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COMPARATIVE STUDY OF SITE SPECIFIC SEISMIC RESPONSE OF MULTI STORY FRAME STRUCTURE WITH DIFFERENT ENGINEERING BED LAYER

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Abstract - Earthquakes are natural hazards under which disasters are mainly caused by damage or collapse of buildings and other man-made structures. During an earthquake, seismic waves radiate away from the source and reach the ground on which these seismic waves produce shaking. The surface ground shaking causes severe damage to the structures, which depends on characteristic of subsurface soil. The seismic force on building depends on peak ground acceleration and time period of building as specified in IS: 1893 (Part I)-2002 in terms of zone factor (Z) and spectral acceleration (Sa/g). Codal provisions usually specify standard normalized response spectra for different soil types irrespective of local conditions. Therefore for a realistic design of earthquake resistant structures site-specific detailed investigation is necessary.

In the present study ground response analysis of eight bore hole of Dholera SIR is carried out using one dimensional equivalent linear analysis. Site specific response spectra are developed using Edushake software. Acceleration time history recorded at El Centro is considered as input motion for different sites to get acceleration time history of ground as well as response spectra. The site specific response spectrum for various sites are then compared with the standard response spectrum plot given in IS: 1893 (Part I)-2002.

The site specific response spectra are used to evaluate response of multi-storied frame structures using ETABS software. The base shear is calculated for 5, 10, 15, 20 and 25 storied regular frame structures for various sites. Also shear forces, bending moments and shear forces for ground floor columns of the structures are obtained using site specific response spectra. The analysis result of site specific response spectrum analysis is compared with that obtained considering IS: 1893 (Part I)-2002 response spectrum.

1. INTRODUCTION

Natural hazard such as earthquake is one of the most shocking of all hazards and unavoidable. The hazards related to earthquakes are denoted to as seismic hazards. Earthquake damage depends upon many parameters such as intensity, duration and frequency content of ground motion, quality of construction, geologic and soil condition, etc. The valuation of strong-motion characteristics is important for engineering design. Such characteristic includes peak ground acceleration and spectral ordinates Experience has shown that for new constructions, establishing earthquake resistant regulations and their implementation is the critical safeguard against earthquake induced damage. As regards existing structures, it is necessary to evaluate and strengthen them based on evaluation criteria before an earthquake.

Sociologic factors are also important, such as density of population, time of earthquake occurrence and community preparedness for the possibility of such an event.

2. SITE SPECIFIC GROUND RESPONSE ANALYSIS

Site specific ground response analysis is required to determine the response of a soil deposit to the motion of the bedrock immediate below the soil. It also determines the effect of local soil conditions on amplification of seismic waves and hence estimating the ground response spectra for future design purposes.

The term site specific is used because as the seismic waves travel from bedrock to the surface, the soil deposits that they pass through change certain characteristics of the waves, such as amplitude and frequency content. Soft deposits of soil amplify (increase) certain frequencies of ground motion thereby increasing earthquake damage. Thus local soil conditions have significant role on amplification of seismic waves. This amplification can be measured by performing ground response analysis which refers to the determination of the response of the soil to the motion of the bedrock below the soil.

According to the site location, it is necessary to know the local soil conditions and topographic conditions. Depending on the subsurface characteristics, seismic waves might undergo amplification and create more severe strong ground motions at the surface.

The seismic hazard is assessed by means of expected ground response of the seismic waves for a given earthquake for a specific site. As the local site has significant effect on seismic waves, "Site Specific Ground Response" is important aspect for earthquake resistant design of structure.

3. STEPS FOR SITE SPECIFIC GROUND RESPONSE ANALYSIS

The study area lies near State Highway No. 6 and between Ratanpur and Pipli in Ahmedabad district and Adhelai of Bhavnagar district Dholera SIR Zone. The total area covered is 800sq km (about 50 km x 20 km). Site specific response spectra are developed for eight borehole using Edushake software. And Acceleration time history recorded at El Centro is considered as input motion for different sites to get acceleration time history of ground as well as response spectra.

Site specific response analysis needs detailed information of geotechnical data, geological information, thickness of subsurface geology profiles, soil profile data etc. In many countries like India which are prone to earthquake hazards, there is need for data and information for seismic response studies. Therefore there is need to obtain the data related to geology, geotechnical parameters, ground motion characteristics, geotechnical investigation, site effects at various locations. In this section, procedure for performing site specific response analysis is provided as shown in Fig-1.

