ANALYSIS OF G+20 RC BUILDING IN DIFFERENT SESIMIC ZONES BY USING STAAD PRO V8I

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ABSTRACT

When a structure is subjected to earthquake, it responds by vibrating. An earthquake force can beresolved into three mutually perpendicular directions-the two horizontal directions (x and y) and the vertical direction (z). This motion causes the structure to vibrate or shake in all three directions; the predominant direction of shaking is horizontal. It is very essential to consider the effects of lateral loads induced from wind and earthquakes in the analysis of reinforced concrete structures, especially for high-rise buildings. The basic intent of analysis for earthquake resistant structures is that buildings should be able to resist minor earthquakes without damage. It resists moderate earthquakes without structural damage but sometimes non-structural damage will resist major earthquakes without collapse the major structure. To avoid collapse during a major earthquake, members must be ductile enough to absorb and dissipate energy by post-elastic deformation. Redundancy in the structural system permits redistribution of internal forces in the failure of key elements. When the primary element or system yields or fails, the lateral force certainly redistributed to a secondary system to prevent progressive failure. The objectives of thepresent work is to study the behavior of a multi storied R C building regular in plan subjected to earth quake load by adopting Response spectrum analysis.

The present study is limited to reinforced concrete (RC) multi-storied commercial building with FOUR different zones II, III, IV & V .The analysis is carried out the help of Staad Pro V8i Structural Software. The building model in the study has twenty storeys with constant storey height of 3m. Models are used to analyze with different bay lengths and the number of Bays and the bay-width along two horizontal directions are kept constant in each model for convenience. Different values of SEISMIC ZONE FACTOR (z) are taken and their corresponding effects are interpreted in the results.

INTRODUCTION

Dynamic actions are caused on buildings by both wind and earthquakes. But, design for wind forces and for earthquake effects are distinctly different. The intuitive philosophy of structural design uses force as the basis, which is consistent in wind design, wherein the building is subjected to a pressure on its exposed surface area; this is force-type loading. However, in earthquake design, the building is subjected to random motion of the ground at its base, which induces inertia forces in the building that in turn cause stresses; this is displacement-type loading. Another way of expressing this difference is through the load deformation curve of the building – the demand on the building is force(i.e., vertical axis) in force-type loading imposedby wind pressure, and displacement(i.e., horizontal axis) in displacement type loading imposed by earthquake shaking. Wind force on the building has a non-zero mean component superposed with a relatively small oscillating component. Thus, under wind forces, the building may experience small fluctuations in the stress field, but reversal of stresses occurs only when the direction of wind reverses, which happens only over a large duration of time. On the other hand, the motion of the ground during the earthquake is cyclic about the neutral position of the structure. Thus, the stresses in the building due to seismic actions undergo many complete reversals and that to over the small duration of earthquake.

The mass of the building being designed controls seismic design in addition to the building stiffness, because earthquake induces inertia forces that are proportional to the building mass. Designing buildings to behave elastically during earthquakes without damage may render the project economically unviable. Therefore, the traditional earthquake-resistant design philosophy requires that normal buildings should be able to resist:

(a) Minor (and frequent) shaking with no damage to structural and non-structural elements;

(b) Moderate shaking with minor damage to structural elements, and some damage to nonstructural elements; and

(C) Severe and infrequent shaking with damage to structural elements, but with NO collapse (to save life and property inside/adjoining the building).

Important Features:

Analytical Modeling

Analytical model can be created using the ribbon-based user interface, by editing the command file or by importing several other files types like dxf, cis/2 etc. The model geometry can even be generated from the data of macro-enabled applications (like Microsoft Excel, Microstation etc.) by using Macros.

Physical Modeling

Physical modeling has been a significant feature included in the program. STAAD.Pro Physical Modeler takes advantage of physical modeling to simplify modeling of a structure, which in turn more accurately reflects the process of building a model. Beams and surfaces are placed in the model on the scale of which they would appear in the physical world. A column may span multiple floors and a surface represents an entire floor of a building, for example. A joint is then generated anywhere two physical objects meet in the model (as well as at the free ends of cantilevered members, for convenience).

