A BRIEF REPORT ON REPUBLIC PLAZA RESPONSE TO THE GREAT SUMATRA-ANDAMAN ISLANDS EARTHQUAKE ($M_W = 9.0$) OF DEC 26, 2004

T.-C. Pan, X. You, C.L. Lim and K.R. Karim
Protective Technology Research Centre, School of Civil and Environmental Engineering
Nanyang Technological University, Singapore

1. Introduction

The massive undersea earthquake (moment magnitude M_w = 9.0) of 26 December 2004 occurred off the north-west coast of Sumatra, Indonesia (Figure 1). It caused tsunamis around the Indian Ocean with a global death toll approaching 290,000 (as of 22 March 2005), making it the deadliest tsunami ever recorded. The epicenter of the recent earthquake is 908 km north-northwest from Singapore. Singapore is located in a low seismicity region of Sunda plate, where the Sumatran fault and the Sumatran subduction zone, are located more than 350 km away. While earthquakes have never posed any real problems for Singapore, previous large earthquakes have induced tremors felt in Singapore [1-4]. The main tremors and a series of aftershocks from the recent earthquake were also reported felt in several areas of Singapore. A local newspaper reported that the areas where the tremors were felt are Tanjung Rhu, Marine Parade, Toa Payoh, Siglap and Meyer Road (*Today*, December 27, 2004). At these locations, the tremors caused no damage.

2. Republic Plaza Response

Since 1996, one of the tallest buildings in Singapore, the Republic Plaza (Figure 2) has been instrumented to study the building responses to dynamic loadings form both winds and long-distance earthquakes [5]. The Republic Plaza is a 66-storey, 280 m high tower that consists of a frame-tube structural system with a central core wall connected to a ring of external columns by a horizontal steel framing system at every floor. The structure sits on a deep, stiff caisson foundation system. The foundation system consists of six 60 m deep interior caissons connected by a 5.5 m thick concrete mat, and eight 40 m deep exterior caissons linked by transfer beams. The experimental results from ambient vibration tests showed that the first two natural frequencies of the building in the x direction are 0.19 Hz and 0.7 Hz, and 0.2 Hz and 0.75 Hz in the y direction, respectively. The instrumentation system consists of four servo-accelerometers, two 3-component anemometers and other hardware for purpose of converting digital data, storage and remote accessing, etc. Two servo-accelerometers are installed at the basement level (B1) along the two principle directions of the building, and the other two are at the roof level. The signal ranges of the accelerometers are set to ±10 mm/s^2 at the B1 level and ±50 mm/s^2 at the roof level.

Figure 1 Sumatra-Andaman Islands earthquake of 26 Dec 2004

Figure 2 Republic plaza

During the main shock of the Sumatra-Andaman Islands earthquake, the instrument system in the Republic Plaza was triggered by the ground wave propagating to Singapore from the epicentre. The motion signals were recorded at both the basement and the roof of the building (Figure 3). The maximum accelerations at the basement are about 5.34 mm/s^2 and 4.11 mm/s^2 in the x- and y-directions, respectively. The maximum roof accelerations are about 18.7 mm/s^2 and 18.11 mm/s^2 in the x- and y-directions. From the basement signals, it can be seen that the far-field ground motions recorded in Singapore are concentrated within a frequency band ranging from 0.05 Hz to 0.1 Hz. This explains why the ground tremors did not cause much response in Singapore. Only some high-rise buildings reported felt vibrations. The response at the roof shows vibrations of the first two modes in both x- and y-directions clearly.

