ABSTRACT
The Plaza Indonesia Extension is a large-scale, multipurpose high-end development project with the basement constructed from the ground floor down and the superstructure from the ground floor up. The project is located in a densely-built prime area. Excavation depth reached 17 m, just meters away from the existing podium block of the Grand Hyatt Hotel and the Japanese Embassy. Using top-down construction method, when the 5th basement level was completed, the superstructure had reached the 10th floor, saving 11 months’ construction time. The columns and the RC core walls were temporarily supported by composite infill steel boxes, 600 x 600 mm, embedded into 70 m deep bored piles.

The building, designed to withstand 2475-year earthquake, exceeded the Indonesian Code requirement of 475-year. A special study on the seismicity of Jakarta, as well as Site-Specific Response Analysis for the project location, were conducted to meet this criterion.

This paper describes the complexity of the design and construction of the Plaza Indonesia Extension project, completed in 2009.

INTRODUCTION
The Plaza Indonesia Extension project is a 200,000 sq m development consisting of a 48-storey residential tower, a 42-storey office tower, a 7-storey retail podium and a 5-level basement. It is located in a densely-built prime area along Jalan M.H. Thamrin in Jakarta, facing the prominent Hotel Indonesia roundabout.

This project forms part of comprehensive large-scale multi-use high-rise complex, in which an existing Plaza Indonesia shopping centre and the 428-room Grand Hyatt Hotel have been in operation since 1990, alongside the 2003 trendy Plaza e’X. Two distinguishing features of this project were the use of the top-down construction method and the earthquake-resistant design. The Plaza Indonesia Extension is designed to resist 2475-year earthquake. This design therefore exceeds the Indonesian Code requirement of 475-year.
TOP-DOWN CONSTRUCTION

The Plaza Indonesia Extension project incorporates two towers, of 48 and 42 stories respectively, built of reinforced concrete. It has a dual system RC core wall and an open frame as the lateral system for both towers, while the 7-storey podium block was constructed using a braced steel frame. The project is located very close to the Japanese Embassy and the existing Grand Hyatt Hotel, which has a 3-level basement sitting on a soil-supported mat. Figure 1 shows the site plan, and figure 2 the completed project.

![Fig. 1: Site plan](image1)
![Fig. 2: Completed project](image2)

Each floor of the 5-level basement under the two towers and podium block occupies a huge area of 12,415 sq m. Its boundary is just meters away from surrounding buildings. Therefore, the 17-m excavation had to avoid causing soil movement that would affect the neighboring structures. Tie-back installation was not possible due to lack of space. The presence of a high groundwater table, just 1.5 m below the surface, and a tight schedule, add complexity to the problem. The solution: top-down construction.

Perimeter diaphragm walls, 800 mm thick and 32 m deep, were first constructed. High-capacity bored piles with a diameter of 1.5 to 1.8 m, 70 m deep, with an allowable bearing capacity up to 1500 tons were installed, with steel columns submerged into them and brought up to B-1 level. These steel boxes, made from ASTM grade-50, were later filled with 55-MPa concrete to form filled composite columns, designed to act as king-posts to take the load of the basement plus the 15-storey above-grade structure, including the RC core. Each single bored pile was calculated to take the load of the basement plus the 15 above-grade levels, borne by the king-posts. Only after the mat foundation had been cast, was the subsequent load from the superstructure distributed to other piles. Some piles have to bear a huge load of up to 1500 tons. Calculation showed that the bored pile needed drilling to a depth of 70 m from the surface. Since a load capacity of this magnitude and dimension had never been encountered in any previous Indonesian construction for buildings, special Bauer machines had to be brought in from a neighboring country. To prevent soil collapse during the drilling operation, bentonite slurry was used.

Another challenge was testing the high-capacity bore pile. The local code stipulates that any deep foundation must be tested to twice its allowable load. This means the
counterweight is in excess of 3000 tons. The restricted site and the problem of transporting the counterweight forced another testing method to be chosen, namely the Osterberg cell. This method had been used in previous projects and approved by the authorities in the municipality of Jakarta. The sacrificial cells were installed within the bored pile, welded to the steel cage and water was used to apply hydraulic pressure to the cells. As the load was applied, the cells moved in two directions: upwards against the upper skin friction and downwards against the lower skin friction and the base resistance. A series of instruments were installed. Figure 3 shows the test during execution in the field.

