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To Determine Dynamic Properties of Soil After a Particular Seismic Activity - A Case Study

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Abstract -Although though India is one of the world's emerging nations, one of the biggest issues our country is currently facing is how to make people's lives safer by reducing the vulnerability to earthquake dangers in the future. According to previous research conducted by a number of researchers and seismologists, ground shaking can seriously harm any infrastructure, pose risks to any country (whether it is developed or developing), and also be potential to demolish urban structures, including structures that can directly affect the economic standard of any country. In addition to the loss of life and property destruction that this natural disaster frequently results in, it also frequently leaves an economic crisis in its aftermath. In this manner, seismic tremor investigation of any site assumes a significant part for safe development in future.

A one-dimensional site-specific site response investigation was carried out at selected locations in the Hoshiarpur area in Punjab for the current research to examine how the dynamic characteristics of the soil changed in response to a given input ground motion during seismic loading. A crucial responsibility for both structural and geotechnical engineers to assess the interaction between soil and structure is the research of ground response parameters for soil and rock.

Keywords: *PGA, Seismic tremor, Reaction spectra, Site response investigation, Dynamic characteristics, Input ground motion*

1-Introduction

An earthquake, also referred to as a quake, is the rapid vibrating of the earth's surface that results from the sudden release of vibrations in the lithosphere, which leads to seismic waves. When these seismic waves arrive at the place of interest, they significantly damage both property and human life. The depth-dependent shift in the soil stratum boundary determines the size and intensity of seismic waves. In summary, the difference in cohesiveness property between soil with low density and hard stratum causes seismic vibration to travel more quickly in the latter. Simply said, this occurred as a result of local soil layers sitting atop bedrock layers.

Estimating the ground reaction's amplified response owing to local soil conditions is one of the hardest challenges faced by structural engineers. According to geotechnical engineering, it is crucial that all substructures be designed while taking earthquake loading into account. As a consequence, a critical feature of the current study's analysis of the interaction between soil and superstructure is the assessment of major dynamic properties. By performing GRA (Ground Response Analysis), the geotechnical engineers will be capable of analysing the natural frequency of any location and calculate the amplification ratio, which will allow us to compare the amplitudes of the soil and the underlying rock. By considering the geotechnical factors as well as other dynamic qualities, structural engineers may use this information to create earthquake-resistant structures. Geotechnical engineers have a difficult task to understand the dynamic soil qualities and motion amplification of different places where earthquake risk prevails.

1.1 Equivalent-Linear (Eql) Approach Of G.R.A

Using the Equivalent-Linear (EQL) technique, the current research of ground response analysis is assessed. It was created to assess the soil's nonlinear response behaviour utilizing the frequency domain (with the aid of linear transfer function). Shear modulus, or G value, is much higher in the case of a linear analysis than a nonlinear analysis when the behaviour is nonlinear (shear stress vs. shear strain exhibits nonlinear behaviour). As a result, the outcome differs from the initial nonlinear one.

1.2 Study Region

In the northeast, **Hoshiarpur (Punjab, India)** shares a border with the Himachal Pradesh cities of Una and Kangra. In the south-west, SBS Nagar, Jalandhar, and Kapurthala, and in the northwest, Gurdaspur district, it also shares a border. The city has 189,371 residents as of the 2011 census, and its average elevation is 296 metres. It is one of the most susceptible cities in north Punjab, thus thorough ground response analysis is crucial to raising construction standards there.

1.3 Defining The Need

Studies conducted in the past by various seismologists have revealed that Punjab has experienced a very small number of earthquakes the vast majority of which were observed in the the northern region, where impact from equivalent earthquakes has traditionally been substantial during big events starting in the Himalayas. Chamba 1905, whose size directly impacts various districts of Punjab including Gurdaspur and the surrounding North Punjab regions, was the largest earthquake recorded in the same area. The intensity is so great that it breaks down parapets, chimneys, and even masonry buildings, causing many fractures and shear failures of structures. Thus, GRA is necessary to meet the demand of safe infrastructure design and to maintain construction standards.

