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COMPARATIVE ANALYSIS OF BUILDING BY RESPONSE SPECTRUM METHOD AND SEISMIC COEFFICIENT METHOD

Mr. Chetan A. Timande [1], Dr. P. P. Saklecha[2] , Prof.M.S.Kitey[3]

[1] P.G. Scholar Dept of Civil Engg, BDCE, Sevagram, [2] Department of Civil Engg. B.D.C.E. Sevagram,

[3] Department of Civil Engg. B.D.C.E. Sevagram

[1] chetantimande@gmail.com

ABSTRACT

Right from the evolution of the earth, Earthquakes have been cause great disasters in the form of destruction of property, injury and loss of life to the population. The effective design and construction of earthquake resistant structures has much greater importance in this country due to rapid industrial development and concentration of population in cities. In this project, the earthquake response of symmetric multi-storied building by two methods will be studied. The methods include seismic coefficient method and response spectrum method as recommended by IS Code 1893-2002 part I, where natural frequencies, period, base shear, lateral forces are calculated by STAAD-PRO software as well as manually by seismic coefficient method. The methods include seismic coefficient method (by empirical formula) and modal analysis using response spectrum method of IS Code in which the stiffness matrix of the building corresponding to the dynamic degrees of freedom is generated by considering the building as shear building. The responses obtained by above methods in zones IV as mentioned in IS code will be studied. Test results on Base Shears, Lateral Forces and Storey Moments will be compared.

INTRODUCTION

A large portion of India is susceptible to damaging levels of seismic hazards. Hence, it is necessary to take into account the seismic load for the design of high-rise structure. In tall building the lateral loads due to earthquake are a matter of concern. These lateral forces can produce critical stresses in the structure, induce undesirable stresses in the structure, induce undesirable vibrations or cause excessive lateral sway of the structure. Seismic design approaches are stated, as the structure should be able to ensure the minor and frequent shaking intensity without sustaining any damage, thus leaving the structure serviceable after the event. The structures withstand moderate level of earthquake ground motion without structural damage, but possibly with some structural as well as non-structural damage. In present study, the earthquake analysis of G+10 storied building will be done by both methods i.e. Seismic Coefficient Method and Response Spectrum Method. In Response Spectrum Method, the Time Periods, Natural Frequencies and Mode Shape Coefficients are calculated by STAAD-Pro program then remaining process will be done by manually. The modal combination rule for Response Spectrum Analysis is SRSS. The main parameters considered in this study to compare the seismic performance of the zone IV are Base Shear, Storey Moment and Lateral Forces.

II.METHODOGY

The present study discuss comparative analysis of G+10 building by response spectrum method and seismic coefficient method using STAAD software with IS 1893-2002 (part-I). STAAD stands for structural analysis and design also it is used for numerical study. In this study , the analysis of G+10 building is done by using STAAD software and results are compared using response spectrum method and seismic coefficient method are mentioned in IS 1893:2002 (part-I). The building is located in zone IV region. The result obtained for base shear, Lateral Forces and Storey Moments obtained from STAAD software match with IS 1893:2002 (part-I) and the value of base shear obtained by response spectrum method and seismic coefficient method are compared. The comparative study of design analysis by response spectrum method and seismic coefficient method are compared.*References*

IV.RESPONSE SPECTRUM METHOD

In order to perform the seismic analysis and design of a structure to be built at a particular location, the actual time history record is required. However, it is not possible to have such records at each and every location. Further, the seismic analysis of structures cannot be carried out simply based on the peak value of the ground acceleration as the response of the structure depend upon the frequency content of ground motion and its own dynamic properties. To overcome the above difficulties, earthquake response spectrum is the most popular tool in the seismic analysis of structures. There are computational advantages in using the response spectrum method of seismic analysis for prediction of displacements and member forces in structural systems. The method involves the calculation of only the maximum values of the displacements and member forces in each mode of vibration using smooth design spectra that are the average of several earthquake motions. The codal provisions as per IS: 1893 (Part 1)-2002 code for response spectrum analysis of multi-story building is also summarized. In this method, first the response acceleration coefficient for the natural vibration period and damping of the structure are required. Based on these values, the horizontal seismic coefficient, α_h, can be computed as:

α_h = Z.I.Sa / 2.R.g

Where, R = Performance factor depending upon the structural framing system and / or ductility of construction.

I = a factor depending upon the Importance of the structure.

Z = Seismic Zone Factor for average acceleration spectra.

Sa/g = average acceleration coefficient based on appropriate natural periods and damping of the structure.