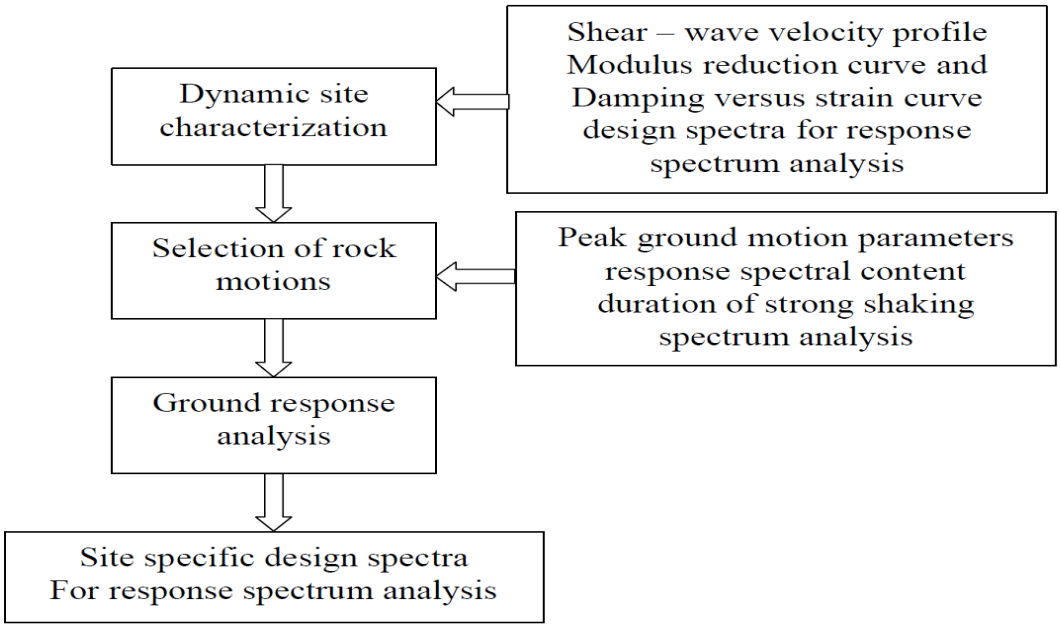


Fig-1 Site Specific Ground Response Analyses

4. RESULTS OF SITE SPECIFIC RESPONSE ANALYSIS

Specific response analysis is required to determine the response of a soil deposit to the motion of the bedrock immediate below the soil and also determining the effect of local soil conditions on amplification of seismic waves. Hence the analysis is required for estimating the ground response spectra and time history plots for future design purposes. Response spectrum is developed based on observation of time history i.e. records of displacement, velocity and acceleration at regular interval of time on the ground surface during the event of an earthquake.

A) AMPLIFICATION (DEPTH) PLOTS

The amplification of the acceleration at all the sites is estimated between ground surface and 15m depth. From the amplification plots obtained it is noticed that there is considerable variation of maximum acceleration between 15m depth and ground surface. The peak acceleration increases from 15m depth to the ground surface at all the sites. This is because of the variation in soil properties at different depths. The comparison of amplification (depth) plots as computed in Edushake for all the sites is illustrated in Fig-2.

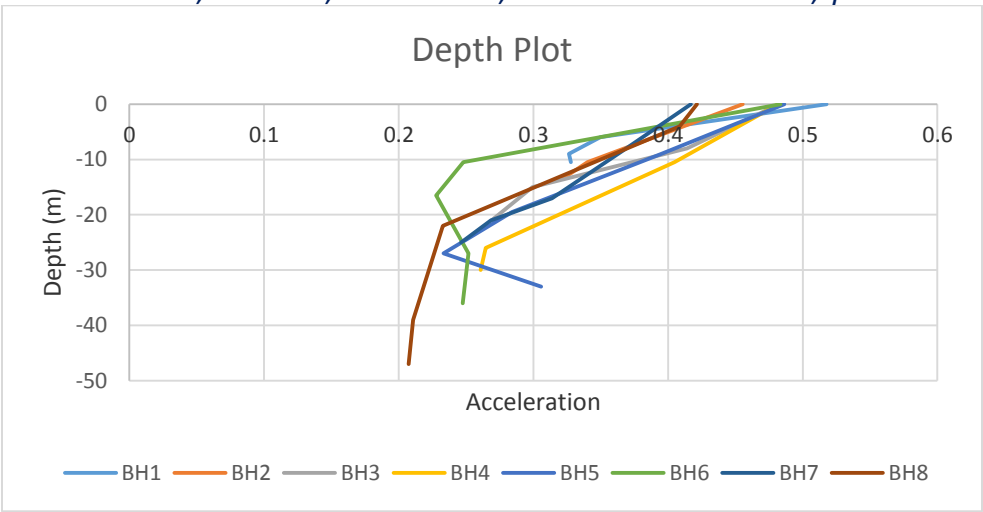


Fig-2 Comparison of amplification plots for various sites

B) Comparison of site specific response spectra with standard response spectra of is: 1893 (part i)-2002.

Local site conditions influence the frequency content, time period of surface motions and thus the response spectra. The normalized response spectra are obtained by dividing spectral accelerations by the peak ground accelerations Response spectra are used to represent seismic loading for dynamic analysis for structures. As a result, design ground motions are expressed in terms of design spectra. The design response spectrum is obtained by multiplying the ordinates of the normalized spectrum by the peak ground acceleration, which can be taken as the value of the seismic zone factor, Z, expressed as a fraction of gravity.