![Fig. 3: Site condition during testing of pile](image1)

![Fig. 4: Work progress upwards and downwards simultaneously](image2)

After the king-posts had been installed, the B-1 slab was cast with several construction holes left open to allow the removal of excavation material. Above-grade and sub-grade construction proceeded simultaneously. After each basement slab had been poured, excavation to 2.5 m to the next basement level followed. Later on the king-posts on that particular level were encased with 55-MPa concrete to make composite encased steel columns. Problems with verticality were found on some king-posts after they were exposed during the removal of the soil, and they exceeded the tolerance criteria employed in the design. Back analysis showed the king-posts were able to take the load of 10 levels of above-grade construction. A revised plan was adopted and it was decided that the above-grade construction should not exceed 10 floors before all the king-posts were encased in concrete. The top-down process took nine months to finish. Figure 4 shows how work progresses upwards and downwards simultaneously and Figure 5 shows the basic construction sequences.

In deep basement construction, it is very important to limit the movement of the wall to avoid damaging existing buildings nearby. As each subsequent sub-grade level was completed, the RC slabs would act as lateral bracing for the diaphragm walls. The slabs provided very rigid support across the excavation. The analysis was performed in stages, simulating the construction sequence.
Due consideration was paid to the problems of heaving and piping at the bottom of the excavation. Two inclinometers were installed to monitor the movement of the diaphragm walls. Figure 6 shows the analysis result of diaphragm wall and figure 7 shows the result of inclinometer measurements. The wall deformation was slightly smaller than had been predicted in the analysis.
SEISMIC DESIGN

The Plaza Indonesia Extension project used a dual system of RC core wall and open frame as lateral resisting system for both towers, while the 7-storey podium block was constructed with steel frame. The code on Earthquake Resistant Design for Buildings in Indonesia stipulates that all buildings must be designed to withstand earthquakes of 475-year return period, but for this development the client required a 2475-year. To meet this criterion, a Probabilistic Seismic Hazard Analysis (PSHA) for Jakarta was conducted, followed by a Site-Specific Response Analysis (SSRA) for the project.

The PSHA was conducted using the 3-D EZ-FRISK computer program. It considered the tectonic setting, regional geology and seismicity of the site. Seismic source characterization of subduction sources and shallow crustal faults within a radius of 500 km from Jakarta was taken into consideration. The result of the analysis and the code requirement is presented in the following table.

<table>
<thead>
<tr>
<th>Hazard Spectra, T = 0 sec</th>
<th>PGA at Base Rock (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniform, site coordinate</td>
<td></td>
</tr>
<tr>
<td>106.85°E, -6.20°S</td>
<td>0.185 0.276</td>
</tr>
<tr>
<td>Indonesian Earthquake Resistant Design Code 2002</td>
<td>0.150</td>
</tr>
</tbody>
</table>

The base rock of Jakarta was assumed at the depth of 300 m below the surface. Field measurement using Seismic Downhole Test (SDT) was conducted at two locations at the site. The SDT provided shear wave velocity profile of the site. Several seismic baserock motions were generated based on Uniform Hazard Spectra (UHS), scaled to T=2 seconds. The spectral acceleration at T=2 sec is 0.1260 g. Spectral matching methodology from several strong motion records provides five input motions representing the potential subduction and shallow crustal earthquakes. The result of SSRA gave 5% damped response spectra at ground surface. Recommended design response spectra were then derived by averaging the result of frequency-domain and time-domain analysis for the considered input motions, and are shown in Figure 8. The seismic response modification factor R was taken as 8.5 as per the Indonesian code. Analysis was also performed for the adequacy of the open frame to serve as a second line of defence against a major earthquake, where the frame alone was required to take 25% of the seismic load. Figure 9 shows the reinforced concrete structure under construction.

The project was commenced in September 2006 and completed in September 2009. The main contractor for the project was SsangYong Engineering Construction Co. Ltd, S.Korea, who appointed Davy Sukamta and Partners Structural Engineers as their structural design consultant for the project. At 225 meters, the Plaza Indonesia Extension is currently one of the tallest buildings in Jakarta.
475-year design response spectra

2475-year design response spectra

Fig. 8 : Design response spectra

Fig. 9 : The concrete structure under construction

BRIEF BIOGRAPHY OF THE AUTHOR

Ir. Davy Sukamta, Fellow P.E., is currently the president of Indonesian Society of Civil and Structural Engineers (HAKI), for the fourth consecutive term ending in 2011. As the principal of Davy Sukamta & Partners, Structural Engineers, Jakarta, he has designed 288 projects, among others are Amartapura (52-storey apartment), The Peak Apartment (55-storey), Plaza Indonesia Extension Jakarta (48-storey and 42-storey + 5 levels of basement), The Oakwood Cozmo Premier (40-storey apartment). He is also the author of numerous publications.