16 Apr 2004, 4:30pm - 6:30pm

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Proceedings: Fifth International Conference on Case Histories in Geotechnical Engineering
New York, NY, April 13-17, 2004

DOMINANT PERIODS OF EXPECTED GROUND MOTION OF GYUMRI TERRITORY BY A METHOD OF CALCULATING DOMINANT PERIODS IN NON-HOMOGENOUS SURFACE LAYERS OF THE EARTH'S CRUST

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ABSTRACT

The seismoresistance of buildings and constructions is substantially connected by the regularity of the ground vibrations during the strong earthquakes. The main character of any vibration is its highness of component periods. The periods firstly depend on the environmental ground. During the strong earthquakes the precise results we can get only by a method of instrumental records. During the Spitak earthquake in 1988 with M = 7.0 in Gyumri town, which is situated 30 km far from the epicenter and had developed net of seismic stations it has been got only one record, which did not give any real imaginations about dominant periods. It's know that many scientists and K. Kanai among came to conclusion that during the numerous earthquakes with M > 6 the main periods of grounds observed coincide with the dominant periods of micro-vibrations of the environmental grounds. Using the method of calculation of dominant periods for non-homogenous surface layers and having the micro-vibration records of Gyumri town there was defined the approximate dominant periods of Gyumri territory during the expecting strong earthquakes.

INTRODUCTION

Armenia having a few developed research institutes, which were busy by building engineering and seismic constructions in 1988, after Spitak earthquake was taken aback simply because how it could be that the existing seismic resistant buildings accounted against 9 intensity were damaged and destroyed in Gyumri, 30km far from the epicenter. So that buildings due to their constructions had different eigenperiods, which is 0,25-0,4s for the 4-5 storied buildings, and 0,5-0,6s for the 9 storied buildings. After that we started to analyze the causes of the buildings damaging. (Abrahamyan H. 1998).

Whether the earthquake dominant periods coincide with the own buildings vibration periods, was there really resonance phenomena or no? Whether the periods of micro-vibrations observed on different grounds of Gyumri have displayed the predominant period results observed during the main strike.

For leading that problem in correct way, we organized micro-vibration recording by the following plan: without counting geological structure of the environment to make records of micro-vibrations of the entire town especially in the places where there were the damaged buildings; after having micro-vibrations dominant period results of that territory we built interesting typical geological stions for different areas. On the basis of the obtained results there were organized 6 regular seismic - stations based on different ground for the recording the earthquake aftershocks. After that only we started to discuss the results and make a conclusions. Fortunately, during the aftershock observations we were not able to record the earthquake with M > 6 magnitude, because during our works there was not any stronger earthquake than M = 4,7. Without instrumental records of the earthquakes with M > 6 we could not give an answer if during Spitak earthquake in what dominant periods were vibrated different grounds conditions areas of Gyumri town. That is why we used the method of calculations of predominant periods on the surfaces of non-homogenous layers.

CALCULATING OF DOMINANT PERIODS ON NON-HOMOGENOUS SURFACE LAYERS FOR DIFFERENT GROUND CONDITIONS

After Spitak earthquake there were many discussions on Gyumri's ground conditions peculiarities. Gyumri is situated in Shirak land which is surrounded by mountain rocks, numerous cliffs, glacier, sands, pebbles and volcanic tuffs. That layers in the town are getting up to 300-500 meters. Micro -vibrations dominant periods observed by us are as follows: on sediments (N 1-4 area) T = 0,21-0,6s and for area N 5 which is situated on the basalt layer T = 0,09- 0,12s. (Abrahamyan H 2002; Khalturin V., 1990). After Spitak earthquake in 1988 there were organized measurements of dominant periods on the northern part of the town using the long-period seismometers by Japanese scientists, which gave T=1.5-3.2 s. It was found that besides of the high frequency Let us consider the main shock of Spitak earthquake (7 Dec 1988, M=7.0), which was registered only in "Leninankan"

seismic station. Its dominant periods band is laying T=1.2-3.0 s. In 1988, 31 of December the aftershock with M=4,7 was registered analyzing of which accelerograms shows that the predominant periods of ground was T=0.8-2.0 s (Borcherdt R., 1989; Khalturtin V. at al., 1990). Let us consider the results of 5 territories predominant period calculations (by the formula below). In the geophysical literature there is a series of rough formulas for computing the predominant periods. (Okomoto S. 1980) accepting that the physical mechanic properties of the layers are not differ from each other for computing the approximate value of T_{01} suggests the following formula

$$T_{01} = \sum_{k=1}^{n} 4H_k / V_{sk} \qquad (1)$$

And in the documents of American conference (NEHRP 1997) of Seismic resistance of structures for T_{01} the following formula is offered.

