International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 13 Issue 6, June-2024, Impact Factor: 8.375

Comparative Studies on Seismic Analysis of Regular and Vertical Irregular Multistoried Building

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ABSTRACT

It is understood that buildings which are regular in elevation (regular building) perform much better than those which have irregularity in elevation (irregular building) under seismic loading. Irregularities are not avoidable in construction of buildings. However, a detailed study to understand structural behaviour of the buildings with irregularities under seismic loading is essential for appropriate design and their better performance. The main objective of this study is to understand the effect of elevation irregularity and behaviour of 3-D R.C. Building which is subjected to earthquake load. In the present study, a 5 bays X 5 bays, G+19 storied structure and each typical storey height 3 m and Ground floor height is 4m, 3-D structure to compare with the irregular i.e. soft storey building. Both the regular and irregular buildings are assumed to be located in all zones. Linear dynamic analysis using Response Spectrum method of the regular and irregular building is carried out using the standard and convenient FE software package. For this the behaviour parameters considered are:

1) **Maximum displacement**
2) **storey drift,**
3) **Base shear and**
4) **Time period.**

INTRODUCTION

Overview

Earthquakes are one of the most devastating natural hazards that cause great loss of life and livelihood. An earthquake is a spasm of ground shaking caused by a sudden release of energy in earth's lithosphere. This energy arises mainly from stresses built up during tectonic processes, which consists of interaction between the crust and the interior of the earth.

Human activity also sometimes modifies crustal stresses enough to trigger small or even moderate earthquakes, such as the swarms of minor tremors resulting from mining in the Midlands of England, or sometimes larger events induced by the impounding of large amounts of water behind dams, such as the earthquakes associated with the construction of Koyna dam in central India in 1967 and recently in Nepal in 2015, 7.8 intensity earthquake has occurred. A major magnitude- 7.8 earthquake struck central Nepal on April 25, 2015 leaving catastrophic impacts across the country. It was the largest earthquake to strike Nepal in over 80 year. That tremor, plus subsequent aftershocks, left more than 9100 people dead and nearly 25000 other injured. Extensive damage was recorded though out Nepal, particularly in the capital city of Kathmandu. The main jolt was later followed by a magnitude-7.3 aftershock on May 12, 2015.

The combined death toll from both tremors stood at 8891 and the number of injured was 22302 in Nepal alone. A further 229 fatalities were registered in India, Bangladesh, china's Tibet, and Mount Everest. Nepal is located in the center of Himalayan concave chain, and is almost rectangular in shape with about 870 km length in NW-SE and 130-260 km in N-S direction. The main frontal thrust system consists of two or three thrust sheet composed entirely of Siwalik rocks, from bottom to top mudstone, multi storied sandstone and conglomerate. The Kathmandu valley, where the 2015 Nepal

earthquake caused heavy damage, comprises of thick semi-consolidated fluvio-lacustrine quaternary sediments on the top of basement rocks.
Earthquake Ground Motions (EQGMs) are the most dangerous natural hazards where both economic and life losses occur. Most of the losses are due to building collapses or damages.

Earthquake can cause damage not only on account of vibrations which results from them but also due to other chain effects like landslides, floods, fires etc. Therefore, it is very important to design the structures to resist, moderate to severe EQGMs depending on its site location and importance of the structure. If the existing building is not designed for earthquake, then its retrofitting becomes important. Seismic requirements were not included in building codes as early as those for wind, although some experimentation had taken place in Europe and even more in Japan, which suffered from frequent seismic activity. Some of the early approaches yielded little result, but that did not stop curious minds from experimenting.

The first application of Newton's first law to building codes dealing with seismic design was reportedly made in Italy following the 1911 Messina earthquake. Mindful that the force is equal to mass times acceleration, the regulations there started to require that all buildings should be designed for a static horizontal force equal to 10% of their weight. Seismic forces are caused by inertia of the structure, which tries to resist ground motions.