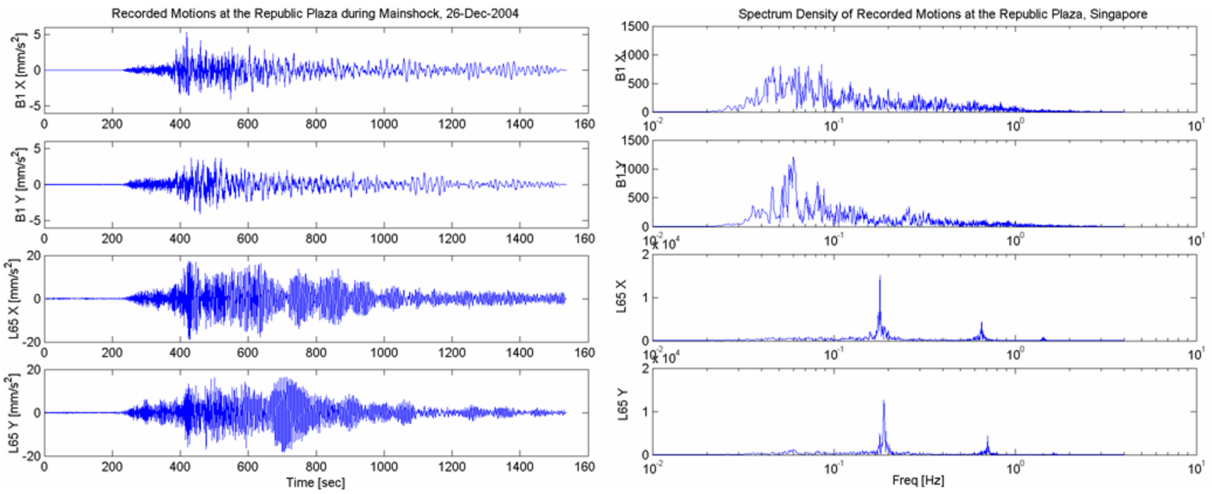

Figure 3 Recorded motions at basement and roof of Republic Plaza

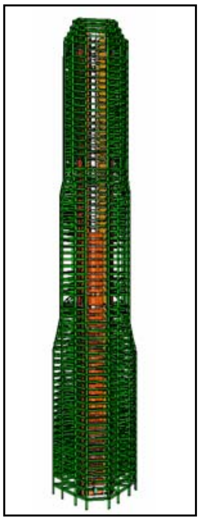

Figure 4 FE Model

The ground signals recorded at the basement were used as the input to the finite element (FE) model shown in Figure 4. The responses at the roof were simulated numerically. The simulated responses are compared with the recorded response, as shown in Figure 5. The blue lines represent the simulated responses from the FE model, and the red lines the recorded responses from the instruments. The FE model does not simulate the high frequency responses well. Therefore, the correlation between the two sets of responses is better for displacement than for acceleration and velocity. The acceleration and velocity signals are relatively more sensitive to the high frequency components than the displacement signals. Since the integration of the response from acceleration and velocity to displacement actually filters out the high frequency components of the signals, a very good match between the simulated displacement response and the recorded displacement response has thus been achieved.

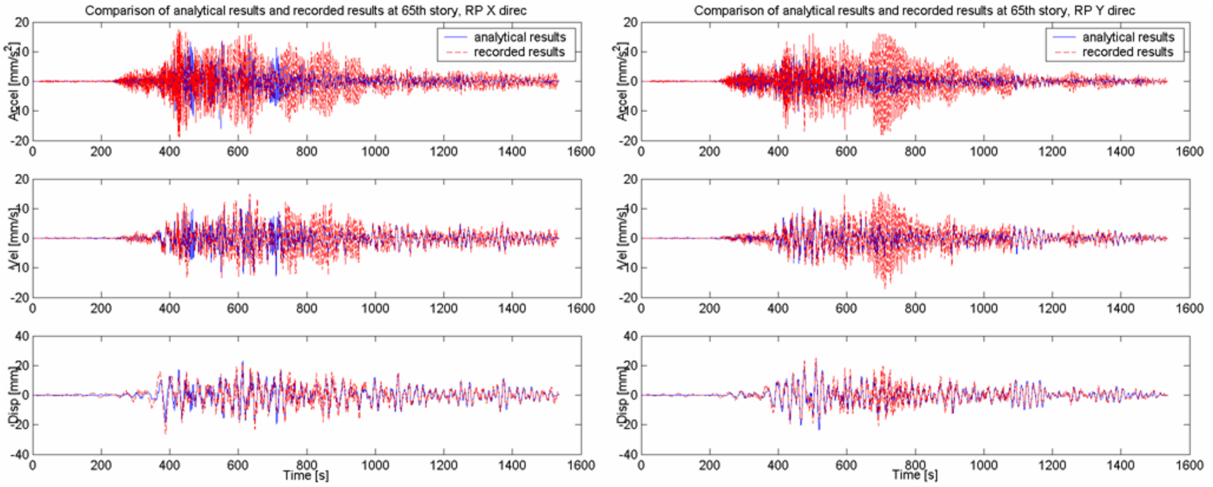

Figure 5 Comparison of recorded and simulated responses at the roof of Republic Plaza

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