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### Effect of Ground Motion Characteristics on Seismic Performance of Structure

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**ABSTRACT**: Time history investigation is the investigation of the dynamic reaction of the structure at each growth of time, when base of structure is exposed to a particular ground movement. Nonlinear dynamic analysis is an accurate method for building's response analysis. Structure is made to undergo nonlinear behavior by plastic hinge modelling which results in inelastic action and energy degrading mechanism.

In this dissertation, analysis of a Single degree of freedom have been done using ETABS, a software package for the analysis and design of civil engineering structures. After the modelling the SDOF system, time history analysis have been done and performance of structure in terms of its displacement, base shear is checked for ground vibrational effect of eight different ground motions from PEER records. Plastic hinge generation, modelling and nonlinear analysis is done as per specifications of IS – codes, ASCE guidelines. Finally, response graphs and tables have been plotted for different Earthquake motions and results are obtained.

**KEYWORDS**: Peak Ground Acceleration (PGA), Response plots, Duration, Demand Capacity Ratio, Base shear, Displacement, Time history Graph, Strong Motion Duration (SGMD) etc.

#### I. INTRODUCTION

India has a large earthquake-vulnerable zone that covers over 59 percent of the country's land area. During an earthquake, severe damage and poor performance of structures across India are a source of concern. Hence it's needed to know earthquake demand on structure. In assessing the earthquake demand on structures, characterization of earthquake motion is very much needed. Ground motion characteristics measured are in the form of maximum ground acceleration, ground velocity and Peak displacement.

A few decades ago performance- based design concept (PBD) was introduced for seismic design. This Performance based design procedures provide more accurate results but are time-consuming in estimating the non-linear responses. According to PBD regulations, the structure should be able to withstand earthquake in a quantifiable manner and provides particular target performance levels of possible damaging effects. Time history analysis Method is used for performance check of SDOF system.

The available accelerograms from different earthquakes, in different seismic environments are selected from PEER ground motion records and are utilized to provide a unique basis for characterizing the ground motion. These accelerograms depends on magnitude of earthquake i.e. on severity of earthquake source, the distance to epicenter, soil characteristics, local site conditions and duration of earthquake event.

#### **II. LITERATURE REVIEW**

"The Duration and Amplitude Characteristics of Earthquake Ground Motions With Emphasis on Local Site Effects", by Y. Shoji, K. Tanii and M. Kamiyama This paper reveals the dependency of location and earhquake event on ground shaking time and amplitude of vibratory motion and observation done by installing a Small-Titanin(Strong Motion Array of Local Lots by the Tohoku Institute of Technology Area Network) in Sendai city of Japan in the year 1997,20 observation sites with different soils of 4-km distance from one seismic station to another station are observed by array observation to obtain accurate local effects of sites and study resulted that duration is greatly influenced by event dependency factors like magnitude of earthquake, hypocenteral distance, focal depth and Amplitude and total power is greatly influenced by site conditions.



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1. "Effect of Strong Ground Motion Duration on Structural Damage", by E. Ozer and S. Soyoz, This paper investigates the correlation between Structural damage and characteristics of earthquake vibrations such as (frequency, duration

and amplitude of ground vibrations).For study,179 earthquakes motions of Japan are considered and grouped according to their PGA and frequency ranges. Arias Intensity was considered to define Strong Ground Motion Duration and Maximum Nonlinear displacement response was chosen as damage indicator. Observation resulted that there is a positive correlation between SGMD and damage of structure. Which depends on predominant and peak frequency of Japan.

3. Multi-Component ground motion response spectra for coupled horizontal, vertical, angular accelerations and tilt by Erol Kalkan and Vladimir Graizer (California Geological Survey Sacramento, CA 95814-3500,U.S.A)ISET Journal of Earthquake Technology, Paper No. 485, Vol. 44, No. 1, March 2007, pp. 259–284. In this study, the response of an SDOF oscillator under a multi-component excitation is computed using a governing equation of motion and The spectra of multi-component excitations are compared with traditional uniaxial excitation spectra. Multicomponent excitation spectrum represents kinematic characteristics of the ground vibrations that are not observed by the traditional response spectra at near -fault region where high vertical and rotational excitation occurs and results that at short period and near source distances, vertical component of ground motion is noticeably more severe than the horizontal component.

#### III. OBJECTIVES

- 1. To characterize the earthquake ground motion parameters for assessing earthquake demand of structure
- 2. To evaluate and design earthquake retrofit solutions for existing structures.
- 3. To design new structures that use structural materials, systems, or other characteristics that do not comply with current building code criteria.
- 4. To evaluate the structural performance of post-earthquake buildings for a particular stakeholder/owners Requirements.