STAAD Building Planner

STAAD Building Planner is a module that enables seamless generation of building models that can be analyzed and designed thereafter in the program itself. Operations like defining geometry, making changes in the geometric specifications are matters of only few clicks in this workflow.

Advanced Concrete Design

The Advanced Concrete Design workflow provides direct access for STAAD.Pro models to leverage the power of the RCDC application. This is a standalone application, which is operated outside the STAAD.Pro environment, but requires a model and results data from a suitable analysis. The model should typically be formed from beams and columns (plates are currently not supported). RCDC can be used to design the following objects: Pile Caps, Footings, Columns and walls, Beams, Slabs.

As the projects progresses, each design created in RCDC is retained and displayed when RCDC is re-entered, so that previous designs can be recalled and/or continued. Detailed drawings and BBS of excellent quality can be generated as required and they are quite ready to be sent for execution.

Advanced Slab Design

The STAAD.Pro Advanced Slab Design workflow is an integrated tool that works from within the STAAD.Pro environment. Concrete slabs can be defined, and the data can be transferred to RAM Concept. The data passed into RAM Concept includes the geometry, section and material properties, loads and combination information, and analysis results.

Advantages:

- It offers a flexible modeling environment to the user that facilitates creating the best structure.
- It provides the user with multiple design codes to choose from; the user can use the most appropriate code for the structure by the virtue of STAAD Pro training.
- STAAD Pro provides an open architecture called Open STAAD, which is like a resource library for the STAAD professionals that provides Application Process Interface (API) and other useful resources.
- Though STAAD pro is a sophisticated structural designing software, it comes with many benefits and can be easily

used by a certified STAAD professional

SEISMIC ZONES OF INDIA

Based on the levels of intensities sustained during damaging past earthquakes, the seismic zone map is revised with only four zones, instead of five. Erstwhile Zone I has been merged to Zone
II. Hence, Zone I does not appear in the new zoning; only Zones II , III , IV , and V.

FIG 1: MODIFIED SEISMIC ZONES OF INDIA (IS 1893-PART1 2002)

Types of seismic waves

Body waves

There are two types of body waves, pressure waves or primary waves (P-waves) and shear or secondary waves (S-waves). P-waves are longitudinal waves that involve compression and expansion in the direction that the wave is moving and are always the first waves to appear on a seismogram as they are the fastest moving waves through solids. S-waves are transverse waves that move perpendicular to the direction of propagation. S-waves are slower than P-waves. Therefore, they appear later than P-waves on a seismogram. Fluids cannot support transverse elastic waves because of their low shear strength, so S-waves only travel in solids.

Surface waves

Surface waves are the result of P- and S-waves interacting with the surface of the Earth. These waves are dispersive, meaning that different frequencies have different velocities. The two main surface wave types are Rayleigh waves, which have both compressional and shear motions, and Love waves, which are purely shear. Rayleigh waves result from the interaction of P-waves and vertically polarized S-waves with the surface and can exist in any solid medium. Love waves are formed by horizontally polarized S-waves interacting with the surface, and can only exist if there is a change in the elastic properties with depth in a solid medium, which is always the case in seismological applications. Surface waves travel more slowly than P-waves and S-waves because they are the result of these waves traveling along indirect paths to interact with Earth's surface. Because they travel along the surface of the Earth, their energy decays less rapidly than body waves (1/distance2 vs. 1/distance3), and thus the shaking caused by surface waves is generally stronger than that of body waves, and the primary surface waves are often thus the largest signals on earthquake seismograms. Surface waves are strongly excited when their source is close to the surface, as in a shallow earthquake or a near-surface explosion, and are much weaker for deep earthquake sources.