$$T_{01} = 4H / \overline{V}_s \qquad (2)$$

Whence

$$H = \sum_{k=1}^{n} H_k \qquad \bar{V}_s = \sum_{k=1}^{n} H_k / \sum_{k=1}^{n} H_k / V_{sk}$$

Where H_k – the thickness of k layer in meters
Vsk –the velocity of slip of k layer in m/s

Simple transformations show that both the formula give the same result. So in our assessments we will use the first equation. The geological structure of the territories investigated in our works has the following form. On the above given 5 territories where were set temporary seismic-stations we have got the records about of 20 aftershocks with M=2,5-3,7 by magnitude on the basis of which analysis the magnitude of predominant periods on 4 areas is T=0,35-0,55 and for 5th area was 0.35-0.55 (Abrahamyan H. 2001).

#1 Point

Grounds	Velocity Vs(m/s)	Thickness H (m)
Sand	200	4
Glacier	300	7
Glacier refractory	550	100
Lake glacier	800	200
T_{01}=1.90 s		

#2 Point

Grounds	Velocity Vs(m/s)	Thickness H (m)
Loam Sandy Loam	200	3
Glacier Refractory	500	100
Glacier lake	800	150
T_{01}=1.61 s		

#3 Point

Grounds	Velocity Vs(m/s)	Thickness H (m)
Glacier	250	4
Loam	200	6
Sand	350	10
Tuff	450	15
Glacier Refractory	550	100
T_{01}=1.15 s		

#4 Point

Grounds	Velocity Vs(m/s)	Thickness H (m)
Loam	200	2
Tuff rotten	350	7
Tuff strength	450	5
Sandy loam	600	15
Glacier lake	450	100
T_{01}=1.15 s		

#5 Point

Grounds	Velocity Vs(m/s)	Thickness H (m)
Sandy loam	250	3
Bazalt	1800	120
T_{01}=0.31 s		

DISCUSSION OF THE RESULTS

Theoretical computations of the predominant periods of grounds shows that in the areas 1-4 during the probable expecting earthquake with M> 6 the approximate values are as much as T_{01}=1,15 – 1,90 s. On the 5th area with basalt layer T_{01}=0.31 s. For hard homogenous rock grounds where Vs exceeds 1000 m/s the H-values should not exceed 100-120 meters because in case of H highness of the first equation could lead to incorrect results.

Results obtained for these areas by Japanese scientists (T_{01}=0,3-0,5 s) coincide well with our results. It was found that during the earthquake with M =2,5- 4,2 on the grounds of Gyumri town the dominant periods are equal T= 0,45-1,0 s but during the stronger earthquake with M = 4,7, T = 0,8-2,0 s. So, it means that in case of high earthquake magnitude the dominant periods are also growing up. So comparing the micro – vibrations with T=0,21-0,6 s (first band), T=1,5 –5,5 s (next band), aftershocks with T= 0,45-1,0 s when M= 2,5-4,2, T=0,8-2,90 when M=4,7, the single record of Spitak earthquake, T = 1,2-3,0 s when M = 7,0 and theoretical computations results T_{01} = 1,15-1,90 it becomes clear that during the expecting earthquake with M>6 on the sediment grounds of Gyumri the results of predominant periods should be equal to 1,15-1,90 s. If we accept that error of the (1) approximate equation is ±20% then both the theoretical and records observed prove that ground predominant periods on the territory of Gyumri in case of expecting earthquake with M> 6 by magnitude is within the range 0,91-2,28 s.

FINAL CONCLUSIONS

Using short period seismometers and high frequency micro–vibrations records of Gyumri territory, it's impossible to predict results of predominant periods during the expecting earthquake with M>6 magnitude.

For the Gyumri town and similar other areas which have thick sediment layers the recording of micro-vibrations should be done only by long period seismometers, which will make a possible to predict the results on predominant periods during the expecting earthquake with M>6 in magnitude.

As it was proved above during the Spitak earthquake there was not the resonance phenomena. The massive damages of the buildings were only because of the bad quality of the constructions. And the sond significant moment was non-reasonable reduction of seismic hazard for this territory.

The results obtained may be useful for engineer-seismologists as well as for specialists in the area of seismic resistant building.

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