As the shifting ground carries building foundations along with it, inertia keeps rest of the structure in place fora short while longer. The movement between two parts of the building creates a force, equal to the ground acceleration time's mass of the structure. In order to have a minimum force, mass of the building should be as low as possible since there can be no control on the ground acceleration being an " Act of God " . The point of application of this inertial force is the center of gravity of the mass (CM) on each floor of the building. Once there is a force, there has to be an equal and opposite reaction to balance this force. The inertial force is resisted by the building and the resisting force acts at the center of rigidity (CR) at each floor of the building.

Concept of Regular and Irregular Configuration

Current earthquake codes define structural configuration as either regular or irregular in terms of size and shape of the building, arrangement of the structural and non-structural elements within the structure, distribution of mass in the building etc. A building shall be considered as irregular for the purposes of this standard, if at least one of the conditions is applicable as per IS 1893(part1):2002

Plan Irregularity

Asymmetric or plan irregular structures are those in which seismic response is not only translational but also torsional, and is a result of stiffness and/or mass eccentricity in the structure. Asymmetry may in fact exist in a nominally symmetric structure because of uncertainty in the evaluation of center of mass and stiffness, inaccuracy in the measurement of the dimensions of structural elements.

Vertical Irregularity

Vertical irregularity results from the uneven distribution of mass, strength or stiffness along the elevation of a building structure. Mass and Stiffness irregularity results from a sudden change in mass and stiffness between adjacent floors respectively.

Objective of Study

As such, the goal of this research is to investigate various seismic responses of RC framed regular and vertical geometric irregular structure. The comparison between various seismic parameters would allow us to propose the best suitable building configuration on the existing condition.

DEFINITIONS

Storey

When the multi-story building or the residential building is constructed in that when the floor to floor gap will be there that is the story.

Storey Shear

We will calculate all the lateral loads at each floor of the building.

Story Drift
Story drift is defined as the difference in lateral deflection between two adjacent stories. During an earthquake, large lateral forces can be imposed on structures; Lateral deflection and drift have three primary effects on a structure; the movement can affect the structural elements (such as beams and columns); the movements can affect non-structural elements (such as the windows and cladding); and the movements can affect adjacent structures. Without proper consideration during the design process, large deflections and drifts can have adverse effects on structural elements, nonstructural elements, and adjacent structures.

Center of Mass
It is the unique point at the center of a distribution of mass in space that has the property that the weighted position vectors relative to this point sum to zero. In analogy to statistics, the center of
mass is the mean location of a distribution of mass in space. According to IS: 1893-2002, center of mass is the point through which resultant of the masses of a system acts. This point corresponds to center of gravity of masses of system. Earthquake induced lateral force on the floor is proportional to mass. Hence, resultant of this force passes through the center of mass of the floor.

Center of Rigidity
Center of rigidity is the stiffness centroid within a floor-diaphragm plan. When the center of rigidity is subjected to lateral loading, the floor diaphragm will experience only translational displacement. Other levels are free to translate and rotate since behavior is coupled both in plan and along height. As a function of structural properties, center of rigidity is independent of loading. Certain building codes require center of rigidity for multistory-building design-eccentricity requirements.

LITERATURE REVIEW

A number of studies have been performed on the seismic behavior of reinforced concrete framed structures. Civil engineering structures are mainly designed to resist static loads. Generally the effects of dynamic loads performing on the structure are not considered. This feature of ignoring the dynamic forces at times becomes the reason of calamity, predominantly in case of earthquake.

Prakash Sangamnerkaret. al. has done the comparative study on the static and dynamic behavior of reinforced concrete framed regular building. Comparison of static and vibrant behavior of a six storey's structure is considered in this paper and it is analyzed by using computerized solution available in all four seismic zones i.e. II, III, IV and V. It is observed that parameters like base shear, nodal displacements and beam ends forces varies in the same ratio as described above, hence it is very important conclusion derived in the analysis.

Mohit Sharmaet. al. considered a G+30 storied regular reinforced concrete framed building. Dynamic analysis of multistoried Building was carried out. These buildings have the plan area of 25m x 45m with a storey height 3.6m each and depth of foundation is 2.4 m. & total height of chosen building including depth of foundation is 114 m. The static and dynamic analysis has done on computer with the help of STAAD-Pro software using the parameters or the design as per the IS-1893-2002 (Part-1) for the zones-II and III. It was concluded that not much difference in the values of Axial Forces as obtained by Static and Dynamic Analysis.