Normal modes

Both body and surface waves are traveling waves; however, large earthquakes can also make the entire Earth "ring" like a resonant bell. This ringing is a mixture of normal modes with discrete frequencies and periods of approximately an hour or shorter. Normal mode motion caused by a very large earthquake can be observed for up to a month after the event. The first observations of normal modes were made in the 1960s as the advent of higher fidelity instruments coincided with two of the largest earthquakes of the 20th century the 1960 Valdivia earthquake and the 1964 Alaska earthquake. Since then, the normal modes of the Earth have given us some of the strongest constraints on the deep structure of the Earth.

METHODOLOGY

It demands to select the exact process to analyse a certain structural frame considering its corresponding characteristics related to seismic as earthquake analysis was very difficult portion in the field in structural engineering.

1. Static Analysis: It is known as equivalent static force method. In this method, the base shear is calculated from the weight of building. Earthquake forces are calculated in normalized way in this method. Live loads and dead loads are considered according to the norms and distributed along in each storey.

2. Dynamic Analysis: It shall be performed to access the design seismic force, and its spreading in various levels or stories along the height of the building, and in the various lateral load resisting element.

• Regular Buildings: All framed buildings height greater than 40m in height in zones IV and V and greater than 90m in height in zone II and III.

• Irregular Building: All framed buildings higher than 12m in zones IV and V, and greater than 40m in height in zones II and III.

LITERATURE

The case study in this paper mainly emphasizes on structural behavior of multi-storey building for different plan configurations like rectangular, C, L and I-shape. Modeling of 15- storeys
R.C.C. framed building is done on the Staad Pro V8i software for analysis. Post analysis of the structure, maximum shear forces, bending moments, and maximum storey displacement are computed and then compared for all the analyzed cases. The analysis of the multi storied building reflected that the storey overturning moment varies inversely with storey height. From dynamic analysis, mode shapes are generated and it can be concluded that asymmetrical plans undergo more deformation than symmetrical plans.

JagMohan Humar et al (2013):

The base shear adjustment factor Mv and the overturning moment reduction factor J are both dependent on the characteristics of the lateral force resisting system. The factor Mv is largest for a flexural wall system and smallest for a momentresisting frame. On the other hand, J is smallest for a flexural wall and largest for a moment resisting frame. The factors Mv and J also depend onthe first mode period Ta. Thus Mv increases with an increase in Ta, whereas J decreases with an increase in Ta. The factors Mv and J strongly depend on the shape of the response spectrum.

J.P Annie Sweetlin (2016):

In this paper the earthquake resistance of a G+20 multi-storey building is analyzed using Equivalent static method with the help of STAAD PRO V8I . The method includes seismic coefficient method as recommended by IS 1893:2002. The parameters studied were displacement, storey drift and storey shear. Seismic analysis was done by using STAAD PRO V8I and successfully verified manually as per IS 1893:2002. Drift is within the limits for the building (0.004 times of the height of the storey) 0.004x3.2=12.8mm. Earthquake Base shear is greater than Wind Base shear. Complete guideline for the use of STAAD PRO V8I for seismic coefficient analysis is made available by this paper.

Narla Mohan, A.Mounika Vardhan:

The objectives were how the seismic evaluation of a building should be carried out. To study the behavior of a building under the action of seismic loads and wind loads. To compare various analysis results of building under zone II, III, IV and zone V using STAAD PRO V8I Software. The building model in the study has twenty storey's with constant storey height of 3m. Five models are used to analyze with constant bay lengths and the number of Bays and the bay width along two horizontal directions are kept constant in each model for convenience.

"**Pralobh S. Gaikwad and Kanhaiya K. Tulani (2015):**

The paper aims towards the dynamic analysis of RCC and Steel building with unsymmetrical configuration. For the analysis purpose models of G +9 stories of RCC and Steel with unsymmetrical floor plan is consider. The analysis is by carried by using F.E based software E TABS. Various parameter such as lateral force, base shear , story drift , story shear can be determined .For dynamic analysis time history method or response spectra method is used. .If the RCC and Steel building are unsymmetrical, torsional effect will be produce in both the building and thus are compared with each other to determine the efficient building under the effect of torsion."