As per the Clause 6.4.5, IS: 1893 (Part I)-2002, response spectra for 5% of Damping are presented for three subsurface soil profiles, namely:-

i. Type I - Rock or Hard soil
ii. Type II - Medium Soil
iii. Type III - Soft Soil

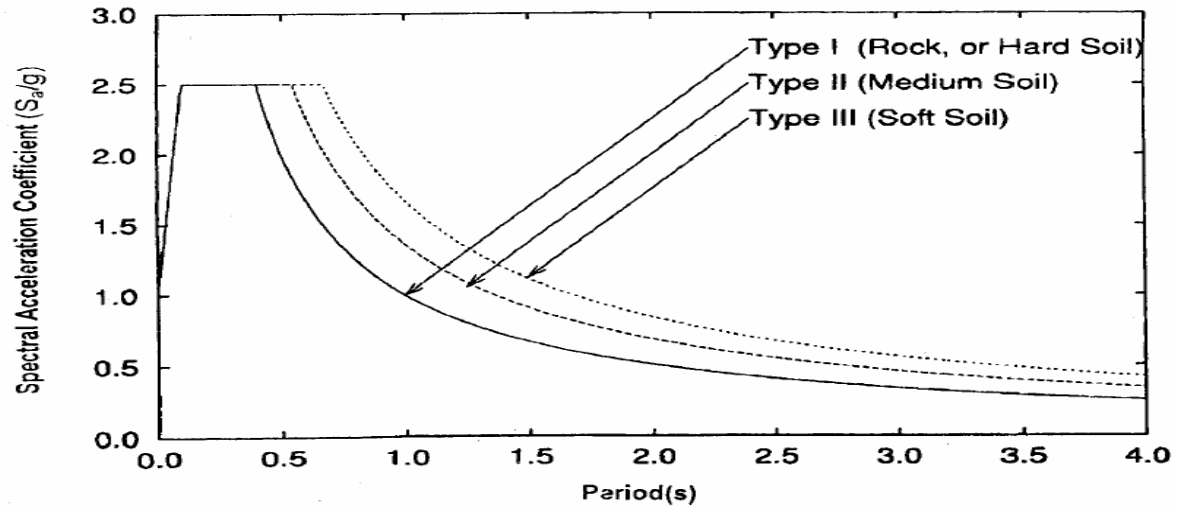
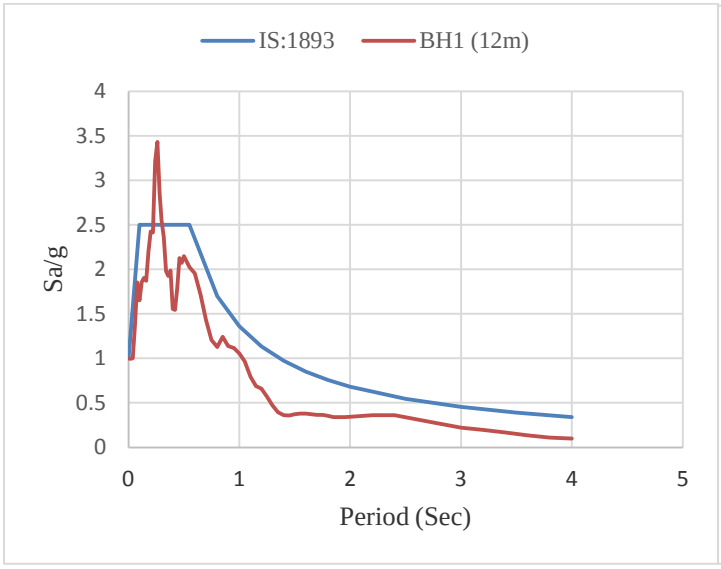
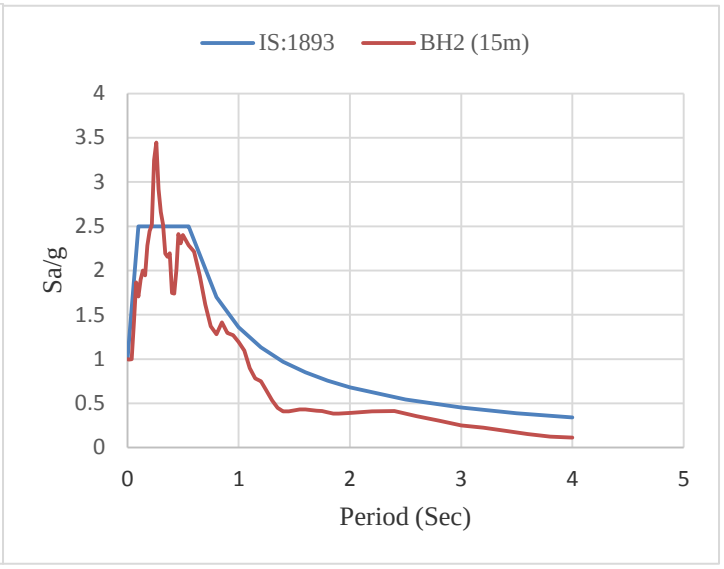
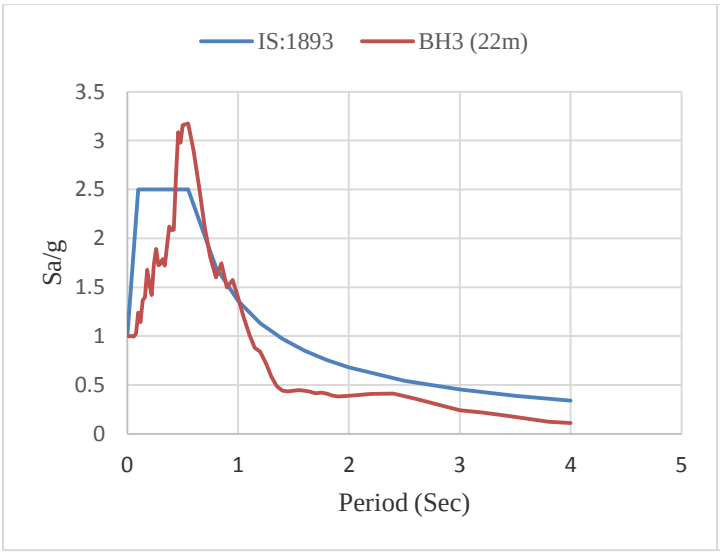