As per IS 1893 (part1)-2002, Response Spectrum Method is summarized in following steps:-

a) Modal mass (M_k) – Modal mass of the structure subjected to horizontal or vertical as the case may be, ground motion is a part of the total seismic mass of the Structure that is effective in mode k of vibration. The modal mass for a given mode has a unique value, irrespective of scaling of the mode shape.

$$M_k = \frac{[\sum W_i \phi_{ik}]^2}{g \sum W_i \phi_{ik}^2}$$

Where, g = acceleration due to gravity.

$\emptyset_{ik}$ = mode shape coefficient at floor i in mode k.

b) Modal Participation factor (P_k) – Modal participation factor of mode k of vibration is the amount by which mode k contributes to the overall vibration of the structure under horizontal or vertical earthquake ground motions. Since the amplitudes of 95 percent mode shape can be scaled arbitrarily, the value of this factor depends on the scaling used for the mode shape.

$$P_k = \frac{\sum w_i \emptyset_{ik}}{\sum w_i \emptyset_{ik}^2}$$

c) Design lateral force at each floor in each mode – The peak lateral force (Q_{ik}) at floor i in Mode k is given by:- $Q_{ik} = A_{hk}\, \phi_{ik}\, P_k\, W_i$

Where,

A_{hk} = Design horizontal spectrum value using natural period of vibration (Tk) of mode k.

$$A_{hk} = Z.I.S_a / 2.R.g$$

Z= zone factor for the maximum considered earthquake,

I= Importance factor depending upon the functional use of the structures,

R= Response Reduction factor

Sa/g= Average response acceleration coefficient for rock or soil sites as given by response spectra and based on appropriate natural periods and damping of the structure.

d) Storey shear forces in each mode – The peak shear force (Vik) acting in storey i in mode k is given

$$V_{ik} = \sum_{j=i+1}^{n} Q_{ik}$$

e) Storey shear force due to all modes considered : The peak storey shear force (Vi) in storey i due to all modes considered is obtained by combining those due to each mode as per SRSS. If the building does not have closely spaced modes, than the peak response quantity due to all modes considered shall be obtained as per Square Root of Sum of Square method Dynamic analysis may be performed either by time history method or by the response spectrum method. However in either method, the design base shear VB shall be compared with a base shear (V_b) calculated using a fundamental period Ta. When VB is less than all the response quantities shall be multiplied by V_b/VB.

SEISMIC COEFFICIENT METHOD

A Seismic coefficient is a subset of structural analysis and is the calculation of the response of a building (or nonbuilding) structure to earthquakes. It is part of the process of structural design, earthquake engineering or structural assessment and retrofit (see structural engineering) in regions where earthquakes are prevalent.This method is simple and may be used for simple structures where Response Spectrum Method is not warrant. In this method, the seismic forces can be computed on the basis of importance of the structures and its soil- foundation systems. The horizontal seismic coefficient αh, can be computed as:

$$\alpha h = \beta\, I\, \alpha 0$$

where: β = a coefficient depending upon the foundation system .

I = a factor depending upon the Importance of the structure.

α0 = basic horizontal seismic coefficient.

As per IS 1893 (part1)-2002, Seismic Coefficient analysis Procedure is summarized in following steps :-a) Design Seismic Base Shear- The total design lateral force or design seismic base shear (Vb) along any principal direction of the building shall be determined by the following expression:- (VB= Ah x W)

Where,

Ah = Design horizontal seismic coefficient

W = Seismic weight of the whole building.

b) Seismic Weight of Building- The seismic weight of each floor is its full dead load plus appropriate amount of imposed load as specified. While computing the seismic weight of each floor, the weight of columns and walls in any storey shall be equally distributed to the floors above and below the storey. The seismic weight of the whole building is the sum of the seismic weights of all the floors. Any weight supported in between the storey shall be distributed to the floors above and below in inverse proportion to its distance from the floors.

c) Fundamental Natural Time Period- The fundamental natural time period (Ta) calculates from the expression:-

Ta = 0.075 h0.75 for RC frame building

Ta = 0.085 h0.75 for steel frame building

If there is brick filling, then the fundamental natural period of vibration, may be taken as:-

$$Ta = 0.09\,H / \sqrt{d}$$

d) Distribution of Design Force- The design base shear, VB computed above shall be distributed along the height of the building as per the following expression.

$$Qi = VB \frac{W_i h_i^2}{\sum_{j=1}^{n} W_j h_j^2}$$

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