IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

A REVIEW PAPER ON TIME HISTORY ANALYSIS / NON LINEAR DYNAMIC ANALYSIS OF HIGH RISE BUILDING USING ETABS

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Abstract : This paper aims to describe the study of the time history analysis using ETABS. An earthquake is the result of a rapid release of strain energy storied in the earth crust that generates seismic waves. Structures are vulnerable to earthquake ground motion and damages the structures. In order to take precaution for the damage of structures due to ground motion, it is important to know the characteristics of the ground motion. The most important dynamic characteristics of earthquake are peak ground acceleration, frequency content, and duration. These characteristics play predominant rule studying the behaviour of structures under the earthquake ground motion. The earthquake analysis of multistorey structure is done by linear and nonlinear methods. Response spectrum method of analysis is linear dynamic analysis. For nonlinear dynamic analysis time history method is used. In this paper, response spectrum method is used for linear analysis. For nonlinear analysis, time history method is used. For time history method Both the analyses are done using ETABs software.

Keywords — **TIME HISTORY METHOD, RESPONSE SPECTRUM METHOD, TIME PERIOD, ETABS.**

I. Introduction

All over world, there is huge demand for construction of high rise buildings due to increasing population Earthquake resistant design of engineering structures is one of the most important method of damage from future earthquake. The earthquake design of structure is based on the specification of ground motion of previous earthquake results. So earthquake resistant design of any important structure according to the seismic frequency is very important to overcame from damage. However the earthquake forces are different and un predictable .so the software tools need to be used for analysing structures under any seismic forces.

Earthquake develops different intensities at different locations and the damage induced in buildings at these locations is also different according to the type of structure. Therefore it is Necessary to study the seismic behaviour of RC framed building for different seismic intensities.

The seismic intensities in terms of various responses such as base shear, lateral displacement. Different types of analysis are used to identify the seismic resistance and behaviour of building under applied seismic frequencies.

The analysis can be performed on the basis of external applied loads, applied structural materials and type of structure, the analysis are classified as 1).Linear static Analysis 2)Non linear static analysis 3)Linear Dynamic Analysis 4)Non linear Dynamic Analysis.

The Time history analysis is response of the structure including inertial effects, this is advanced to response spectrum analysis, and gives base acceleration, displacement, and duration.

This is useful for very high rise structures to know the behaviour of structure under any seismic attacks. This analysis requires previous earthquake data to perform the analysis. It is a step by step analysis of response of structure under specified load that may vary with time.

II. SEISMIC METHOD OF ANALYSIS

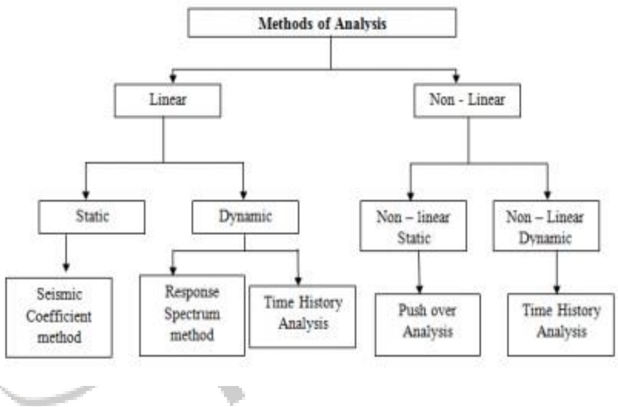
For the determination of seismic responses there is necessary to carry out seismic analysis of structure. The analysis can be performed on the basis of external action, the behaviour of structure or structural materials, and the type of structural model selected. Based on the type of external action and behaviour of structure, the analysis can be further classified as: (1) Linear Static Analysis, (2) Nonlinear Static Analysis, (3) Linear Dynamic Analysis; and (4) Nonlinear Dynamic Analysis. Linear static analysis or equivalent static method can be used for regular structure with limited height. Linear dynamic analysis can be performed by response spectrum method. The significant difference between linear static and linear dynamic analysis is the level of the forces and their distribution along the height of structure. Nonlinear static analysis is an improvement over linear static or dynamic analysis in the sense that it allows inelastic behaviour of structure. A nonlinear dynamic analysis is the only method to describe the actual behaviour of a structure during an earthquake. The method is based on the direct numerical integration of the differential equations of motion by considering the elasto-plastic deformation of the structural element.