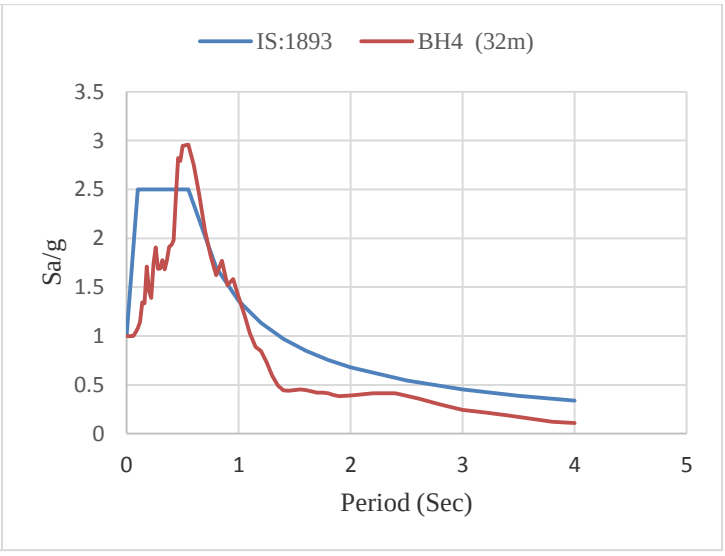
Fig -3 Response Spectra for Rock and Soil Sites for 5 Percent Damping

In the present study, response spectrum for Type II (Medium Soil) is selected. Comparisons of the site specific response spectrum with the response spectra as illustrated in Fig-.3 for Type II (Medium Soil) are carried out. The design of multi-storied frame structures is carried out using the site specific selected response spectra.