M. S. Aainawalaet. al. done the comparative study of multistoried R.C.C. Buildings with and without Shear Walls. They applied the earthquake load to a building for G+12, G+25, G+38 located in zone II, zone III, zone IV and zone V for different cases of shear wall position. They calculated the lateral displacement and story drift in all the cases. It was observed that Multistoried R.C.C. Buildings with shear wall is economical as compared to without shear wall. As per analysis, it was concluded that displacement at different level in multistoried building with shear wall is comparatively lesser as compared to R.C.C. building without shear wall.

Anwaruddin M. et. al. carried out the study on non linear Static Pushover Analysis of G plus 3 medium rise reinforced cement concrete structure with and without vertical irregularity. It was seen that irregularity in height of the building reduces the performance point of structure. There was reduction in displacement or deformation of the RCC building also. They concluded seeing that the no of bays reduces upright, the lateral load carrying capacity increases with decline in lateral displacement.

RuiPinhoet.al .revised eurocode8 formulae for periods of vibration and their employment in linear seismic analysis. This paper takes a critical look at the way in which seismic design codes around the world have allowed the designer to estimate the period of vibration for use in both linear static and dynamic analysis. Based on this review, some preliminary suggestions are made for updating the clauses related to the estimation of the periods of vibration in Eurocode8.

Rakesh K. Goeland Anil K. (1997)studied the period formulas for moment-resisting frame buildings. Based on analysis of the available data for the fundamental vibration period of 27 RC MRF buildings and 42 steel MRF buildings, measured from their motions recorded during earthquakes different formulas were used for estimating, conservatively, the period of RC and steel buildings; respectively .Regression analysis was done to obtain the coefficient of empirical formula for fundamental period.

Sarkaret. al. proposed a new method of quantifying irregularity in vertical geometric irregular building frames, which deals with the dynamic characteristics i.e. stiffness and mass. This paper discusses some of the important issues regarding analysis and design of stepped buildings. They proposed a fresh method for quantifying the irregularity in stepped building. This approach is found to execute better than the existing procedures to quantify the irregularity. The total 78 stepped frames with varying irregularity and height were taken in this study. They proposed a correction factor to the empirical code formula for fundamental period, to provide it applicable for vertical geometric stepped buildings.

Sujit Kumar et. Al(2014) studied the effect of sloping ground on structural performance of rcc building under seismic load. The seismic analysis of a G+4 storey RCC building on varying slope angles i.e., 7.50 and 150 is carried and compared with the same existing on the flat ground. The seismic loadings are as per IS: 1893: 2002. STAAD Pro v8i is used in this study to see the effect of sloping ground on building performance during earthquake. Seismic analysis has been done using equivalent Linear Static method. The analysis is carried out to estimate the effect of sloping ground on structural forces. The bending moment, horizontal reaction in footings and axial force in columns are critically analyzed to enumerate the effects of various sloping ground.

Dr. S.SureshBabu (2015) study, he performed linear static analysis and dynamic analysis on multistoried buildings with plan irregularities for the determination of lateral forces, base shear, storey drift, storey shear. The paper also deals with the effect of the variation of the building plan on the structural response building. Dynamic responses under prominent earthquake, related to IS 1893 :2002(part1).

Bagheri Krishna, Ehsan (2013), in this paper they Assess damage percentage of irregular building when analyzed by static and dynamic analysis. Displacement demands of model have been obtained, using equivalent static, time history and response spectrum analysis. ELCENTRO and CHI-CHI recorded accelerograms are used to perform time history analysis on building. Finally push over analysis has been done in order to estimate the displacement capacities of building. As a result, the level of damage has been obtained for building, based on each methods of analysis, and then the results are compared with each other.

REGULAR AND VERTICAL IRREGULAR STRUCTURE

Overview

To perform well in an earthquake, a building should possess four main attributes, namely simple and regular configuration, and adequate lateral strength, stiffness and ductility. Buildings having simple regular geometry and uniformly distributed mass and stiffness in plan as well as in elevation, suffer much less damage than buildings with irregular configurations.