2. Methodlogy

The planning of an experimental programme (DEEPSOIL) for the calculation of GRA Profiles and other amplification factors will be undertaken. Following are the steps;

1. A specimen taken from several locations in the Hoshiarpur region is subjected to laboratory testing, and the subsurface profile is approximated using geotechnical investigation data.
2. On-site observations of soil characteristics every 1.5 meters (or fewer, if soil strata are changing before 1.5 meters) and laboratory tests to determine the kind of soil will be conducted.
3. G is used to determine shear velocity Vs, where G stands for shear modulus and D for soil density. As illustrated in Table 2, co-relations are used to compute shear modulus.
4. In Fig. 2, specifics of the input motion used for the investigation are shown.
5. DEEPSOIL will be used to create material curves. Curves in DEEPSOIL have been developed for creating modulus reduction curves and damping ratios for different soils.
6. Examine the PGA and response spectrum of a particular location.

These findings can be used to the safe and reliable building of several significant structures.

2.1 Characteristics Of The Location

The presented research for the prediction of earthquake shaking heavily relies on the properties of the geotechnical strata underneath NGL. SPT (Standard Penetration Test) was used to sample the soil from each stratum, and information was gathered from 41 bore holes. According to SPT work done at several sites, the land is covered in layers of silty sand and sandy soil (SP) (ML). The range of soil's mass per cubic metre is 1640 kg/m3 to 1740 kg/m3. Seismic waves have shear wave velocities between 98.8 and 255.5 m/s.

Table 1: Location of site with geotechnical parameters

Location of site	**Site code**	**Average Shear velocity Vs= √(/) m/s**
Village Sagran (Dasuya)	HSP 1	207.51
Village Garh Shanker	HSP 2	199.58
Village Naloyian	HSP 3	227.41
Village Piplanwala	HSP 4	203.7
Purheeran, Hoshiarpur	HSP 5	201.95
Village Tanda	HSP 6	186.34
Village Guri Sangar	HSP 7	206.21
Village Mukhaliana	HSP 8	195.62
Village Bainchan	HSP 9	170.41
Village Mohkamgarh	HSP 10	210.51
Village Nurpur	HSP 11	218.90
Kandi Canal Stage-II’	HSP 12	208.24
Village Kotli Bawa	HSP 13	191.71
Village Brahmjit’	HSP 14	193.55
Village Badal Malsian	HSP 15	222.64
Village Bhekhuwal, Hoshiarpur’	HSP 16	185.85
Village Ghasipur,	HSP 17	200.70
Village Badla	HSP 18	182.88
Village Marnian Attowal	HSP 19	180.9
Village Kali Bein	HSP 20	223.64
Village Phambra Bhatolian	HSP 21	149.79
Village Bhat Khadiala	HSP 22	165.3
Village Bhonga’	HSP 23	177.90
‘Village Jamsher	HSP 24	183.30
Village Johal	HSP 25	209
Village Khun Kalan, Tanda	HSP 26	193.20

Village Badala Pukhta’	HSP 27	173.72
‘Village Dhoot Khurd	HSP 28	190.94
Village Lahle Block Hoshiarpur	HSP 29	195.78
‘Village Mal Majara	HSP 30	180.3
Village Bassi Mroof	HSP 31	183.54
Village Jaura Block Tanda	HSP 32	183.6
Village Nurtalian	HSP 33	208.14
at Village Halar	HSP 34	207.2
Village Singhpur	HSP 35	171.68
Village Tanuli	HSP 36	193.22
Village Fattowal	HSP 37	186.52
Village Miani	HSP 38	180.95
Village Chhangla	HSP 39	179.38
Village Ralhan Shahpur	HSP 40	178.25
Village Usman Shahida	HSP 41	191.4

