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Analysis of Seismic Forces for A Multi-Storied (G+15) Residential Building by Using STAAD.Pro

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***Abstract*— This project discusses the analysis procedure adopted for the evaluation of symmetric high rise multi-storey building (G+15) under the effect of Earthquake(EQ) forces. Earthquake occurred in multistoried building shows that if the structures are not well designed and constructed with and adequate strength it leads to the complete collapse of the structures. To ensure safety against seismic forces of multistoried building hence, there is need to study of seismic analysis to design earthquake resistance structures. In seismic analysis the response reduction was considered for two cases both ordinary moment resisting frame and special moment resisting frame. The main objective of this report is to study the seismic analysis of structures for static and dynamic analysis in ordinary moment resisting frame and special moment resisting frame. Equivalent static analysis and response spectrum analysis are the methods used in structural seismic analysis. We considered the residential building of G+ 15 storied structures for the seismic analysis and it is located in zone II. The total structure was analyzed by computer with using STAAD.PRO software. We observed the response reduction of cases ordinary moment resisting frame and special moment resisting frame values with deflection diagrams in static and dynamic analysis. The special moment of resisting frame structured is good in resisting the seismic loads.**

The main parameters consider for comparing wind performance of buildings are bending moment, shear force, deflection and axial force. The seismic design of building presented in this project is based on IS: 1893:2002 and IS: 1893:2005. And the wind load values were generated by STAAD.Pro considering the given wind intensities at different heights and strictly abiding by the specifications of IS: 875. Analytical results are compared to achieve the most suitable resisting system & economic structure against the lateral forces. The designed structure was analyzed and results were compared in terms of sections used.

Keywords: **Equivalent static analysis, response spectrum analysis, ordinary moment resisting frame, special moment resisting frame, STAAD.PRO V8i.**

1. Introduction

STAAD.Pro is structural engineering software widely used for the design of multistoried buildings. It is a comprehensive structural engineering software that addresses all aspects of structural engineering including model development, verification, analysis, design and review of results. It includes advanced dynamic analysis and push over analysis for wind load and earthquake load. STAAD.Pro is a comprehensive, integrated design and finite element analysis tool. The exponential growth of the Indian as well as the global construction industry has directly impacted the demand for structural engineers. It has become important for civil design engineers to be well equipped with the structural software like STAAD.Pro, since most of the companies are using STAAD as a tool for designing massive structures, it is imperative that professionals should get trained in this field too to gain advantage in the highly competitive construction market. It's a known fact that computers reduce man hours required to complete a project, and knowledge of STAAD will ensure fast and efficient planning as well as accurate execution. The commercial version STAAD.Pro is one of the most widely used structural analysis and design software. It supports several steel, concrete and timber design codes. It can make use of various forms of analysis from the traditional 1st order static analysis, 2nd order p-delta analysis, geometric non linear analysis or a buckling analysis. It can also make use of various forms of dynamic analysis from modal extraction to time history and response spectrum analysis.

In recent years it has become part of integrated structural analysis and design solutions mainly using an exposed API called OpenSTAAD to access and drive the program using an VB macro system included in the application or other by including OpenSTAAD functionality in applications that themselves include suitable programmable macro systems. Additionally STAAD.Pro has added direct links to applications such as RAM Connection and STAAD. Foundation to provide engineers working with those applications which handle design post processing not handled by STAAD.Pro itself. Another form of integration supported by STAAD.Pro is the analysis schema of the CIM steel Integration Standard, version 2 commonly known as CIS/2 and used by a number modelling and analysis applications.

Fast and gives accurate results.

Accurate and quick production of plans for massive constructions.

Reduces cost and saves labor.

1.2 Introduction of Seismic Analysis

A study of earthquake engineering calls for a good understanding of geophysical process that causes earthquakes and various effects of earthquakes. For the design of structures to resist earthquakes, it is necessary to have some knowledge on ground motions. Earthquakes motion can be recorded in terms of ground displacement, velocity or acceleration. Earthquake or seismic analysis is a subset of structural analysis which involves the calculation of the response of a structure subjected to earthquake excitation. This is required for carrying out the structural design, structural assessment and retrofitting of the structures in the regions where earthquakes are prevalent. Various seismic data are necessary to carry out the seismic analysis of the structures.

These data are accessible into two ways

- **Deterministic form**
- **Probabilistic form**

Data in deterministic form are used for design of structures etc whereas data in probabilistic form are used for seismic risk analysis, study of structure subjected to random vibration and damage assessment of structures under particular earthquake ground motion. Major seismic input includes ground acceleration/velocity/displacement data, magnitude of earthquake, peak ground parameters, duration etc.