Regular Structure

Regularity of a building can significantly affect its performance during a strong earthquake. Past earthquakes have repeatedly shown that buildings having irregular configurations suffer greater damage than buildings having regular configurations. Regular structures have no significant physical discontinuities in plan or vertical configuration or in their lateral force systems.

Vertical Irregularity Structure

Irregular structures have significant physical discontinuities in configuration or in their lateral force resisting systems. Static lateral force method is based on a regular distribution of stiffness and mass in a structure. Mass and/or stiffness irregularities by requiring a dynamic analysis for “taller” buildings in “higher” seismic zones.

Vertical Stiffness Irregularity

Under stiffness irregularity the stiffness of the member in a frame are not equal and they vary according to the floor height, modulus of elasticity of concrete and moment of inertia of that member.

This is considered to exist when the lateral stiffness of the SFRF in a storey is less than 70% of any adjacent storey, or less than 80% of the corresponding average stiffness of the multistory structures'.

Weight (MASS) Irregularity

Mass irregularity will be induced by the presence of a heavy mass on a floor, say a swimming pool. IS 1893 has been defined when weight of a floor exceeds twice the weight of the adjacent floor.

Mass irregularity shall be considered to exist where the seismic weight of any storey is more than 200 percent of that of its adjacent storeys. The irregularity need not be considered in case of roofs.

Vertical Geometric Irregularity

Vertical geometric irregularity shall be considered to exist where the horizontal dimension of the lateral force resisting system in any storey is more than 150 percent of that in its adjacent storey. Building may have no apparent offset but its lateral load carrying elements may have irregularity.

For instance, shear wall length may suddenly reduce.

When building is such that larger dimension is above the smaller dimension, it acts as an inverted pyramid and is undesirable.

Discontinuity in Capacity-Weak Storey

A weak storey is one in which the storey lateral strength is less than 80 percent of that in the storey above, The storey lateral strength is the total strength of all seismic force resisting elements sharing the storey shear in the considered direction.

Diaphragm Discontinuity

Diaphragms with abrupt discontinuities or variations in stiffness, including those having cut-out or open areas greater than 50 percent of the gross enclosed diaphragm area, or changes in effective diaphragm stiffness of more than 50 percent from one storey to the next.

Torsion Irregularity

To be considered when floor diaphragms are rigid in their own plan in relation to the vertical structural elements that resist the lateral forces. Torsional irregularity to be considered to exist when the maximum storey drift, computed with design eccentricity, at one end of the structures transverse to an axis is more than 1.2 times the average of the storey drifts at the two ends of the Structure.

RE-Entrant Corners

Plan configurations of a structure and its lateral force resisting system contain re-entrant corners, where both projections of the structure beyond the re-entrant corner are greater than 15 percent of its plan dimension in the given direction.

Non-Parallel Systems

The vertical elements resisting the lateral force are not parallel to or symmetric about the major orthogonal axes or the lateral force resisting elements

Failures Occurred During the Past Earthquakes

A building structure may collapse or suffer severe damage under the action of seismic forces due to sudden change in mass, stiffness and strength along vertical or a horizontal plane. As discussed in the previous section, presence of structural irregularities triggers the structural collapse. The next subsections give examples of building failures that have occurred during the past earthquakes due to presence of different types of structural irregularities.

Failure Due To Vertical Irregularities

The vertical irregularities can be sub - classified into mass, stiffness, strength and setback irregularity. The Teaching Hospital was one of the building which failed during Nepal earthquake in 2015. It was a six-storeyed building with mass irregularity in the form of excess earth fill at the first storey. structural walls were present at the second floor level which resulted in stiffness and strength irregularities. it was observed that the first two storeys which supported the whole building incurred heavy damage, and in contrary the upper four floors sustained a very less damage in fig. The previous earthquake damages and results of analytical studies showed that the structural systems with a soft storey led to serious problems during severe earthquake ground shaking. Many failures and collapses can be attributed to the increased deformation demands in conjunction with poorly designed columns.