#### **IV. METHODOLOGY**

- 1. In the current research a single storied Industrial building is considered as SDOF system, measuring 60m x 30m along X and Y direction using AutoCAD.
- 2. This research work is carried out to study the comparison of performance of structure, formation of hinges, Demand to Capacity ratios for different elements at different acceleration time histories of different earthquake vibrations.
- 3. Modeling of a single storied structure using ETABS for the mentioned systems and time history analysis of same to check the effect of ground motion characteristics on seismic performance of structure.

Sl.No	Serial Number of Record	Earthquake Event Name	Year	Station Name	Magnitu de	Lowest U Frequenc y(Hz)	Usable
1	289	"Irpinia_ Italy-01"	1980	"Calitri"	6.9	0.25	
2	313	"Corinth_ Greece"	1981	"Corinth"	6.6	0.25	
3	5623	"Iwate Japan"	2008	"IWT 015"	6.8	0.0875	
4	3948	"Tottori_ Japan"	2000	"SMNH02"	6.61	0.25	
5	524	"N. Palm Springs"	1986	"Joshua Tree"	6.06		0.375
6	2490	"Chi-Chi_ Taiwan-03"	1999	"CHY074"	6.2	0.04	

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7	1616	"Duzce_ Turkey"	1999	"Lamont 362"	7.14	0.075
8	1664	"Northridge-02"	1994	"Lake Hughes #12A"	6.05	1.2

Table-1 Details of selected 8 earthquakes for analysis

4. After checking the behavior after analyzing, it is represented in terms of table and graphs.

#### V. RESULTS

A. <u>BASE SHEAR</u>: Performance of structure for given input ground acceleration time histories are observed in terms of shear development at base of structural model along both X and Y directions



Fig.1. Base shear along X - direction (N. Palm Springs Earthquake Motions)



Fig.2. Base shear along Y- direction (N. Palm Springs Earthquake Motions)

B. <u>DISPLACEMENT</u>: Due to both lateral and earthquake loadings ,development of displacement at plinth level at joint 1 of column C1 is studied by displacement VS time curves.

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Fig. 1. Displacement result of SDOF structure in X – direction for N. Palm Springs Earthquake Motion



Fig. 2. Displacement result of SDOF structure in Y- direction for N. Palm Springs Earthquake Motion





Fig. 1. Acceleration response for Ux Component for Duzce Turkey Earthquake Motions

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Fig. 2. Acceleration response for Uy Component for Duzce Turkey Earthquake Motions

D. <u>RESPONSES OF FRAME ELEMENTS:</u> For a time step of 25 seconds of total earthquake duration of Tottori Japan earthquake is considered as hinge development time step and response of frame elements of SDOF structure at this time are given in terms of moment M3 and plastic rotation of hinges ,acceptance criteria of plastic hinges are as shown below:



Fig. 1. Hinge Response of C1H11 element for Tottori Japan Earthquake Motions





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Fig. 4. Hinge Response of B1H11 element for Tottori Japan Earthquake Motions

Moment M3 159.8389 kN-m Hinge State B to  $\leq C$ Plastic Rotation -0.000051 rad Hinge Status A to <=IO Element type Element Dimensio n Deman d momen t kN.m Momen t capacit y kN.m DC R Result Plinth C1H11 900\*750 1266.46 1057.97 1.19 O K **C5H9** 900\*750 1.46 O K Plinth 1449.032 991.068 **B64H10** 700\*450 67.21 73.84 Story1 0.91 O K

Table-2 DCR for elements of SDOF for Tottori Japan Earthquake

159.83

Story1

B1H11 700\*450

175.49

0.91 O K

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#### VI. CONCLUSION

- Hinges developed are at the I-O level, hence requires minor repair for functional and safety reasons to achieve good performance level.
- Maximum displacements are observed along Y direction in all eight earthquakes are 9.715 mm for Irpinia\_ Italy-01, 8.632 mm Corinth\_ Greece, 10.37 mm for Iwate Japan, 10.15 mm in Tottori\_ Japan, 11.0 mm for N. Palm Springs, 10.12mm for Chi-Chi\_ Taiwan-03, 10.272 mm for
- Duzce \_Turkey,8.35 for Northridge-02 earthquake .
- Maximum base shear development at each time history loading case varied due to variation in ground motion input forces.
- Maximum acceleration at joint 1 of column C1 varied for each time history analysis due to varying time durations of earthquakes.
- In each time history hinge development is observed at varying vibrational duration.

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