Romy Mohan and C Prabha:

In this, two multi storey buildings, one of six and other of eleven storey have been modeled using software package SAP 2000 12 for earthquake zone V in India. Six different types of shearwalls with its variation in shape are considered for studying their effectiveness in resisting lateral forces. The paper also deals with the effect of the variation of the building height on the structural response of the shear wall. Dynamic responses under prominent earthquake, El-Centro have been investigated. This paper highlights the accuracy and exactness of Time History analysis in comparison with the most commonly adopted Response Spectrum Analysis and Equivalent Static Analysis.

Saurabh G Lonkar and Prof. Riyaz Sameer Shah (Dec 2015) :

In this journal on the seismic behavior of the concrete reinforced building , storey displacements, accuracy and exactness of time history analysis and response spectrum analysis, relative displacement of regular and irregular building by different method of seismic analysis and also tocheck the relative percentage damages to of regular and irregular building in different seismic zones. They did this project on four phases. By this project they found that the displacement of each storey at center of mass is lower as those compared to maximum displacement of joints. Static analysis is not sufficient for the high raise building its necessary to provide dynamic analysis. And as result of comparison it is observed that the displacement and corresponding damage obtained from static analysis are higher than the dynamic analysis including response spectrum and time history analysis.

Ali Kadhim Sallal (2018):

The main purpose of this software is to design and analysis multi-Storeyed building in a systematic process. This paper present a building where designed and analyzed under effect of earthquake and wind pressure by using STAAD PRO V8I software. In this case, (18m x 18m) and eight stories structure are modeled using STAAD PRO V8I software. Ten story is taken as (3m) height and making the total height of the

BUILDING BYE LAWS

Re-planning of building activity.

- Allow orderly growth and prevent haphazard development.
- Provisions of bye-laws usually afford safety against fire, noise,health hazard and structure failure.
- Provide proper utilization of space to achieved maximum efficiency in planning.
- They provide health, safety and comfort to the people who live in building.

BUILDING BYE-LAWS:

Building bye laws set standards for building work. There aim is to ensure the health and safety of people around the building by setting requirements for building design and construction. The bye-laws also promote energy efficiency and aim to improve access for disable people.

Line of building frontage and minimum plot sizes.

Open spaces around residential buildings.

Individual commercial buildings -1.25m.

Other residential buildings, e.g., Hotels, Group housing e.t.c.- 2m

Maximum size of plot of a residential building is upto10,000 sq.m..

Materials Used:

Grade of concrete: M30

Grade of steel: TMT 415 (Thermo mechanically treated)

IS: 1893 (Part 1) 2007 for Earthquake Resistant Design of Structures.

IS: 13920 (1993), for Ductile Detailing of Reinforced Concrete Structures Subjected to SeismicForces.

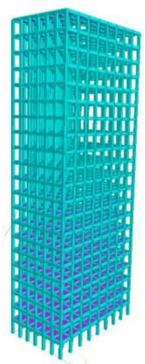

Fig 3: Diagram of Structure in STAAD PRO V8I

METHODS OF ANALYSIS

The seismic analysis should be carried out for the buildings that have lack of resistance to earthquake forces. Seismic analysis will consider seismic effects hence the exact analysis sometimes become complex. However for simple regular structures equivalent linear static analysis is sufficient one. This type of analysis will be carried out for regular and low rise buildings and this method will give good results for this type of buildings. Dynamic analysis will be carried out for the building as specified by code IS 1893-2002 (part1). Dynamic analysis will be carried out either by Response spectrum method or site specific Time history method. Following methods are adopted to carry out the analysis procedure.