The soft-storey effect was the main reason for collapse of many multi-storey R/C buildings during the earthquakes that occurred in Turkey during the last decade (Adalierand Aydingun 1998; Durumus et al. 1999; Huang and Skokan 2002; Sezen et al. 2003; Eyidogan et al. 2003. The majority of the residential and commercial buildings built in Turkey had soft storeys at the first-floor level which were often used for commercial purposes. These storeys were generally enclosed with glass windows instead of brick infill walls so as to be used as showrooms. The heavy masonry infills starting immediately above the soft storey which created a large variation of mass, stiffness and strength in the bottom storeys.

Failure Mode of Different Structures
Failure mode is the manner by which an earthquake induced failure is observed. It, generally, describes the way the failure occurs. Though costly and time consuming, learning from each real earthquake failure remains a routine recipe for advancement in seismic design methods. Below, some typical modes of earthquake-generated failures are presented

The lack of reinforcement coupled with poor mortar and inadequate roof-to-wall ties can result in substantial damage to an unreinforced masonry building. Severely cracked or leaning walls are some of the most common earthquake damage. Also hazardous is the damage that may occur between the walls and roof or floor diaphragms. Separation between the framing and the walls can jeopardize the vertical support of roof and floor systems.

Soft Storey
A soft story building is a multi-story building in which one or more floors have windows, wide doors, large unobstructed commercial spaces, or other openings in places where a shear wall would normally be required for stability as a matter of earthquake engineering design. A typical soft story building is an apartment building of three or more stories located over a ground level with large openings, such as a parking garage or series of retail businesses with large windows.

Soil Liquifaction
Soil liquefaction describes a phenomenon whereby a saturated or partially saturated soil substantially loses strength and stiffness in response to an applied stress, usually earthquake shaking or other sudden change in stress condition, causing it to behave like a liquid.

In the cases where the soil consists of loose granular deposited materials with the tendency to develop excessive hydrostatic pore water pressure of sufficient magnitude and compact, liquefaction of those loose saturated deposits may result in non-uniform settlements and tilting of structures. This caused major damage to thousands of buildings in Niigata, Japan during the 1964 earthquake.

Pounding against Adjacent Building
This is a photograph of the collapsed five-story tower, St. Joseph's Seminary, Los Altos, California which resulted in one fatality. During Loma Prieta earthquake, the tower pounded against the independently vibrating adjacent building behind. A possibility of pounding depends on both buildings' lateral displacements which should be accurately estimated and accounted for.

TYPES OF FAILURE

Structural failure can occur from many types of problems, most of which are unique to different industries and structural types. However, most can be traced to one of five main causes.

- The structure is not strong and tough enough to support the load, due to either its size, shape, or choice of material. If the structure or component is not strong enough, catastrophic failure can occur when the structure is stressed beyond its critical stress level.
- Failure is from fatigue or corrosion, caused by instability in the structure’s geometry, design or material properties. These failures usually begin when cracks form at stress points, such as squared corners or bolt holes

close to the material's edge. These cracks grow as the material is repeatedly, eventually reaching a critical length and causing the structure to suddenly under normal loading conditions.

- Failure is caused by manufacturing errors, including improper selection of materials, incorrect sizing, improper heat treating , failing to adhere to the design, or and shoddy workmanship. This type of failure can occur at any time and is usually unpredictable.
- Failure is from the use of defective materials. This type of failure is also unpredictable, since the material may have been improperly manufactured or damaged from prior use.
- Failure is from lack of consideration of unexpected problems. This type of failure can be caused by events such as vandalism, sabotage, or natural disasters. It can also occur if those who use and maintain the construction are not properly trained and overstress the structure.

Reinforcement must undergo large plastic deformation (ductile behaviour) before rupture during a very strong earthquake. Otherwise, if steel has low deformation capacity (brittle behaviour) before rupture the structure may not stand in a severe earthquake. This low-quality steel should never be used due to economic causes or quality control defects.

Correct mix design of concrete and correct firm choice as well as the preference of a qualified firm in RC reinforcement production are very important in the earthquake resistant RC building construction. In addition an intensive quality control should be carried out during construction.
As a final result, even in very strong earthquakes, a ductile performance is observed in the regular structures designed and built in accordance with regulations.

