A Study of Nonlinear Analysis of RCC Structure For Specified Ground Motion Using Time History Analysis

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Abstract- *Earthquakes occurred in recent past have indicated that if the structures are not properly designed and Constructed with required quality may cause great destruction of structures. This fact has resulted in to ensure safety against earthquake forces of tall structures hence, there is need to determine seismic responses of such building for designing earthquake resistant structures by carrying seismic analysis of the structure.*

Keywords- Response Spectrum ,Wind load Analysis, symmetrical building

I. INTRODUCTION

The earthquake waves passes and shakes the earth surface, which discharge energy that had been confined in stressed rocks, and were radiated when a slip broke and the rocks slid to release the repressed stress. The strength of ground quaking is determined in the acceleration, duration, and frequency content of the ground motion.

The frequency content of ground motion decides the response of RC building. Low, intermediate, and high are frequency contents for ground motions .Low, mid, and high-rise reinforced concrete buildings show different response for low, intermediate, and high-frequency content ground motions.

According to the present work low, mid, and high-rise reinforced concrete buildings behave as low, intermediate, and high-frequency content ground motions

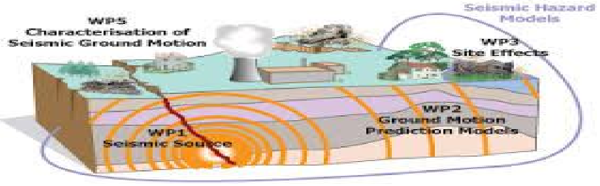

Fig 1.1A Schematic representation of ground motion

The lateral loads used in seismic design are highly unpredictable. Actual forces that action structures during earthquakes are much higher than the design forces. It is clear that neither design alone based on strength criteria is justified nor the complete protection against earthquakes of all sizes is economically feasible. The lateral strength as well as deformability and ductility capacity of structure with limited damage but no collapse should be the basic approach of earthquake resistant design.

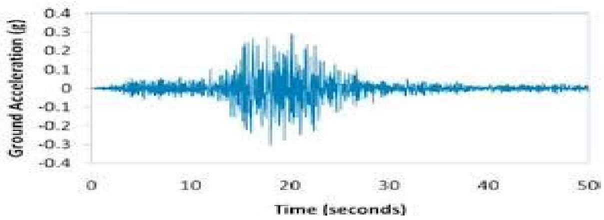

Fig 1.1 B- Ground motion recorded by seismograph

The most determinant effect on a structure is generally caused by lateral component of earth quake load. The earthquake load effects on buildings are quite variable and increase rapidly as the height of building increases as compared to gravity load effect. For gravity loads, area supported by a column and spans of beam is considered for structure design; whereas for earthquake loads, design is a function of total mass, height. It is likely that low and midrise structures, having good structural form can carry most of earthquake loads. The strength requirement is a dominant factor in the design of structure. As height increases the rigidity (i.e. the resistant to lateral deflection) and stability (i.e. resistant to overturning moments) of structure gets affected.

DETAILED EVALUTION METHOD

a) Equivalent Static Method
b) Time History Method
c) Response Spectrum Method

- RESPONCES SPECTRUM METHOD

Interaction between ground accelerations and structural systems are reported through response spectrum. Peak responses over time are plotted for a range of single-degree-of-freedom (SDOF) systems subjected to a particular base motion as a function of their natural frequency ωi, or vibration period Ti. For any linear system, the resulting plot can then be used to pick off the response of a, given its natural frequency of oscillation. Response spectra are used by earthquake engineers for analyzing the performance of structures in earthquakes, since many behave principally as single degree of freedom systems. The purpose of the response spectrum is to know the response of a single degree of freedom system if the ground moves as per the given accelerogram. An accelerogram is the recording of the acceleration of the ground during an earthquake. Response may mean any quantity like acceleration, velocity or deformation.

- Time History method

A time history analysis will give the response of a structure over time during and after the application of a load. The structure's equation of motion gives the solution.

Design Spectrum

Even with a little change in natural frequency of the structure response spectrums vary a lot and so have very irregular shape with local maxima and minima. For design purposes, local maxima and minima are ignored because natural period of structures cannot be calculated very accurately. Thus design spectrum is a smooth response spectrum specifying level of seismic resistance required for design. It is a specification of the required strength of the structure.