- Equivalent Static Analysis
- Response Spectrum Method
- Time History Analysis
- Pushover Analysis

Response Spectrum Method:

It is very useful tools of earthquake engineering for analyzing the performance of structures and equipment in earthquakes, since many behave principally as simple oscillators (also known as single degree of freedom systems). Thus, if you can find out the natural frequency of the structure, then the peak response of the building can be estimated by reading the value from the ground response spectrum for the appropriate frequency. In most building codes in seismic regions, this value forms the basis for calculating the forces that a structure must be designed to resist (seismic analysis).

Analysis by using STAAD Pro V8i software:

STAAD Pro is the ultimate integrated software package for the structure analysis and design of buildings. Incorporating 40 years of continuous research and development, this latest STAAD Pro offers unmatched 3-D object based modeling and visualization tools, blazingly fast linear and non-linear analytical power, sophisticated and comphrensive design capabilities design capabilities for a wide range of materials, and insightful graphic displays, reports and schematic drawings that allow users to quickly and easily decipher and understand analysis and design results.

STAAD Pro is a sophisticated yet easy to use special purpose analysis and design program developed specifically for building systems. It handles the largest and most complex building models, including wide range of non-linear behavior making it the tool of choice for structural engineers. It consists of simple grid system defined by horizontal floors and vertical column lines can establish building geometry with minimal effort.

In most buildings, the dimensions of the members are large in relation to the bay widths and story heights .Those dimensions have a significant effect on the stiffens of the frame . STAAD Pro correct for such efforts in the formulations of the member stiffness, unlike most general purpose programs that work on center line to center line dimensions.

MODELLING PROCESS

The procedure carried out for Modeling and analyzing the structure involves the following flow chart.

Step 1:**Project Setup:**

Set the units to those to be used most often in the model (i.e.the base units). Select those units in the STAAD Pro software Initial setup Page.

Step 2: Creation of Modelling/ Generation of structure

After getting opened the program, select a new Grid appears where we had entered the details of Input Dimensions and story dimensions of our building By using Run Structure Wizard Tool Available in Geometry Tab. Here the program had generated 2D and 3D structure by specifying the building details.

Step 3: Define property

After created the Model in Wizard window , start to define the material property by selecting Define menu (material properties like concrete and steel reinforcements).→ Select the Type of Material & Mention Input values like Width/Depth/ Diameter of Particular Structural component

Step 4: Assigning of Property

After that define section properties (beams, columns, slabs, and walls) by giving the specified details are assigned to the Structural Components based on the Select Tool based on X, Y, Z, Planes, Properties are Applied to the Structure.

Step 5: Assigning of Supports

Initially we are Created a Support Like Fixed / Pinned/ Rolled and After by using Node Tool, select the Required nodes and Assign to the Particular Node Points at the Structure.

Step 6: Defining of loads

In Staad Pro V8i all the load considerations are first defined and then assigned. The loads in Staad Pro V8i are defined Load Cases through General Tab → Load & Definition → Create the Load Case Details.

Step 7: Assigning of Dead loads

After defining all the loads, dead loads are assigned to the Structure

Step 8: Assigning of Live loads

Live loads are assigned for the entire structure including floor finishing.

Step 9: Assigning of wind loads

Wind loads are defined and assigned as per IS 875 1987 PART 3 (Indian code) by giving the value of wind speed and wind angle in X ,X1, Z & Z1 directions as 0, 180, 90, 270 respectively

Step 10: Assigning of Seismic loads

Seismic loads are defined and assigned as per IS 1893: 2002 (Indian code) by giving the detailsof zone, soil type, and response reduction factor in X and Y directions

Step 11: Assigning of load combinations

Load combinations are given based on IS 875 1987 PART 5 (Indian code) using load combinations command in define menu

Step 12: Analysis

After the completed all the above steps, we have performed the analysis and check for the errors.

Step 13: Design

This step consider the last step of procedure. After completed the analysis, now performed concrete design on the structure as per IS 456: 2000 (Indian code). For this go to Design menu Select Concrete Design, Select the Code Provisions IS 456: 2000, and Select Parameters of the Design and Define the Parameters of structure Staad Pro V8i performs the design for every structural element.