METHODOLOGY

Overview
Structure has been defined into stiffness irregularity as specified in IS1893-2002 code. In this dissertation work, an effort is made to study the seismic effects on structures due to this irregularity. Different configurations of structures are considered for the FE analysis using SAP 2000 software. FE analyses involving Modal, Equivalent Static, and Response Spectrum are studied for the structure and results like natural frequencies, accelerations, displacements. base shear and storey drifts are obtained for regular and irregular building.

Method of Analysis
Seismic analysis is a major tool in earthquake engineering which is used to understand the response of buildings due to seismic excitations in a simpler manner. There are different types of earthquake analysis methods.

(a) Linear Static Procedure

(b) Linear dynamic Procedure

(c) Response Spectrum method

(d) Time history method

(e) Nonlinear Static Procedure (Pushover analysis)

(f) Nonlinear dynamic procedure

(a) Time history method
Time-history analysis provides for linear or nonlinear evaluation of dynamic structural response under loading which may vary according to the specified time function. Dynamic equilibrium equations, given by $K\ u(t) + C\ ^{d}/dt\ u(t) + M\ d^{2}/dt\ u(t) = r(t)$, are solved using either modal or direct-integration methods.

Initial conditions may be set by continuing the structural state from the end of the previous analysis. Time history functions are loading magnitude versus time functions for use in time history analysis. The loading values in a time history function may be ground acceleration values or they may be multipliers for specified (force or displacement) load patterns.

Time history analysis is detailed analysis in which response is calculated for each time step in the time domain of the multi-degree-of-freedom (MDOF) equations of motion which represent the actual response of a building. It requires more time but gives good results. It is the most sophisticated analysis method available to a structural engineer. Its solution is a direct function of the earthquake ground motion selected as an input parameter for a specific building. This analysis technique is usually limited to checking the suitability of assumptions made during the design of important structures rather than a method of assigning lateral forces themselves. The steps involved in time history analysis are as follows:

(a) Obtaining of Displacement response in normal coordinate.
(b) Calculation of maximum response
(c) Calculation of time Vs acceleration, time Vs displacement and time Vs velocity.

(b) Response spectrum analysis

Response-spectrum analysis (RSA) is a linear-dynamic statistical analysis method which measures the contribution from each natural mode of vibration to indicate the likely maximum seismic response of an essentially elastic structure. Response-spectrum analysis provides insight into dynamic behavior by measuring pseudo-spectral acceleration, velocity, or displacement as a function of structural period for a given time history and level of damping. It is practical to envelope response spectra such that a smooth curve represents the peak response for each realization of structural period. Response-spectrum analysis is useful for design decision-making because it relates structural type-selection to dynamic performance. Structures of shorter period experience greater acceleration, whereas those of longer period experience greater displacement.

Structural performance objectives should be taken into account during preliminary design and response-spectrum analysis.

This approach permits the multiple modes of response of a building to be taken into account. This is required in many building codes for all except for very simple or very complex structures. The structural response can be defined as a combination of many modes. Computer analysis can be used to determine these modes for a structure. For each mode, a response is obtained from the design spectrum, corresponding to the modal frequency and the modal mass, and then they are combined to estimate the total response of the structure. In this the magnitude of forces in all directions is calculated and then effects on the building are observed

The result of a RSM analysis from the response spectrum of a ground motion is typically different from that which would be calculated directly from a linear dynamic analysis using that ground motion directly, because information of the phase is lost in the process of generating the response spectrum.

(c)Equivalent static analysis

The response of a structure to earthquake-induced forces is a dynamic phenomenon. Consequently, a realistic assessment of the design forces can be obtained only through a dynamic analysis of the building models. Although this has long been recognized, dynamic analysis is used only in frequently in routine design, because such an analysis is both complicated and time-consuming.

A major complication arises from the fact that most structures are designed with the expectation that they would be strained into the inelastic range when subjected to the design earthquake In the equivalent static analysis method, the response of the building is assumed as linear elastic manner.

STRUCTURAL MODELLING IN SAP2000

Overview

The SAP name has been synonymous with state-of-the-art analytical methods since its introduction over 30 years ago. Sap2000 follows in the same tradition featuring a very sophisticated, intuitive and versatile user interface powered by an unmatched analysis engine and design tools for engineers working on transportation, industrial, public works, sports, and other facilities.