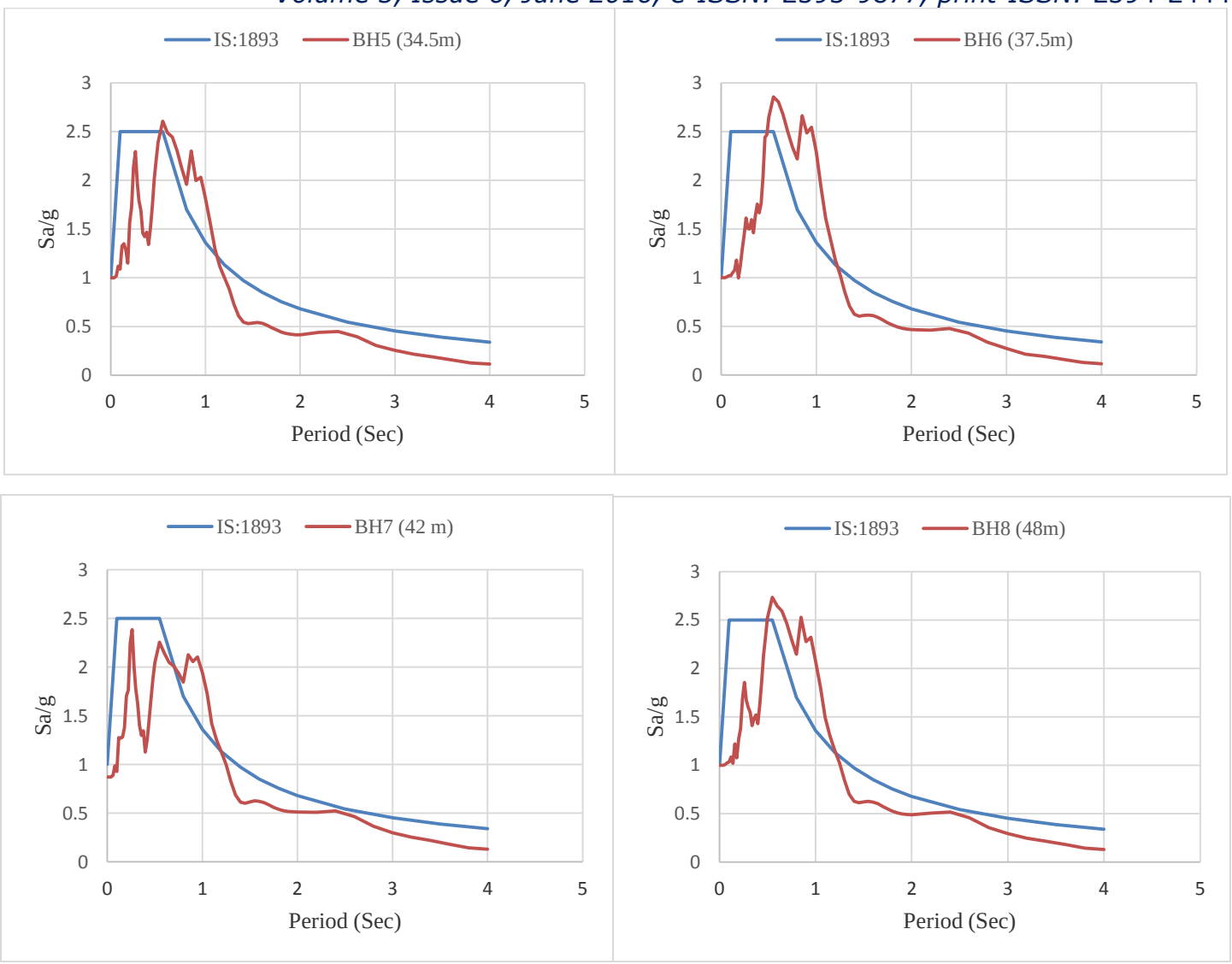


Fig-4 Comparison of Response Spectrum at Various Sites

5. ANALYSIS OF MULTI-STORY FRAME STRUCTURES

A) GENERAL

Response spectrum analysis is carried out for the determination of the likely response of a structure to seismic loading. In ETABS, as per the given guidelines, response spectrum analysis of a structure is considered as dynamic analysis of the structure. The earthquake ground acceleration obtained from site specific response analysis for all sites Boreholes in longitudinal direction are given as a digitized response spectrum curve i.e. spectral acceleration response Vs time period of the structure. Any number of response spectrum Analysis Cases can be defined.

B) ANALYSIS

The structural data of all framed structures is given in Table 1. The typical floor plan of frame structure considered is shown in Fig. 5. For simplicity a symmetrical building plan is considered in the present study. Analysis of each frame structure is carried out and results are compared in terms of internal forces of the ground floor columns.

Table-1 Multi-Storied Frame Structure Data

Building Type	Bay Size m × m	Story Height m	Column Size m × m	Beam Size m × m	Slab Thickness m
5-storey	6 × 5	3	0.4 × 0.4	0.4 × 0.6	0.15
10-storey	6 × 5	3	0.55 × 0.55	0.4 × 0.6	0.15
15-storey	6 × 5	3	0.75 × 0.75	0.4 × 0.6	0.15
20-storey	6 × 5	3	1 × 1	0.4 × 0.6	0.15
25-storey	6 × 5	3	1.25 × 1.25	0.4 × 0.6	0.15