Step 14: Detailing

We design the elements subjected to Shear, Bending and Torsion. We get the corresponding area of the steel to counter Bending, Shear and Torsion (number of Main bars, Distribution bars and spacing between the stirrups or tie bars). Double Click on Element →Then we get the Reinforcement details.

STAAD EDITOR PROGRAMME IN STAAD PRO

STAAD SPACE
START JOB INFORMATION
ENGINEER DATE 11-Jun-21
JOB NAME G+20
JOB CLIENT Project Analysis in Zones
JOB NO 01
ENGINEER NAME G+20
END JOB INFORMATION
INPUT WIDTH 79
UNIT METER KN
JOINT COORDINATES
1 0 0 0; 2 3.25 0 0; 3 6.5 0 0; 4 9.75 0 0; 5 13 0 0; 6 16.25 0 0; 7 19.5 0 0;
8 22.75 0 0; 9 26 0 0; 10 0 3 0; 11 3.25 3 0; 12 6.5 3 0; 13 9.75 3 0;
14 13 3 0; 15 16.25 3 0; 16 19.5 3 0; 17 22.75 3 0; 18 26 3 0; 19 0 6 0;
20 3.25 6 0; 21 6.5 6 0; 22 9.75 6 0; 23 13 6 0; 24 16.25 6 0; 25 19.5 6 0;
26 22.75 6 0; 27 26 6 0; 28 0 9 0; 29 3.25 9 0; 30 6.5 9 0; 31 9.75 9 0;
32 13 9 0; 33 16.25 9 0; 34 19.5 9 0; 35 22.75 9 0; 36 26 9 0; 37 0 12 0;
38 3.25 12 0; 39 6.5 12 0; 40 9.75 12 0; 41 13 12 0; 42 16.25 12 0;
152 22.75 48 0; 153 26 48 0; 154 0 51 0; 155 3.25 51 0; 156 6.5 51 0;
157 9.75 51 0; 158 13 51 0; 159 16.25 51 0; 160 19.5 51 0; 161 22.75 51 0;
162 26 51 0; 163 0 54 0; 164 3.25 54 0; 165 6.5 54 0; 166 9.75 54 0;
167 13 54 0; 168 16.25 54 0; 169 19.5 54 0; 170 22.75 54 0; 171 26 54 0;
172 0 57 0; 173 3.25 57 0; 174 6.5 57 0; 175 9.75 57 0; 176 13 57 0;
177 16.25 57 0; 178 19.5 57 0; 179 22.75 57 0; 180 26 57 0; 181 0 60 0;
182 3.25 60 0; 183 6.5 60 0; 184 9.75 60 0; 185 13 60 0; 186 16.25 60 0;
187 19.5 60 0; 188 22.75 60 0; 189 26 60 0; 190 0 63 0; 191 3.25 63 0;
192 6.5 63 0; 193 9.75 63 0; 194 13 63 0; 195 16.25 63 0; 196 19.5 63 0;
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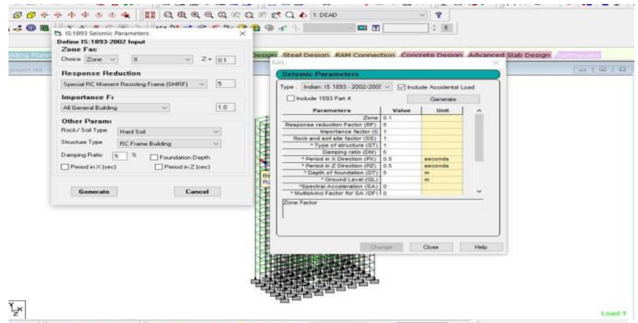
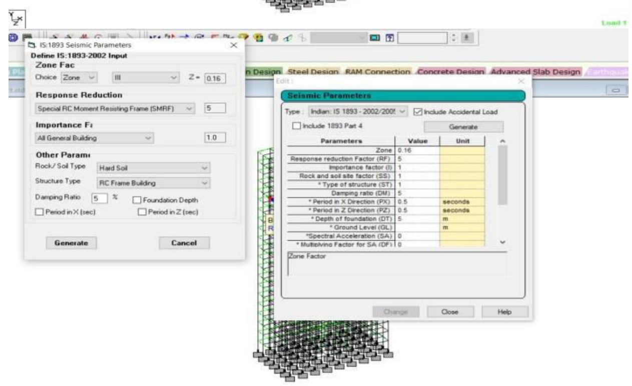
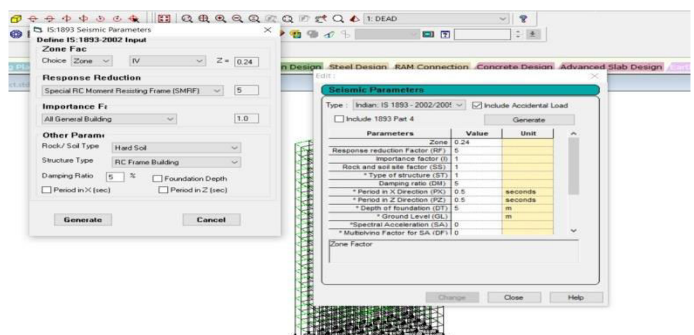