Complex models can be generated and meshed with powerful built in templates. Integrated design code features can automatically generate wind, wave, bridge, and seismic loadswith comprehensive automatic steel and concrete design code checks per US, Canadian and international design standards. In Sap2000 following steps must be followed:

1. Geometric Modeling
2. Sectional Properties and Material Properties
3. Supports : Boundary Conditions
4. Loads & Load combinations
5. Analysis Specification and Design command

Geometric Modeling

To model any structure in SAP2000 the first step is to specify the nodal co-ordinate data followed by selection of elements from element library. For the present work beam elements are selected to model the structure.

Sectional Properties and Material Properties

The element selected for modeling is then assigned the properties if the element is beam the cross section of beam is assigned. For plate elements thickness is assigned. After assigning the sectional property to the member it is important to assign it with member properties. Material properties include modulus of elasticity, poisson's ratio; weight density, thermal coefficient, damping ratio and shear modulus.

Supports : Boundary Conditions

After assigning the sectional and material properties, boundary condition is assigned to the structure in form of fixed, hinged and roller support to structure. In the present work boundary condition is assigned in form of fixed support.

Loads & Load combinations

Loads are a primary consideration in any building design because they define the nature and magnitudes of hazards are external forces that a building must resist to provide a reasonable performance (i.e., safety and serviceability) throughout the structure's useful life.

The anticipated loads are influenced by a building's intended use (occupancy and function), configuration (size and shape) and location (climate and site conditions). Ultimately, the type and magnitude of design loads affect critical decisions such as material collection, construction details and architectural configuration. Thus, to optimize the value (i.e., performance versus economy) of the finished product, it is essential to apply design loads realistically. In the present project works following loads are considered for analysis.

i. Dead Loads (IS- 875 PART 1).

ii. Live Loads (IS 875 PART 2).

iii. Earthquake Loads by SCM (IS 1893:2002).

In addition to the above mentioned loads, dynamic loads in form of Response Spectrum method can also be assigned. SAP2000 also uses IS 1893 – 2002 (Part 1) parameters mentioned below to evaluate seismic output parameters in form of design seismic coefficient, base shear storey, shear and mass participation factor.

i. Seismic Zone Coefficient

ii. Response Reduction Factor

iii. Importance Factor

iv. Soil Site Factor

v. Type of Structure

vi. Damping Ratio (obtain Multiplication Factor for Sa/g)

vii. Depth of Foundation below Ground Level

RESULT AND DISCUSSION

Overview
The results of regular and irregular (soft storey) building model are presented in this chapter. The analysis carried out is equivalent static analysis and Dynamic analysis.

The result of Base shear, Lateral displacement, story drift, Fundamental time period at the first, second and third mode were presented for different irregularities and regular structure for different seismic zones of India.

The graph of Zone v/s Base shear of an Irregular model i.e. Stiffness irregularity (Soft storey). It shows that as the zone increases Base shear also increases, so the maximum Base shear is 14618.54KN in zone V, i.e. zone V base shears is 3.6 times greater than zone II which is the most vulnerable seismic zone of India.

CONCLUSION

When irregular buildings are analyzed using linear equivalent static analysis and Response spectrum analysis considering different seismic zones according to code provisions, the results obtained highlights the importance of stiffness of the structure. Following broad conclusions can be made in this respect:

- This study quantifies the effect of vertical irregularities in stiffness on seismic demands.
- The Base shear and lateral displacements are gradually increased with increase in zone factors for both the models.
- The lateral displacement is less in regular model compare to vertical irregular model.
- The base shear is different in regular model and irregular model, max base shear is in zone 5 in regular is 6091.07 KN and in irregular 14618.58KN.
- The regular model shows almost same displacement compare to irregular model (soft storey), max displacement in zone 5 in regular is 44.7mm and in irregular it is 43.7mm.
- The drift is observed in the storey in which the stiffness is reduced.

From the overall study and observation it can be conclude that, Base shear and lateral displacement will increases as the seismic intensity increases from zone-2 to zone-5 which indicates more seismic demand the structure should meet.

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