Equivalent Static Analysis:- This procedure does not require dynamic analysis, however, it account for the dynamics of building in an approximate manner. The static method is the simplest one-it requires less computational efforts and is based on formulate given in the code of practice. First, the design base shear is computed for the whole building, and it is then distributed along the height of the building. The lateral forces at each floor levels thus obtained are distributed to individuals lateral load resisting elements.

Linear Dynamic Analysis:- Linear dynamic analysis can be performed in two ways either by mode superposition method or response spectrum method and elastic time history method. This analysis will produce the effect of higher modes of vibration and the actual distribution of forces in the elastic range in a better way. They represent an improvement over linear static analysis. The significance difference between linear static and linear dynamic analysis is the level of force and their distribution along the height of the structure.

Non linear static analysis:- Non linear static analysis is an improvement over linear static or dynamic analysis as it allows the inelastic behavior of the structure. The method still assumes a set of static incremental lateral load over the height of the structure. The method is relatively simple to be implemented and provides information on the strength, deformation and ductility of the structure and the distribution of demands. This permit to identify critical members likely to reach limit states during the earthquake, for which attention should be given during the design and detailing process. But this method contains many limited assumptions, which neglects the behaviour of loading patterns, the influence of higher modes, and the effect of resonance. Push over analysis has acquired a great deal of popularity nowadays in spite of these deficiencies this method provides reasonable estimation of the global deformation capacity, especially for structures which primarily respond according to the first mode.

Non linear Dynamic Analysis:- A non linear dynamic analysis of inelastic time history analysis is the only method to describe the actual behavior of the structure during an earthquake. Time history analysis is a step-by step analysis of the dynamic response of a structure to a specified loading that may vary with time. Time history analysis is used to determine the seismic response of a structure under dynamic loading of representative earthquake. This method is based on the direct numerical integration of the differential equations of motions by considering the elasto-plastic deformation of the structure element. This method capture the effect of amplification due to resonance, the variation of displacements at diverse levels of a frame, an increase of motion duration and a tendency of regularization of movements result as far as the level increases from bottom to top. [2]



III. TIME HISTORY ANALYSIS

In order to examine the exact nonlinear behavior of structures, nonlinear time history analysis has to be carried out. In this method, the structure is subjected to real ground motion records.[6] This makes this analysis method quite different from all of the other approximate analysis methods as the inertial forces are directly determined from these ground motions and the responses of the building either in deformations or in forces are calculated as a function of time, considering the dynamic properties of the structure.

In Etabs , the nonlinear time-history analysis can be carried out as follows: 1. The models representing the buildings are created and vertical loads (dead load and live load), member properties and member nonlinear behaviors are defined and assigned to the model.

The ground motion record is defined as a function of acceleration versus time. Here after, the analysis and the time history parameters are defined in order to perform a nonlinear time history analysis. The total time of the analysis is the number of output time steps multiplied by the output time-step size. To match time history to target response spectra, there are two options in ETABS.[3]

IV. RESPONSE SPECTRUM METHOD

Response spectrum analysis (RSA) is a method widely used for the design of buildings. Conceptually the method is a simplification of modal analysis, i.e., response history (or time history) analysis (RHA) using modal decomposition, that benefits from the properties of the response spectrum concept.[7] The purpose of the method is to provide quick estimates of the peak response without the need to carry out response history analysis. This is very important because response spectrum analysis (RSA) is based on a series of quick and simple calculations, while time history analysis requires the solution of the differential equation of motion over time. Despite its approximate nature, the method is very useful since it allows the use of response spectrum, a very convenient way to describe seismic hazard.[4,7]

V. TIME FUNCTION

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.

CSI Software handles the initial conditions of a time function differently for linear and nonlinear time-history load cases.

Linear cases always start from zero, therefore the corresponding time function must also start from zero.

