Abstract

Local soil conditions influence the characteristics of earthquake ground shaking and these effects must be taken into account when specifying ground shaking levels for seismic design, as well as for various seismic related studies of any region which are seismically active. These local site effects are quantified by means of Site Response Analysis (SRA).

The study area covers the western region of Guwahati city, comprising of an area spanning from Guwahati Central to Goalpara. The study area consists of soil deposits which consist of mainly soft alluvium along the south bank of the river Brahmaputra. Although a few seismic amplification studies were carried out in the Guwahati City area in the past, no such study for the western Guwahati region is observed in the literature.

Site response analysis or site amplification studies (as it is sometimes also referred to) may involve the use of recorded earthquake accelerogram at a specific region. It is difficult to define the site response characteristics of how much area does a specific ground acceleration cover, considering the spatial variability of the subsoil conditions and topographical features. It can, however, be said; it is better to have an “as dense as possible” seismic array to record earthquake information so that site response analysis of a specific area which has importance to human civilization can be undertaken. Two methods, involving evaluation of earthquake records in ascertaining site response, which is commonly used are reference site i.e. Standard Spectral Ratio (SSR) method and non-reference site i.e. Horizontal to Vertical Spectral Ratio (HVSR) method. The former, involves, comparison of the Fourier amplitude of the components of the earthquake records of a soil site to that of a

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reference site for the same earthquake, while, the latter involves the comparison of the Fourier amplitude of the horizontal component of the soil site to that of the vertical component. The assumption is that the vertical component does not undergo substantial changes and hence retains the seismic signature of the source, which in turn helps in determining the effects of local soil condition on the earthquake waves.

The HVSR method generally overcomes the limitations of the SSR method in terms of requirement of reference site (which may not always be available). However, the results of SSR method is generally considered more convincing as compared to HVSR, if a proper reference site can be located for the analysis.

However, the above two method requires very densely placed seismic array. It is preferred to have local seismic arrays in addition to the regional arrays. However, installation and maintenance of seismic arrays remain a very costly affair and various regions which are seismically very active do not have the resources and technical manpower to do so.

An alternative method to evaluate site response analysis is to study the propagation of earthquake motions from the base rock through the overlying soil layers to the ground surface. This study generally involves propagation of shear waves vertically through the assumed horizontal soil layers and solving the wave equation. Although, site response analysis with the help of wave propagation can be performed in two-dimensional (2-D) as well as three-dimensional (3-D) domain, one-dimensional (1-D) site response analysis is preferred over the other methods because of its simplicity and lesser requirement of computational resources without compromising the accuracy.
Earthquake records used in this study is obtained from PESMOS - Program for Excellence in Strong Motion Studies, Department of Earthquake Engineering, IIT Roorkee (www.pesmos.in). Earthquake records were also obtained from Atlas of Indian Strong Motions Records, Department of Earthquake Engineering, IIT Roorkee. The dataset had information of 38 (thirty-eight) earthquake records from the year 1984 to 2014 which were recorded in the north east region of India.

Soil data is collected from Standard Penetration Test (SPT) Bore logs that are carried out in the study area by various agencies. Apart from the soil reports, Litholog ascertaining the lithology of the study area is collected from the Central Ground Water Board (CGWB).

An attempt has been made in this study, to evaluate the site response analysis of the study area. The analyses conducted can be subdivided into five phases.

**In the first phase,** estimation of the site response by studying the Fourier spectrum of the recorded ground motions is carried out for a selective numbers of ground motions recorded in 3 (three) seismic stations viz., Guwahati Central (26.190 N, 71.746 E), Boko-Palashbari (25.976 N, 91.230 E) and Goalpara (26.152 N, 90.627 E) within the study area. The Fourier Amplitude Spectra (FAS) of the ground motions were obtained.

**In the second phase,** site response is studied by using the SSR method. The station Nongstoi (25.522 N, 91.264 E) has been used as a reference site for the analysis. The Spectral Ratios of the two horizontal and one vertical component of various soil sites within the study area to that of the reference site were studied.
In the third phase, site response study has been carried out by HVSR analysis. The components of 15 (fifteen) earthquake records recorded within the study area by the three seismic stations were analysed.

In the fourth phase, One Dimensional Site Response Analysis (1-DELSRA) was carried out with the recorded motions of the reference site Nongstoin as input motions. The free-field motions obtained from the analysis were compared with the recorded motions in the frequency domain to establish the soil modelling methodology. The methodology was then applied to define the soil types at 10 (ten) different locations around Guwahati Airport area. The 5 (five) recorded motions of Nongstoin were used as input motions for these locations of Guwahati Airport area after scaling them to PGA of 0.36 g and 0.18 g to reflect the MCE and DBE respectively.

In the fifth and last phase, an attempt has been made to study the dynamic response of a few representative building structures to the input seismic free-field motions obtained from the 1-DELSRA analyses. First, Design Response Spectrum (DRS) was constructed for the sites. The DRS is then compared to the DRS given in IS:1893-2002 to compare the deviation from the average DRS prescribed in the code. Second, Linear Time History Analysis (THA) was performed on the representative building structures to compare the building responses for recorded earthquake time history and as well for simulated time history at the site considering local site effects.

From the site response analyses, it has been finally observed that seismic waves in Western Guwahati region are subjected to significant site response. Maximum site amplification value of 15.33 was observed in the Guwahati Airport area from 1-DELSRA method. A maximum site amplification value of 18.59, 5.15
and 8.06 was observed by the SSR, HVSR and 1-DELSRA methods respectively for the Boko-Palashbari site. For Goalpara in the far western part of the study area the amplification values observed were 33.74, 7.6 and 8.24 by SSR, HVSR and 1-DELSRA method respectively. The SSR and HVSR methods indicated a fundamental resonance frequency band of 0.66-1.89 Hz, 0.63-1.88 Hz in the Boko-Palashbari and Goalpara sites respectively.

From the dynamic response of representative buildings, a significant deviation of the DRS constructed for Western Guwahati was observed as compared to the DRS prescribed in IS: 1893-2002, which suggests that perhaps a site-specific spectrum needs to be developed for the study area. Time History Analysis (THA) was performed with two set of time histories. First, the THA analysis was conducted with recorded ground surface motion. Second, the THA analysis was performed with the surface ground motions generated by 1-DELSRA. THA performed indicated significant spectral amplification of PGA in the range of 2-3. Spectral amplification of PGV and PGD has been observed in the range of 2-4 and 3-6 respectively. General agreement of results (regarding spectral amplification of acceleration, velocity, and displacement) has been observed in both the analysis approaches, i.e., use of recorded versus generated ground motions. This agreement of results indicates that in the case of unavailability of recorded ground motions, artificially generated ground motions by 1-DELSRA may be used for seismic analysis.

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