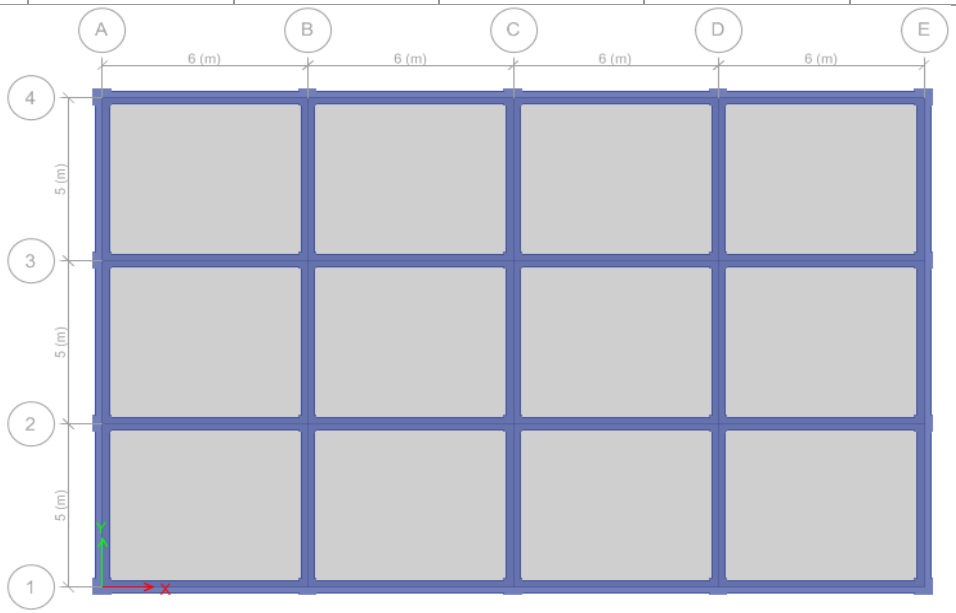


Fig-5 Plan of Multi-Storied Frame Structure

6. ANALYSIS RESULTS

The effect of site specific response spectrum analysis on building is discussed in this section. Various results are compared such as time periods of the structures obtained from dynamic analysis with the time period derived from IS: 1893 (Part I)-2002, Story Displacements, Story Drift, base shear of multi-story framed structures. The comparisons are presented in the following sections.

A) FUNDAMENTAL TIME PERIOD

The seismic response of a structure depends upon its fundamental time period. The fundamental time period of structures is its time period of undamped free vibration**.**

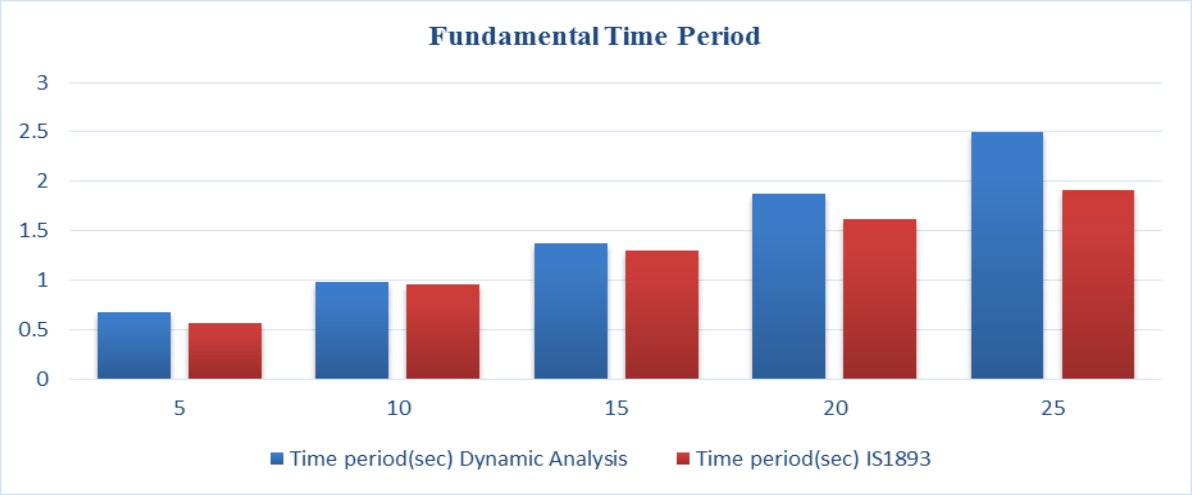


Fig-6 Time Period Comparison

B) STORY DISPLACEMENTS

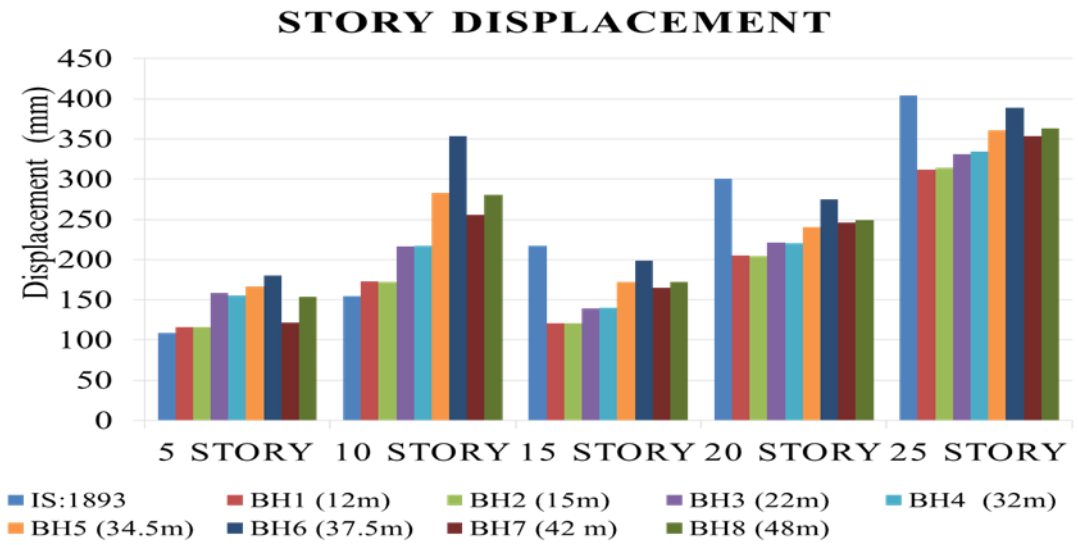


Fig-7 Comparison of Story Displacements from site specific response spectrum analysis