The strength depends on the following factors:

a) Frequency
b) Maximum velocity
c) Maximum displacement
d) Maximum acceleration

Design spectrum must also be accompanied by

a) Load factors, as different choices of load factors will lead to different seismic safety of the structure.
b) Damping, variations in the values of damping used in the design will affect the design force.
c) Method of calculation of natural period of the structures, which depends upon the assumptions made while modeling.

AIM

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OBJECTIVE

a) To study and analyses RCC building for specified ground motion using Time history analysis considering previous earthquake data.
b) To study and analyses non linearity effect of building in high seismic zone, of different categories i.e. High Rise ,Low Rise, Medium Rise
c) To validate result of base shear and vertical distribution of base shear for low rise building for zone-III in STAAD-Pro.
d) To compare nonlinear results such as Acceleration, Displacement, Natural frequency and time period for High Rise ,Low Rise, Medium Rise implanting shear wall in existing building.

II. LITERATURE REVIEW

Rathje, et al. [12] :- studied three simplified frequency content, which are mean period (Tm), predominant period (Tp), and smoothed spectral predominant period (Tp). They computed the frequency parameters for 306 motion records from twenty earthquakes. They used the data for developing a model to describe the site reliance, magnitude, and distance of the frequency content parameters. Model coefficients and standard error terms are evaluated by means of nonlinear regression analyses. The results show that the conventional parameter Tp has the highest uncertainty in its prediction and the earlier correlation suggested predicting Tp are unreliable with their current data set. Moreover, the best frequency content characterization parameter is Tm.

The stochastic method is a basic and powerful method for simulation of ground motions. The adjustment are specified as a combination of combination of parametric or functional description of the amplitude spectrum of ground motion with a random phase spectrum such that the motion is distributed over a time span related to the earthquake magnitude and to the distance from the source. This method is useful for simulation of higher-frequency ground motions (e.g. 0-1 Hz) and when the recordings of the potentially damaging earthquakes are not accessible, it is used to predict them. [13]
Chin-Hsun [15] :- proposed a new stochastic model of ground excitation in which both frequency content intensity are time dependent. The stimulations can be effectively employed by the proposed ground motion moel as well as random vibration and reliability studies of nonlinear structures. Responses of

single-mass nonlinear systems and three-story space frames, with or without deterioration under the no stationary biaxial ground motion are found through the equivalent linearization method and Monte Carlo simulations. His results indicate that the time-varying frequency content and the dominant frequencies of ground motion are close to the structural natural frequency. In addition, biaxial and torsional response may become noteworthy in an unsymmetrical structure.

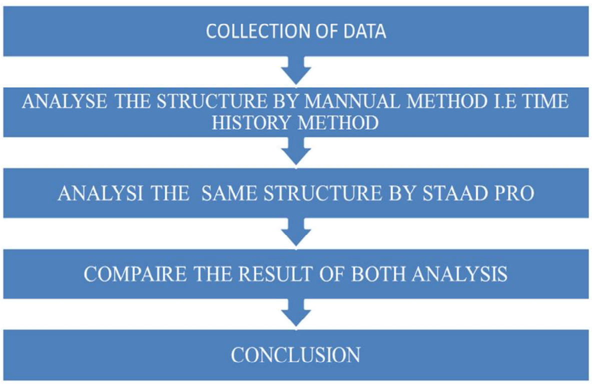
Omer Mohamad Amine (2000) :- They covers various aspects of seismic design of reinforced concrete structures with an emphasis is on Design for regions of high seismicity. The principal departure from the conventional design for gravity and wind loading is represented by the greater requirement of earthquake resistant building, the Major part of the discussion in this chapter will be devoted to considerations associated with providing Ductility in members and structures. The discussion in this chapter will be confined to monolithically cast Reinforced concrete buildings. The concepts of seismic demand and capacity are introduced and specific provisions for design of seismic resistant reinforced concrete members and systems are presented in detail. Appropriate seismic detailing considerations are discussed. Finally, a numerical example is presented where these principles are applied dynamic forces due to the wind and earthquake.

III. METHODOLOGY

In this project we determine fundamental mode shapes of building like natural time period, base shear, acceleration by manually by using time history method. At the same time we are analysing the structure by using FEM tool i.e. STAAD-Pro.

The way of working is tabulated in flow chart format bellow.

