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Path dependant Seismic Energy Attenuation at Site from the Himalayan and Hindu Kush region Earthquakes

ABSTRACTS

The Himalayas and Hindu Kush region are home to frequent moderate level earthquakes and rare great earthquake events. They are felt in the foothills of lower Himalayas also. Therefore, Chandigarh city is chosen as the site for the study and is shaken by earthquakes from two directions, North-West (NW) and South-East (SE) named as Path A2 and Path A1 respectively. Study is done for 35 real earthquake recordings of M 3.5 to M 7.9 from August 2012 to January 2016 from sensors placed on ground floor in a building at Chandigarh site. The study is carried out for a stretch of 900 km on both sides, covering 1800 km of the Himalayan arc and Hindu Kush region.

OBSERVATIONS

•Seismic energy received by the site is calculated from the power spectral density function of recordings after signal processing of ground motions. This energy at the site gives a cumulative effect of path attenuation characteristics of small regions encountered in between by the seismic waves. Seismic energy imparted to the structure from earthquakes of the same magnitude and distance from the site, but travelling from paths A1 and A2 is compared and is presented in the table below.

•To investigate how seismic energy is transmitted by Fault Normal (FN) and Fault Parallel (FP) in far field regions, ground motions are rotated in FN/FP directions. NS/EW components are as recorded components of ground motion in our case. Figure 2 presents orientation of faults near earthquake occurrence locations. Strike angle of a each fault is measured and NS EW components are rotated to check the FN/FP ratio.

Table 1 List of earthquake sources in path A1 and A2 arranged in ascending order of distance from the site.

Eq_ID	Distance from site (km)	Focal Depth (km)	Magnitude	Earthquake Date and Place
A1_01	154	10	M4	20131225 Uttarkashi
A1_02	163	12	M4.8	20121127 Uttarkashi
A1_03	164	5	M4.8	20130211 Uttarkashi
A1_04	165.3	11	M3.5	20130905 Uttarkashi
A1_05	223.6	13	M4.3	20150718 Uttarakhand
A1_06	223.6	10	M4.3	20130406 Rudraprayag
A1_07	242	10	M4	20150603 Chamoli
A1_08	258	10	M5.1	20150401 Chamoli
A1_09	270	10	M4	20151129 Chamoli
A1_10	365	33	M4.8	20150929 Pithoragarh
A1_11	485.6	10	M5	20121111 Nepal
A1_12	500	10	M5.4	20151218 Nepal
A1_13	637	10	M5	20120823 Nepal
A1_14	827	15	M7.9	20150425 Nepal
A1_15	966	15	M7.3	20150512 Nepal
A2_01	175	10	M4.1	20140617 Kangra
A2_02	176	10	M5	20140821 Kangra
A2_03	179	5	M4.1	20121106 Kangra
A2_04	216	10	M4.8	20130604 Lahul Spiti
A2_05	231	10	M4.5	20130605 Chamba
A2_06	276	15	M5.8	20130501 J&K-H.P. Border
A2_07	279	10	M4.6	20130501 J&K-H.P. Border
A2_08	289	10	M3.9	20130502 J&K-H.P. Border
A2_09	297	18	M4.6	20140613 J&K
A2_10	486	10	M5.3	20150724 Pakistan
A2_11	545	10	M5.3	20150227 Pakistan
A2_12	660	97	M4.9	20140708 J&K
A2_13	742	66	M5.7	20130424 Afghanistan
A2_14	757	237	M5.8	20130404 Afghanistan
A2_15	800	80	M6	20151122 Afghanistan
A2_16	817	210	M6.2	20150810 Afghanistan
A2_17	826	206	M6.5	20151225 Afghanistan
A2_18	841	170	M5.8	20160102 Afghanistan
A2_19	847	212	M7.5	20151026 Afghanistan
A2_20	914	26	M7	20151207 Tajikistan

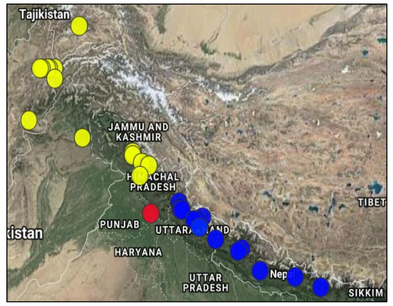

Figure 1 : Earthquakes grouped on the basis of wave path propagation

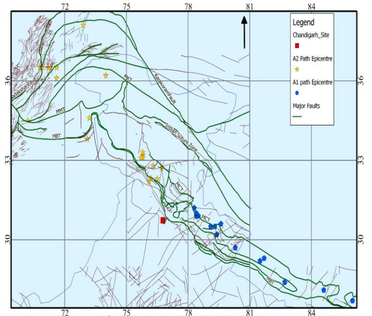

Figure 2 : Orientation of Faults near earthquakes considered for the study

Table 2 Comparison of Energy imparted by earthquakes of same magnitude and distance from path A1 and A2 at site B.

Eq_ID (i)		Distance from site D (km) (ii)	Focal Depth (km) (iii)	M (iv)	Energy (J) (v) NS	EW	UD	Comparison of energy received from Path A1 and A2 (Same M and Same D) (vi)
Case 1	A1_01	154	10	4	107	81	164	Path A2 Energy > Path A1 Energy
	A2_01	175	10	4.1	133	125	110	
	Energy Difference with almost same M and same D				27	44	54	
Case 2	A1_09	270	10	4	106	79	157	Path A2 Energy > Path A1 Energy
	A2_08	289	10	3.9	180	169	2176	
	Energy Difference with almost same M and same D				74	90	2019	
Case 3	A1_12	500	10	5.4	174	146	232	Path A2 Energy > Path A1 Energy
	A2_10	486	10	5.3	813	756	485	
	A2_11	545	10	5.3	1613	1752	581	
	Energy Difference with almost same M and same D				1439	1606	349	
Case 4	A1_13	637	10	5	136	126	311	Path A2 Energy > Path A1 Energy
	A2_12	660	97	4.9	2647	3188	1672	
	Energy Difference with almost same M and same D				2511	3062	1361	
Case 5	A1_14	827	15	7.9	95926	59387	30032	Path A2 Energy > Path A1 Energy
	A2_19	847	212	7.5	610471	803308	221108	
	Energy Difference with almost same M and same D				514545	743921	30032	

CONCLUSION

1. For Chandigarh site, it is concluded that same magnitude earthquakes originating at the same distance from the site, travelling from Northwest direction i.e. Himachal Pradesh, Jammu & Kashmir, Pakistan and Afghanistan impart more energy than the South East direction which is Uttarakhand and Nepal, i.e., energy attenuation is more in path A1.
2. Unlike, near field ground motions huge seismic energy in Fault Normal components is not observed in Far field regions. Therefore, North-South and East-West components of ground motions to be carefully used for further applicability in structures to bring maximum responses.

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