NATIONAL HERITAGE FIVE STORY WOODEN PAGODA RESPONSE IN 2011 EAST JAPAN GREAT EARTHQUAKE

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ABSTRACT: Severe earthquake hit eastern part of Japan on March 11th, 2011. Tokyo area experienced most strong motion after Second World War. Using image processing system and acceleration observation system, we have been continuing the monitoring of deformation and acceleration responses of national heritage five story wooden pagoda at Hokekyouji temple in Ichikawa city close to Tokyo East. Maximum horizontal ground velocity in the earthquake was about 30cm/s. The acceleration response time histories have been saturated. However, the estimated velocities, which were obtained by integrating original acceleration time histories, showed the reasonable wave forms and amplitudes. Maximum horizontal deformation was about 10cm. Small residual deformation observed.


1 INTRODUCTION

In Japan, there are five storied pagodas of more than 22, which were built before 1850. Although there are many reports of the response characteristics of five story wooden pagoda, we could not find reports on long term deformation monitoring of five story wooden pagoda. Therefore, we started the earthquake and wind responses monitoring of national heritage five story wooden pagoda at Hokekyo-ji Temple close to Tokyo East, using image processing and acceleration sensors, from July 2007. We presented the monitoring method in previous paper WCTE 2010. On March 11th 2011, East Japan Great Earthquake occurred. The area from Aomori to Kanagawa was affected by the seismic quakes. The national heritage five story wooden pagoda was largely shaken by the quake. We report the responses of the pagoda by the quake.

2 2011 EAST JAPAN GREAT EARTHQUAKE

The earthquake occurred at 14:47 on March 11th, 2011. The JMA seismic intensities would be 6 in major damaged area, such as Miyagi, Sendai. Ibaraki, Tochigi, in minor damaged area, but liquefied large, would be 5. In Hokekyo-ji Temple, it estimated seismic intensity 5.

The maximum amplitudes original observed ground accelerations

<table>
<thead>
<tr>
<th>Axis</th>
<th>Acceleration</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>0.276G</td>
</tr>
<tr>
<td>Y</td>
<td>0.135G</td>
</tr>
<tr>
<td>Z</td>
<td>0.167G</td>
</tr>
</tbody>
</table>

Figure 1: Observed Ground accelerations

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3 RESPONSES OF PAGODA

Positions of image processing markers were given in numerical data of 10Hz sampling. Two horizontal components X and Y were recorded in PC. The outline sensor system is, resolution 16bits, maximum recording span 1.73g and sampling 100Hz in pagoda frame, 4.33g and 1000Hz in centre column. Original acceleration time histories in pagoda frame and centre column were saturated. However, velocities of one time integral on accelerations shows reasonable wave forms and amplitudes. The maximum response velocity would be 53.5cm/s at top of centre column. Maximum deformation between marker position and video camera was 7cm at 5th story, approximately. Response modes at each time would be first mode. Small residual deformations were found in every story time histories. We could not find the considerable differences in responses between pagoda frame and centre columns.

4 CONCLUSION

Centre column effect for dynamic response would be negligible.