Methodology flow chart diagram



- Material Properties

The table shows the concrete and steel bar properties, which are used for modeling of the reinforced concrete buildings in STAAD Pro [1]. Concrete and steel bar properties as per IS 456 [30]

Concrete properties:-

Unit weight (γcc)	25 (kN/m3)
Modulus of elasticity ($EEcc$)	22360.68 (MPa)
Poisson ratio (νcc)	0.2
Thermal coefficient ($\alpha\alpha cc$)	5.5x10-6
Shear modulus ($GGcc$)	9316.95 (MPa)
Damping ratio (ςcc)	5 (%)
Compressive strength ($FFcc$)	30 (MPa)

Steel bar properties:-

Unit weight (γss)	76.9729 (kN/m3)
Modulus of elasticity ($EEss$)	2x105 (MPa)
Poisson ratio (νss)	0.3
Thermal coefficient ($\alpha\alpha ss$)	1.170x10-6
Shear modulus ($GGss$)	76923.08 (MPa)
Yield strength ($FFyy$)	415 (MPa)
Tensile strength ($FFuu$)	485 Pa)

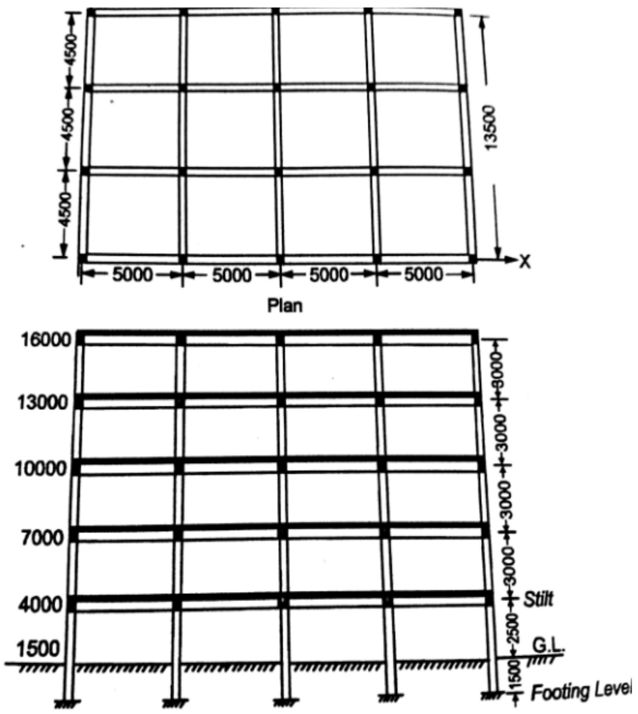
IV. PROBLEM STATEMENT

For the analysis of non-linear behavior of RCC structures 3 categories of building is selected i.e. Low rise, Medium Rise, High Rise following models are prepared using FE tool STAAD-Pro. Time History analysis previous recorded earthquake data of Elcentro is used, which is referred by many papers. The Time history record is given in table below

Time step(sec)	Acceleration(m/s2)
0.0000	0.006300
0.0200	0.003640
0.0400	0.000990
0.0600	0.004280
0.0800	0.007580
0.1000	0.010870

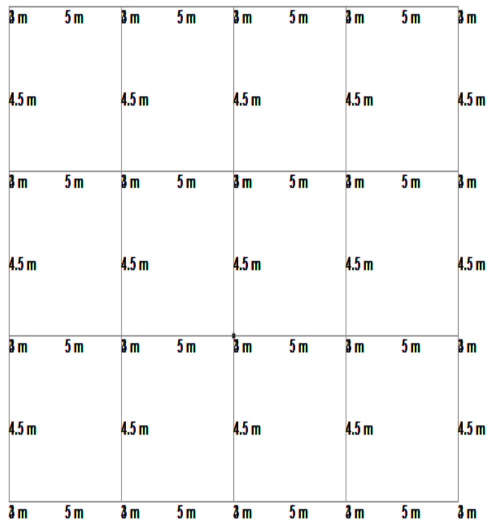
Thickness of slab: 130mm
Beam size: 250mm X 350 mm
Column size at G.L.:250mm X 400 mm
Thickness of outer wall including plaster: 250 mm
Thickness of partition wall including plaster: 175 mm
Load due to roof finish: 2kN/m2
Load due to floor finish: 1kN/m2
Imposed load: 4kN/m2
Type of foundation: Isolated footing