Table: 2 Important relations used for study

Shear modulus	**Classification of soil**	**units**
$G=1221\ (N)^{0.621}$	Clayey soil	t/m2
$G=652\ (N)^{0.945}$	Sandy soil	t/m2
$G=1181\ (N)^{0.767}$	Int. soil	t/m2
$G=82.58\ (N)^{0.768}$	Gravel	Kg/cm2
$G=24.27\ (N)^{0.552}$	Silty sand with low percent of clay	MPa

2.2 Methodology Selection And Input Motion

Several scholars have used linear, non-linear, and comparable linear methods to analyse ground reaction. One-dimensional EQL ground response analyses are employed in the current study's outputs. Using DEEPSOIL software, the output was assessed in terms of PSA, PGA, response spectra, amplification factor, etc. In order to evaluate the nonlinear reaction characteristics of soil classes, a frequency domain equivalent linear approach was established. This technique offers the possibility of specifying the soil curves using discrete points; neither the linear nor non-linear approaches do.

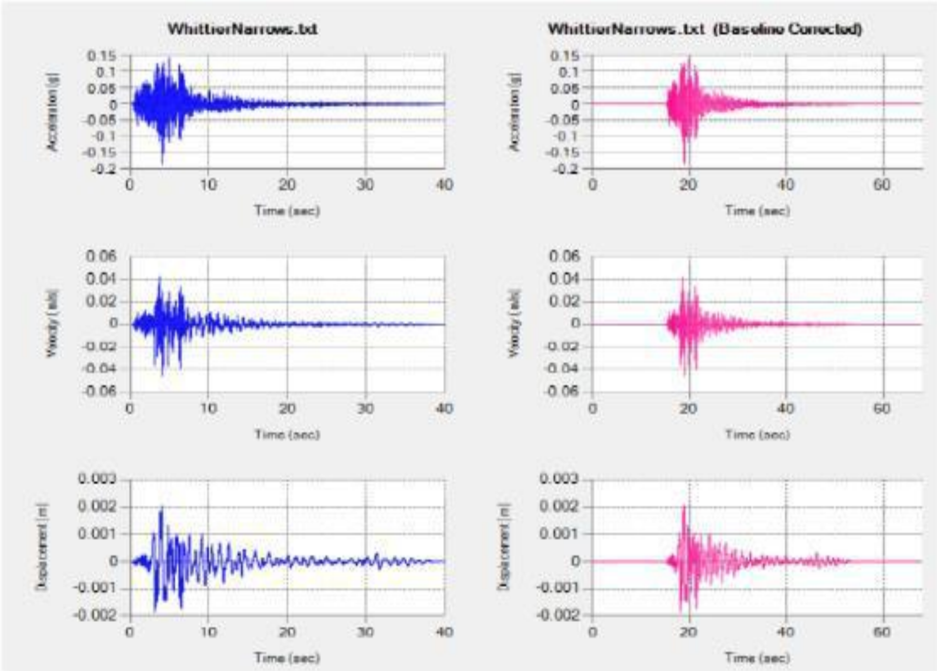

Fig 01-Detailed input motion

3-Results

Table 3: Results of all 41 sites

Denotation	PSA (g)	PGA (g)	Relative displacement (m)	Maximum strain percent	Maximum stress ratio	Frequency (Hz)	Amplification ratio
HSP 01	1.216	0.234	0.0037	0.0059	0.2337	0.292	1.005
HSP 02	1.208	0.2564	0.0114	0.1977	0.2348	0.256	1.012
HSP 03	1.233	0.2446	0.0034	0.0047	0.2444	0.2929	1.005
HSP 04	1.104	0.2530	0.0035	0.0060	0.2544	0.256	1.007
HSP 05	1.126	0.2565	0.0032	0.0093	0.2540	0.2929	1.007
HSP 06	1.246	0.2921	0.0037	0.0080	0.2913	0.256	1.008
HSP 07	1.037	0.2157	0.0031	0.0058	0.2417	0.2929	1.0072
HSP 08	1.184	0.2447	0.0033	0.0078	0.2441	0.2931	1.0062
HSP 09	1.127	0.2932	0.0034	0.0276	0.2730	0.1831	1.0032
HSP 10	1.397	0.2671	0.0035	0.0021	0.2665	0.2932	1.0052
HSP 11	1.471	0.2138	0.0035	0.0087	0.2721	0.2929	1.0049
HSP 12	0.674	0.1450	0.0020	0.0028	0.1458	0.2564	0.9819

