EFFECTS OF LONG DISTANCE EARTHQUAKES ON LONG SPAN BRIDGES AND TALL BUILDINGS

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Poster Abstract – This poster focuses on the effects of far-field, (long distance) earthquakes on the response of long period structures such as long span bridges and tall buildings. The project used two different earthquake ground motions. One was the 1994 Northridge Newhall, a relatively strong near-field quake with MPGA of 0.60g. The other was the 1999 Chi-Chi-002 record, which was relatively weak far field (long distance) quake with MPGA of only 0.08g. These ground motions, were applied to the foundations of two major structures in San Francisco, the long span Golden Gate Bridge and the tall 49-story Embarcadero Building, Fig. 1. The force response as well as acceleration, velocity and displacement responses of these two structures to the two earthquakes was studied. The research indicated that the force and displacement response of these long period structures to far field, but weak ground motion were far greater than the response of the same structures to much stronger ground motion recorded close to the epicenter. The main parameter affecting the response was the long dominant period of vibration for far field motion being close to or longer than the fundamental period of vibration of the structures.

Figure 1. The Golden Gate Bridge (left) and the Embarcadero Building

Far Field Ground Motions - When a fault ruptures; it sends shock waves travelling from the ruptured area. The surface waves, which are the most structurally significant seismic waves, particularly the surface shear waves, travelling through the ground lose their short period components and become a long period motion. During the travel, while the period of vibration is elongates the maximum peak ground accelerations decreases and the duration increases. When such weakened but elongated long period surface waves arrive at the site of a long span bridge or tall building structure, with fundamental period of vibration close to the dominant period of vibration of the ground motion, there will be resonance and the response of the structure to such ground motions can be quite significant even when the maximum peak
ground acceleration can be quite small. Fig. 2 shows one component of each of the two ground motions used in these studies. Both graphs have the same horizontal and vertical axis scales. Note that the 1994 Northridge Newhall on the left has relative high MPGA, but short period and short duration while the 1999 Chi-Chi-002 has relatively small MPGA but quite long duration.

![Figure 2. Near field, strong (left) and far field weak ground motions used in the studies](image)

A few Important Results - Figure 3 shows roof drift response of the Embarcadero tower. The full line time history on the left side, which is relatively small, is created by strong near field Northridge earthquake, while the relatively large drift history on the right is the result of relatively weak but far field earthquake. Figure 4 shows time history of transverse movement of midspan in the Golden Gate Bridge when subjected to strong near field and weak far field (long distance) earthquakes. Again, similar to the response of the Embarcadero Building, the response of this bridge to the weak but long distance earthquake (Chi-Chi-002) is larger than its response to much stronger but near field quake (the Northridge Newhall quake). The poster will have more results of these studies in terms of forces in the members as well as displacements of various critical points on the structures. Conclusions and recommendations on what design ramifications these findings might have will also be provided.

![Figure 3. Response of Embarcadero Building to near field a far field earthquakes](image)

![Figure 4. Response of Golden Gate Bridge to near field a far field earthquakes](image)