A seismic zone is a region in which the rate of seismic activity remains fairly consistent. This may mean that seismic activity is incredibly rare, or that it is extremely common. Some people often use the term "seismic zone" to talk about an area with an increased risk of seismic activity, while others prefer to talk about "seismic hazard zones" when discussing areas where seismic activity is more frequent. Many nations have government agencies concerned with seismic activity. These agencies use the data they collect about seismic activity to divide the nation into various seismic zones.

A number of different zoning systems are used, from numerical zones to colored zones, with each number or color representing a different level of seismic activity. Most high-activity seismic zones are located along what are known as fault zones, regions of the Earth's crust which are prone to seismic activity. Fault zones often occur where continental plates meet, but they can also be found around volcanoes. A major fault zone in North America far from any plate boundaries is caused by a huge bubble of Magma under the Earth's crust which periodically bubbles up into an explosive volcanic eruption. By breaking a country up into different seismic zones, a nation can identify areas which are at increased risk. These areas may have more stringent building codes which are designed to make them safer in the event of an earthquake, and emergency services in a high risk seismic zone may be required to have special earthquake training and frequent drills to practice responding to an earthquake. Insurance companies usually also increase their rates in a high-activity seismic zone.

2. LOADS CONSIDERED

2.1 General

The basic requirements of any structure or structural components is that it should be strong enough to carry or Support all types of loads to which it is likely to be subjected.

- **Dead loads**
- **Imposed loads**
- **Wind loads**

Seismic loads [As per IS 1893-2002]

2.1.1 Dead load

The dead load in a building shall comprise the weight of all walls, partitions, floors and roofs and shall include the weights of all other permanent construction in the building. Such loads do not change their position and do not vary in magnitude. The dead loads may be calculated from the dimensions of various members and their unit weights. The unit weights of plain concrete and reinforced concrete made with sand and gravel or crushed natural stone aggregate may be taken as 24 kn/m and 25 kn/m respectively.

2.1.2 Imposed load

These are loads which are not permanently acting on the structure. They can classified into five categories. These are service loads or working loads caused by superimposed loads which vary only in a gradual manner. Loads due to furniture, stored materials and persons occupying or moving into the room come in this category. In the case of buildings, for simplicity in design calculations, these loads are assumed as uniformly distributed on the area considered.

2.1.3 Wind load

Wind is the air motion relative to the surface of the earth. Since the vertical components of atmospheric motion are small, specially near the surface of earth. The radiation effects are primarily responsible for convection either upwards or downwards. The wind generally blows horizontal to the ground at high wind speeds. Since vertical components of atmospheric motion are relatively small, the term 'wind' denotes almost exclusively the horizontal wind, vertical winds are always identified as such. The wind speeds are assessed with the aid of anemometers or anemographs which are installed at meteorological observatories at heights generally varying from 10 to 30 meters above ground.

Design wind speed:

The design wind speed for a place is obtained from the basic wind speed the basic wind speed at the place by using the formula

$$V_z = V_b * k_1 * k_2 * k_3$$

Risk Coefficient(k_1 Factor):

, Gives basic wind speeds for terrain Category 2 as applicable at 10 m above ground level based on 50 years mean return period. In the design of all buildings and structures, a regional basic wind speed having a mean return period of 50 years shall be used.

Terrain, Height and Structure Size Factor(k_2, Factor):

Terrain - Selection of terrain categories shall be made with due regard to the effect of obstructions which constitute the ground surface roughness. The terrain category used in the design of a structure may vary depending on the direction of wind under consideration. Wherever sufficient meteorological information is available about the nature of wind direction, the orientation of any building or structure may be suitably planned.

Topography (k_3 Factor):

The basic wind speed V_b takes account of the general level of site above sea level. This does not allow for local topographic features such as hills, valleys, cliffs, escarpments, or ridges which can significantly affect wind speed in their vicinity. The effect of topography is to accelerate wind near the summits of hills or crests of cliffs, escarpments or ridges and decelerate the wind in valleys or near the foot of cliff, steep escarpments, or ridges.

Design wind pressure (P_z)

The design wind pressure at any height above mean ground level shall be obtained by the following relationship between wind pressure and wind velocity.