C) BASE STORY SHEAR

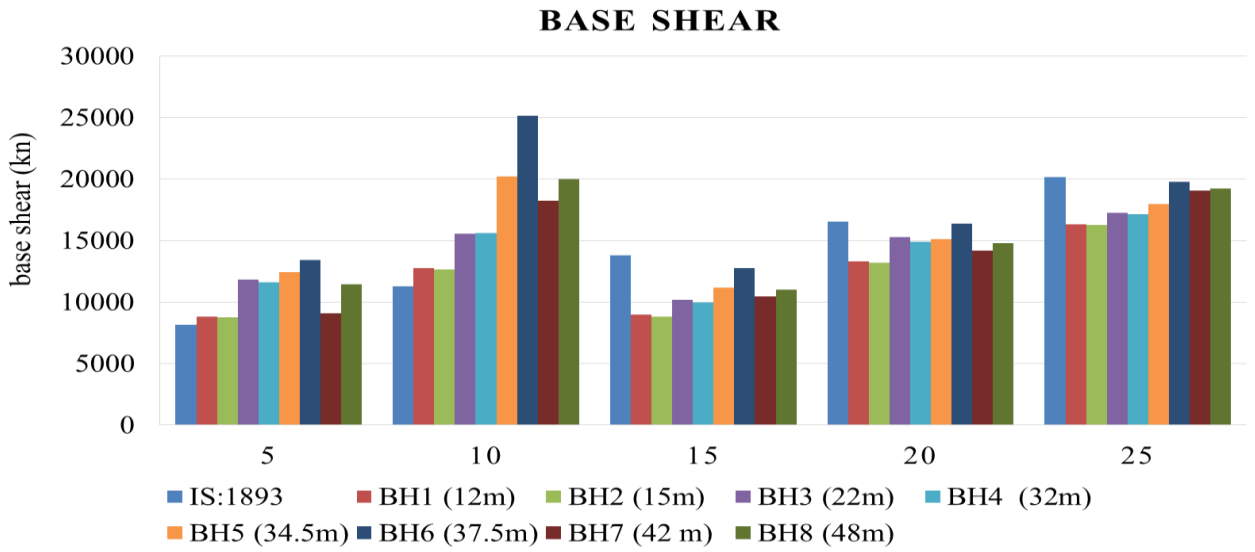
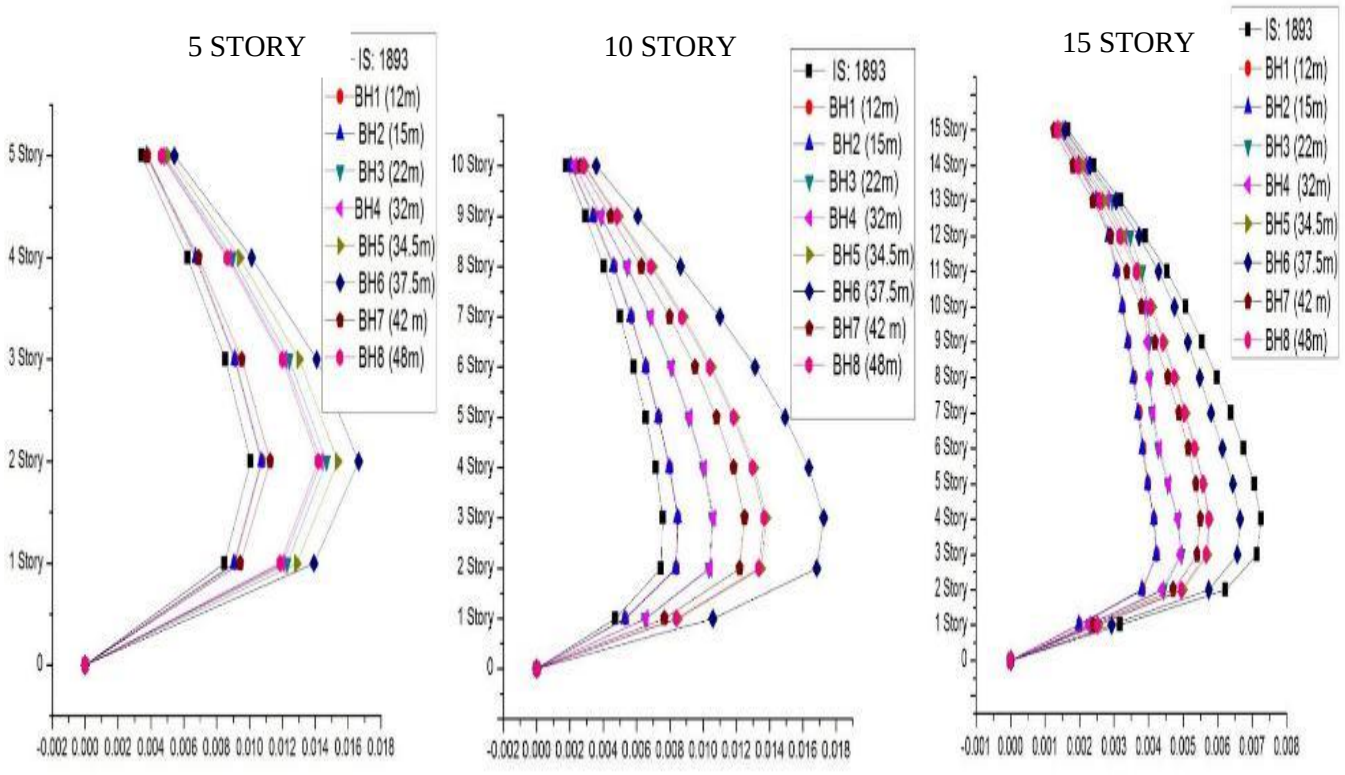