Nonlinear cases may either start from zero or may continue from a previous case. When starting from zero, the time function is simply defined to start with a zero value. When analysis continues from a previous case, it is assumed that the time function also continues relative to its starting value. A long record may be broken into multiple sequential analyses which use a single function with arrival times. This prevents the need to create multiple modified functions.[4]

VI. GROUNG MOTION EXCITATION

Selecting the seismic loading for design and/or assessment purposes is not an easy task due to the uncertainties involved in the very nature of seismic excitations. One possible approach for the treatment of the seismic loading is to assume that the structure is subjected to a set of records that are more likely to occur in the region where the structure is located. [4,5]

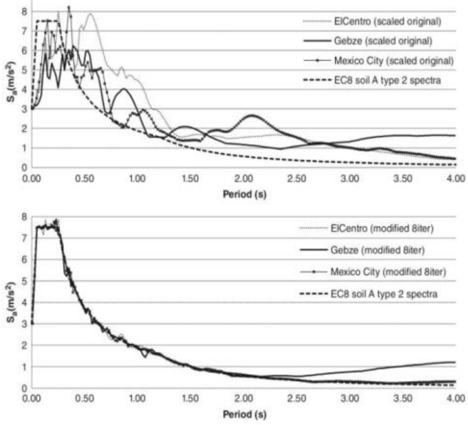


FIGURE 1- ARTIFICAL ACCELEROGRAM GENERATOR.[4]

This figure shows the example of an artificial accelerogram generator code written in software with iteration program.[4]

VII. ETABS

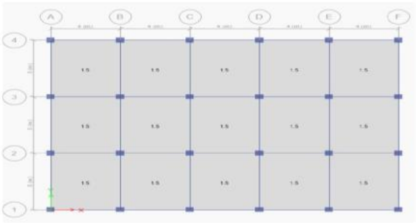
ETABS is one of the most powerful software tools for structural analysis. 3D modeling, visualization, and automatic code-based learning are some of the unique features of this software. ETABS also supports several analytical models like response spectrum analysis, time-history analysis, and line direct integration time-history analysis. ETABS is engineering software which is used to analysis and design multi-storey building. ETABS stands for Extended Three-Dimensional (3D) Analysis of Building Systems. CAD drawings can be converted directly into ETABS models or used as templates in which ETABS objects may be overlaid. Report is generated directly in the software with complete reinforcement details. Many of the floor levels in buildings are similar which reduce modelling and design time. Fast model generation using the concept of similar stories. Different materials can be assigned to the structural elements within the same model such as steel, RCC, composite or any other user-defined material.

VIII. STRUCTURAL MODELING AND ANAYLSIS

Kaushal Vijay Rathod[4] has studied , a nonlinear time history analysis is performed on a multi storey RCC building frame considering time history of EL CENTRO EARTHQUAKE 1940.

Problem Statement:-
A 10 storey RCC masonry infilled RCC building have
Floor to Floor height- 3.1 m.
LL on Typical floors 2 KN/m2 & SIDL or FF- 1kN/m2
Live Load on Terrace - 1.5 KN/m2 & SIDL- 2kN/m2
Column size - 0.45 m X 0.45 m
Beams size - 0.23 m X 0.45 m
Slab Thickness - 0.150 m;
Brick wall thickness -0.23m
Density of concrete- 25 kN/m3
Density of brick wall- 20kN/m3
Load intensity for 10mm thick mortar- 0.21kN/m2
Height of parapet wall-1m
Number of modes considered initially - 12 nos.
Circular frequency, ω (rad/sec) = $2\pi\ T$

Eigen value = ω2
Frequency (cycle/sec) = 1 /*T*
Use M25 concrete and Fe415 steel.



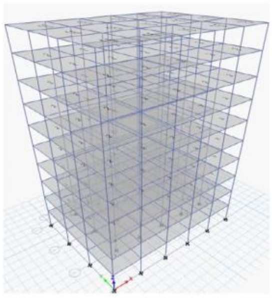


FIGURE 2 :- THE MODE OF STRUCTRUE [4]

TIME	MAX BASE REACTION
5.624 sec	664.143 kN in X-dir
2.96 sec	565.974 kN in y-dir

Result obtain in this paper are
Base reaction conclude that the base reaction increases with the time in sec from the time history plot we can see that the base reaction is max at 5.624 sec with 664.147 kN at x-direction where as the max base reaction obtain on in y direction is at 3.5sec with 565.974 kN. both reaction are comparably very high and should be designed appropriately.[4]

IX. CONCLUSIONS

1. Based on Literature review concerning time history analysis and response spectrum analysis. In time history analysis uses the time history of input force or acceleration directly which is then united to get the response. In response spectrum analysis the time evolution of response cannot be computed. Only the maximum response is estimated. No information is available also about the time when the maximum response occurs.
2. The study is based on linear and nonlinear analysis of multistorey structure for finding base shear, storey displacement and time period.[6]
3. It is recommended that time history analysis should be performed as it predicts the structural response more accurately than the response spectrum analysis.[2]

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