Soil Condition: Hard Murum available at depth of 1.5m below G.L. Zone-III

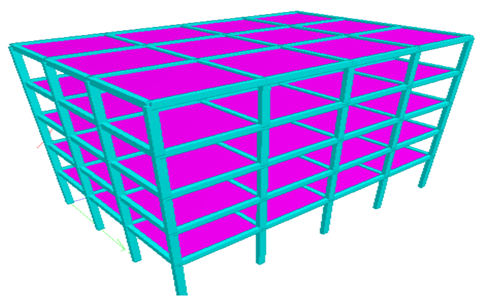


Above problem isanalys with the help of time history methid by using IS 1893 : part2 and also with the help of STAAD-Pro.The following results are found out by both calculation

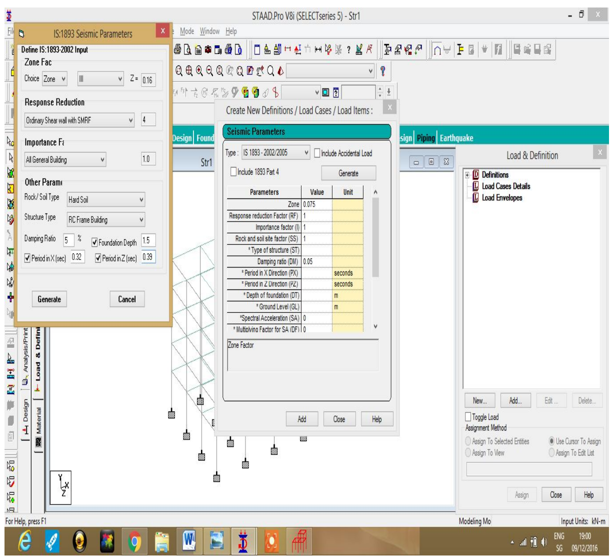
Story level	Wi	Hi	Wi* hi2	Qi= $V_B \cdot \frac{W_i h_i^2}{\sum_{j=1}^{n} W_j h_j^2}$	Qi STAAD-Pro
4	234 3	16	599808	212.5	221.06
3	353 8	13	597922	211.9	220.40
2	353 8	10	353800	125.4	130.42
1	353 8	7	173362	61.4	63.9
Plinth	271 6	4	43456	15.7	16.3



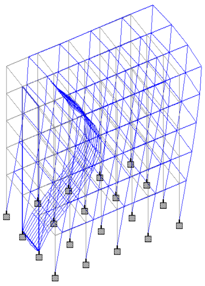
Plan in STAAD- Pro



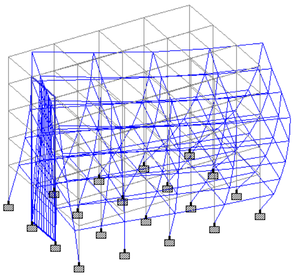
3D Model Structure Of Low Rise Building



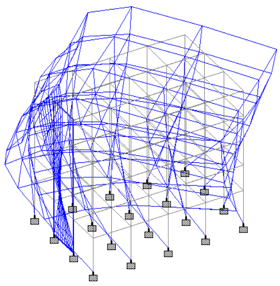
Implantation of IS 1893:2002 provision in STAAD-Pro



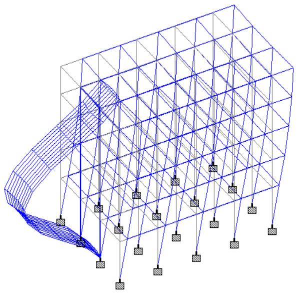
mode shape 1



mode shape 2



mode shape 3



mode shape 4

After validation of above problem we find out mode shape for various G+4, G+7, G+15 building with shear wall and without shear wall and finally effect of shear wall over each fundamental properties of structure is found out.

V. RESULTS AND CONCLUSION

In later part, the study of low rise building, medium rise building and high rise building is done using previous earthquake data. For checking non linearity effect of structure Time history analysis is applied in given models ; Using Time History method apart from bending moment, shear force, beam stress ; Time vs deformation Time vs velocity, Time vs acceleration is obtained and following results are obtained The natural frequency of G+4, G+7, G+15 is increased nearly 15-20% by using shear wall which implies decrease in time period.

Using Time History method apart from bending moment, shear force, beam stress ; Time vs deformation,

- Acceleration of top most node for G+4, G+7, G+15 (node no. 26,41,81) reduced by 6% along X-direction,Y-direction 3%, Z –direction 43%
- Velocity of top most node for G+4, G+7, G+15 (node no. 26,41,81) reduced by 2% along X-direction, Y-direction 3%, Z –direction 44%
- Deformation of top most node for G+4, G+7, G+15 (node no. 26,41,81) reduced by 1% along X-direction, Y-direction 2%, Z –direction 54%

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