Fig-8. Comparison of Base story shear from site specific response spectrum analysis

D STORY DRIFT



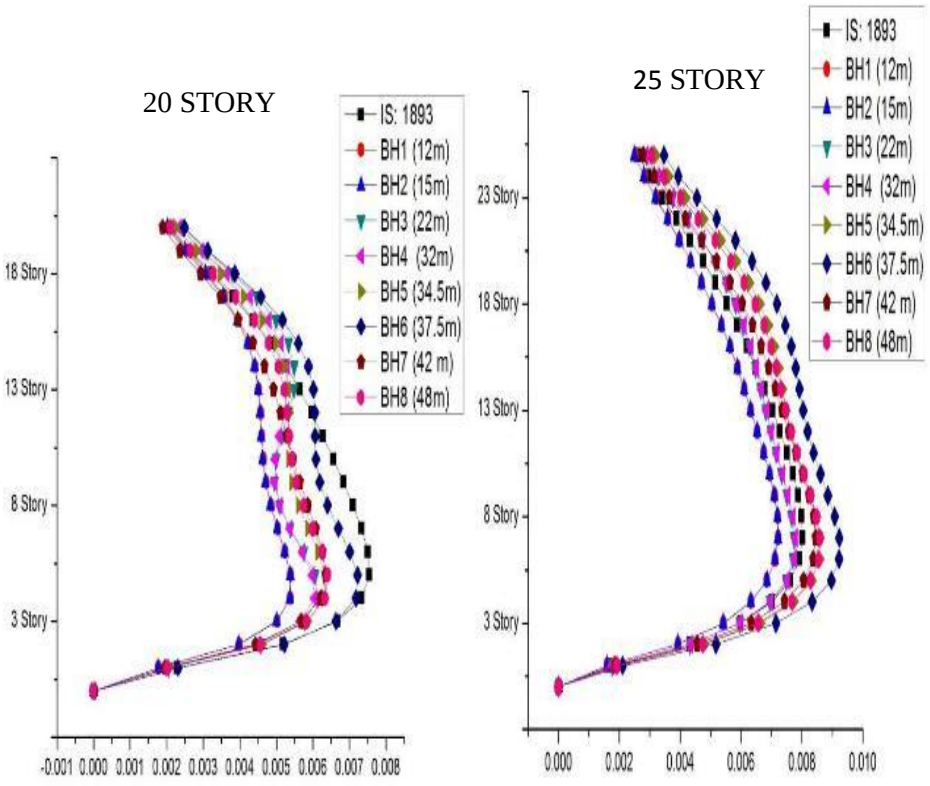


Fig-9. Comparison of Story Displacements from site specific response spectrum analysis

7. CONCLUSIONS

- Local sub-soil characteristics have significant effects on acceleration time histories on ground and response spectrum.
- There is amplification in the acceleration from the bed rock to the ground surface for all the sites due to soil layers of varying characteristics.
- Time period obtained from Dynamic analysis for all the multi storey framed structures is higher in comparison with the time period obtained from IS1893-2002.
- Time periods ranging between 0.2 to 1.5 seconds, spectral accelerations of site specific response spectra are higher as compared to that of IS: 1893 (Part I)-2002.
- Time periods greater than 1 or 1.5 seconds, the spectral accelerations of site specific response spectra are lower as compared to IS: 1893 (Part I)-2002.
- Story Displacement and base shear obtained by site specific response analysis for 5 storey, 10 storey buildings are higher compared to Sa/g coefficient values of IS1893-2002.

- Story Displacement and base shear obtained from site specific response analysis for 15 storey, 20 storey, and 25 storey buildings are lower compared to Sa/g values of IS1893-2002.

- Story Drift obtained by site specific response analysis for 5 story, 10 story, 20 story, 25 story buildings are respectively 30% , 25%, 10% and 15% higher compared to Sa/g coefficient values of IS1893-2002. And 15 story Building story drift is equal to both cases.

- It is required to carry out site specific investigation and ground response analysis for important structures for realistic estimation of seismic forces and better earthquake resistance.

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