$P_z = 0.6(Vz)^2$

Where

P_z = Design wind pressure

V_z = Design wind speed

2.1.4 Seismic load

The resultant loads on structures due to earthquake are called earthquake loads or seismic loads, denoted by E or EL. Even though earthquake motion involves, horizontal and torsional oscillations, only horizontal motion is considered to be importance in structural design. Vertical seismic forces are only a fraction of the gravity loads and these are assumed to be taken care of by the factor of safety provided for dead and live loads

3. METHODS OF SEISMIC ANALYSIS

3.1 Introduction

Methods of seismic analysis are

- Equivalent static analysis
- Response spectrum analysis
- Linear dynamic analysis
- Nonlinear static analysis
- Nonlinear dynamic analysis

3.1.1 Equivalent Static Analysis

This approach defines a series of forces acting on a building to represent the effect of earthquake ground motion, typically defined by a seismic design response spectrum. It assumes that the building responds in its fundamental mode. For this to be true, the building must be low-rise and must not twist significantly when the ground moves. The response is read from a design response spectrum, given the natural frequency of the building (either calculated or defined by the building code). The applicability of this method is extended in many building codes by applying factors to account for higher buildings with some higher modes, and for low levels of twisting. To account for effects due to "yielding" of the structure, many codes apply modification factors that reduce the design forces (e.g. force reduction factor).

3.1.2 Response Spectrum Analysis

This approach permits the multiple modes of response of a building to be taken into account (in the frequency domain). This is required in many building codes for all except for very simple or very complex structures. The response of a structure can be defined as a combination of many special shapes (modes) that in a vibrating string correspond to the "harmonics". Computer analysis can be used to determine these modes for a structure. For each mode, a response is read from the design spectrum, based on the modal frequency and the modal mass, and they are then combined to provide an estimate of the total response of the structure. In this we have to calculate the magnitude of forces in all directions i.e. X, Y & Z and then see the effects on the building..

Combination methods include the following:

absolute - peak values are added together

square root of the sum of the squares (SRSS)

complete quadratic combination (CQC) - a method that is an improvement on SRSS for closely spaced modes

The result of a response spectrum analysis using the response spectrum from a ground motion is typically different from that which would be calculated directly from a linear dynamic analysis using that ground motion directly, since phase information is lost in the process of generating the response spectrum. In cases where structures are either too irregular, too tall or of significance to a community in disaster response, the response spectrum approach is no longer appropriate, and more complex analysis is often required, such as non-linear static analysis or dynamic analysis.

3.1.3 Dynamic Analysis Methods

It is performed to obtain the design seismic force and its distribution to different level along the height of the building and to the various lateral load resisting elements for the regular buildings and irregular buildings also as defined in IS-1893-Part-1-2000 in clause 7.8.1.

(i) **Regular building**:

(a) Those > 40 meter height in zone IVth and Vth.

(b) Those > 90 meter height in zone IInd and IIIrd.

(ii) **Irregular building**:

(a) All framed building higher than 12 meter in zone IVth and Vth.

(b) Those greater than 40 meter in zone IInd and IIIrd.

4. CONCLUSIONS

The obtained results of static and dynamic analysis in OMRF & SMRF are compared for different columns under axial, torsion, bending moment and displacement forces.

The results in graph-1 shows that there is equal values obtained of axial forces in static and dynamic analysis of OMRF structure. The results in graph-2 shows that the values are obtained for torsion in static analysis are negative and dynamic analysis values are positive. The results in graph-3 here we can observe that the values for bending moment at dynamic analysis values are high in initially for other columns it decreased gradually as compared to that of static analysis. The results in graph-4 we can observe that the values for displacement in static analysis of OMRF values are more compared to that of dynamic analysis values of same columns.

The results in graph-5 shows that the values obtained of axial forces in dynamic analysis of SMRF structure values are high compare to static analysis. The results in graph-6 shows that the values are obtained for torsion in static analysis are negative and dynamic analysis values are positive with more difference. In the results graph-7, we can observe that the values for bending moment at dynamic analysis values are more as compared to that of static analysis SMRF structure. In the results graph-8, we can observe that the values for displacement in dynamic analysis of SMRF values are gradually increased compared to that of static analysis values of same columns.

The static and dynamic analyses of OMRF & SMRF values are observed. Finally it can conclude that the results of static analysis in OMRF & SMRF values are low when comparing to that of dynamic analysis in OMRF & SMRF values. Hence the performance of dynamic analysis SMRF structure is quiet good in resisting the earthquake forces compared to that of the static analysis OMRF & SMRF.

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