be as high as required to protect the property during the period of construction.

3. Athletic Facilities. Fencing around athletic facilities, including, without limitation, tennis courts, may be fourteen feet in height so long as all portions above six feet are constructed with at least fifty percent non-opaque materials.

D. Lighting. All lights placed on property entrances or on building facades shall be down-directed and shielded to direct light to the entry or pedestrian way. The lighting design shall minimize light trespass. Spotlights and floodlights are prohibited. All pedestrian pathways shall include either bollard lighting, or down-directed lighting which shall not exceed twelve feet in height. Up lighting for landscaping accentuation purposes is permitted. Awnings shall not be backlit.

E. Screening. Trash collection and recycling areas, service areas, mechanical equipment and loading docks shall be screened on all sides so that no portion of such areas is visible from public streets and alleys and adjacent properties. Required screening may include new and existing plantings, walls, fences, screen panels, doors, topographic changes, buildings, horizontal separation, or any combination thereof.

F. Miscellaneous. Security devices shall have materials and colors that complement the building's material. Accessory structures shall be architecturally compatible with the primary development. Satellite dishes over eighteen inches shall not be placed in front yards.

Parking requirements:

An applicant for new development must provide off-street parking with adequate provisions for independent ingress and egress by automobiles and other motorized vehicles. If any land, structure, or use is changed to create more off-street parking demand, the owner must provide additional off-street parking for the new use as required by this chapter. Required parking must be on-site unless the planning commission allows such parking on adjacent or nearby deed-restricted lots. Off-street parking shall meet the following standards:

A. Driveway Widths and Parking Lot Standards. The following driveway width dimensions and parking lot standards apply to all new development and to the expansion by more than twenty-five percent of an existing building mass or site size. The city engineer may approve minor variations (equal to or less than ten percent) in driveway width and spacing.

1. Parking. No parking is allowed within the required front yard setbacks.

a. If a parking lot or driveway to a parking lot is proposed to about a residential use, the applicant must screen the lot or drive and provide adequate sight distance triangle.

b. Required Landscaping. The following landscaping standards apply to new development:

i. Parking areas with more than four stalls must have perimeter landscaping of at least five feet in width;

ii. Parking areas with over ten stalls must have a minimum of ten percent interior landscaping, and perimeter landscaping of at least five feet in width;

iii. Parking areas with over fifteen spaces shall provide landscaped islands at the end of each parking row, an island for every fifteen spaces, perimeter landscaping of at least five feet in width, and a minimum of ten percent interior landscaping.

2. Driveway Standards. For all new development, driveways shall comply with the following standards:

a. No driveway shall be less than fifty feet from intersecting rights-of-way.

b. Commercial driveways that exceed fifteen feet in width at the lot frontage must be separated by a landscaped area of at least twelve feet in width and ten feet in depth.

c. Commercial Requiring Five or More Parking Spaces. The minimum two-way drive width is twenty-four feet. The maximum two-way drive width is thirty-six feet.

d. Commercial Requiring Four or Fewer Parking Spaces. The minimum two-way drive width is twenty feet. The maximum two-way drive width is thirty feet.

3. Spacing. New development shall provide the following:

a. Commercial. A minimum of seventy-five feet spacing between major commercial driveways is recommended. Shared use of commercial drives is strongly recommended.

b. Centerline. The centerline of intersections of the driveways of major traffic generators entering from opposite sides of roadway must be either perfectly aligned or offset by a minimum of one hundred fifty feet.

c. Deviations. The city engineer may approve minor spacing deviations (equal to or less than ten percent).

Utilities:

All utilities within the proposed development shall be buried. The owner shall install conduit within the development's proposed right-of-way for the eventual burial of overhead utilities throughout the zoning district. If the planning commission finds, upon the review and recommendation of the city engineer, that such installation is not feasible at the time of development, the applicant shall bond for the future installation of said conduit. All underground conduit shall be installed in conformance with city standards as identified in City Construction Standards and Specifications.

4. CONCLUSION

The effect of the basement on the seismic response of high-rise buildings and the effect of the lateral forces applied to the superstructure on the member forces in the basement were investigated in this study and the following conclusions could be drawn.

- Lateral stiffness of a high-rise building structure may be significantly overestimated resulting in larger lateral displacements and shorter natural periods of vibration if the basement of a high rise building is ignored in the analytical model. Especially in the case of the building structures with shear walls, the effect of the basement on the seismic response turned out to be more significant. Therefore, it is necessary to include the effect of basement in the analysis of high rise building structures.
- Lateral loads affect not only the response of the super structure but also that of the basement structure. Therefore, seismic loads as well as gravity loads should be considered in the analysis of a high-rise building structure for the design of the basement structure.
- The story shear forces in the basement may be significantly over estimated if the rigid diaphragm assumption is applied to the basement. Therefore, an efficient analysis method using partial rigid diaphragms is proposed in this study for the analysis of high-rise buildings subjected to lateral forces such as the seismic loads including the effects of basement.

REFERENCES

1. IS: 875-1987. 'Indian Standard Code of Practice for Design Loads (other than Earthquakes) for Buildings and
2. Structures, (2nd revision).' Bureau of Indian Standard, New Delhi
3. IS: 456-2000. 'Indian Standard Code of Practice for Design of reinforced concrete", Bureau of Indian Standard, New Delhi
4. Design of Reinforced concrete structures by S. Ramamrutham and R. Narayanan, 17 th edition Dhanpat Rai Publishing Company.
5. User manual for E tabs.
6. A Sathawane R.S Deotale 'Analysis and design of flat and grid slab and their comparision, international journal of engineering Research and their applications vol 1. Issue.3.PP 837-848.
7. Baishali Das Static and dynamic analysis of grid beams, project report of Bachelor of technology, Deportment of