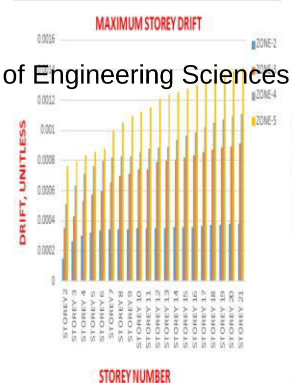


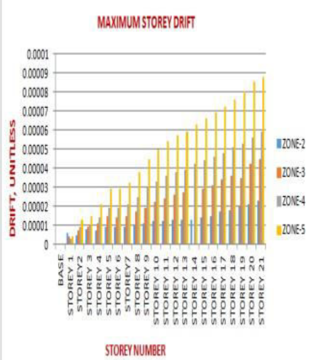
Zone IV & Zone V Input Data:



BASE SHEAR:

Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure or the seismic force at base of the building is above cracking is the shear force that broke the





building. Typically earthquake damage occurs at base

of building..The base shear, or Earthquake force, is given by the symbol "V_B". the weight of the building is given as the symbol "W".

$$V_B = A_h \times W$$

V_B = Base shear

ZONES	BASE SHEAR (KN)
ZONE-II	675.6956
ZONE-III	1555.8811
ZONE-IV	2351.9935
ZONE-V	3589.6957

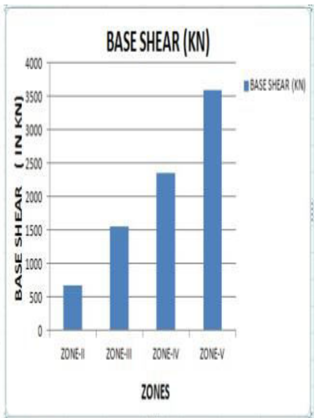


Table No.5: Values of Base Shear

From the above storey drift graph it is clear that, the storey drift increases with the increasing of seismic zone factor. And the maximum storey drift is available at ZONE V. The storey drift for ZONE II is 0.000023 and storey drift for ZONE V is 0.000088.

STOREY SHEAR FOR EARTHQUAKE LOAD:

The storey shear in the building along X direction is obtained for the seismic load combination (1.2DL+1.2LL+1.2EQX) and along Y direction is obtained for the seismic load combination (1.2DL+1.2LL+1.2EQY).

DISPLACEMENT OF RESPONSE SPECTRUM :

The maximum displacement in the building along X direction is obtained for the Response spectrum load combination (1.2DL+1.2LL+1.2 RSX) and along Y direction is obtained for the Response spectrum load combination (1.2DL+1.2LL+1.2RSY).

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the seismic load combination (1.2DL+1.2LL+1.2EQX) and along Y directio

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