HSP 13	1.164	0.2412	0.0034	0.0057	0.2403	0.2930	1.0067
HSP 14	1.209	0.2465	0.0033	0.0067	0.7449	0.2929	1.0063
HSP 15	1.437	0.2771	0.0034	0.0042	0.2665	0.2929	1.0049
HSP 16	1.226	0.2456	0.0035	0.0076	0.2445	0.2929	1.0069
HSP 17	1.378	0.2809	0.0035	0.0185	0.2732	0.2999	1.0057
HSP 18	1.241	0.3009	0.0040	0.0108	0.2979	0.2563	1.0098
HSP 19	1.008	0.2415	0.0031	0.0065	0.5756	0.2929	1.0078
HSP 20	0.953	0.2238	0.0030	0.0037	0.5284	0.2930	1.0075
HSP 21	1.094	0.2242	0.0029	0.0210	0.2169	0.2808	1.9927
HSP 22	1.071	0.2642	0.0033	0.0267	02587	0.1832	1.0035
HSP 23	1.012	0.2283	0.0032	0.0080	0.2269	0.2929	1.0078
HSP 24	1.187	0.2585	0.0033	0.0133	0.2544	0.2929	1.0068
HSP 25	1.556	0.2888	0.0037	0.0092	0.2863	0.2929	1.00519
HSP 26	1.557	0.264	0.0038	0.0038	0.3040	0.2929	1.0061
HSP 27	0.918	0.2263	0.0032	0.0032	0.2270	0.2931	1.0089
HSP 28	1.228	0.2736	0.0033	0.0033	0.2685	0.2929	1.00642
HSP 29	1.346	0.3033	0.0035	0.0164	0.3003	0.2808	1.0071
HSP 30	1.082	0.2469	0.0035	0.0108	0.2471	0.2564	1.0072
HSP 31	1.085	0.2483	0.0033	0.0126	0.2436	0.2563	1.00655
HSP 32	0.982	0.2227	0.0052	0.0052	0.2214	0.2929	1.00729
HSP 33	1.806	0.3382	0.0039	0.0383	0.3189	0.2929	1.00516
HSP 34	1.292	0.2443	0.0033	0.0060	0.2421	0.2930	1.00558
HSP 35	1.173	0.2824	0.0034	0.0327	0.2736	0.2929	1.00803
HSP 36	1.230	0.2711	0.0033	0.0140	0.2679	0.2929	1.00618
HSP 37	1.050	0.2233	0.0032	0.0047	0.2221	0.2932	1.00734
HSP 38	0.761	0.2105	0.0029	0.0056	0.2087	0.2929	1.0086
HSP 39	1.534	0.3084	0.0038	0.0127	0.3012	0.2807	1.00834
HSP 40	1.163	0.2850	0.0035	0.0323	0.2753	0.2929	1.00736
HSP 41	1.126	0.2394	0.0032	0.0062	0.2387	0.2930	1.00663

4. Conclusion

Across all 41 sites in the Hoshiarpur district, the subsurface Peak spectral acceleration ranges from 0.6841 g to 1.5878 g.

For specified regions, the amplification ratio calculated from peak acceleration at rock and peak ground acceleration at surface changes from 0.981 to 1.0102 and ranges from 0.1550g to 0.3382g on the surface.

The potential maximum strain % range is 0.00241% to 0.1987%, while the estimated relative displacement range is 0.0020m to 0.0114m.

The estimated maximum stress ratio lies in between 0.1458–0.3189.

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