HYDRAULIC UPLIFT PREVENTION BY CUT-OFF WALL: A CASE STUDY ON LARGE EXCAVATION IN CENTRAL JAKARTA

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1. INTRODUCTION

This paper presents a case study of hydraulic uplift prevention below 14.5m deep excavation for basement construction in Central Jakarta. A 36m x 63m basement was planned to be constructed by in soft to medium still clay layers. 600mm thick D-wall had been designed and constructed as temporary earth retaining structure by other parties. The D-wall toe is embedded 3.5m below final excavation level. During the detail design stage for the temporary support system and permanent structure, 3m to 4m thick diluvium sand layer was found below D-wall toe. **Figure 1** shows structural plan, elevation, and geotechnical condition of the basement structure.

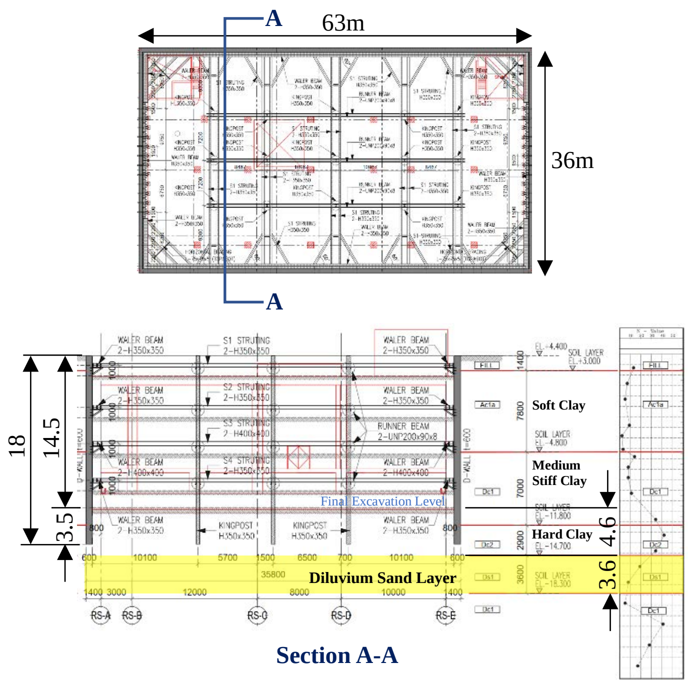

Figure 1 *structural plan, elevation, and geotechnical condition of basement structure*

The presence of sand layer as a continuous aquifer was confirmed by pumping test. This imposed the risk of hydraulic uplift failure during excavation. Based on flow analysis result, water cut-off wall and pressure relief wells were proposed as preventive measure. The cut-off wall was then built along perimeter of D-wall by dual rows of jet grouting and chemical injection. The effectiveness of the cut-off wall was proven by confirmation pumping test. The excavation reached the final excavation level safely with manageable rate of water ingress. This paper summarizes the technical and construction issues encountered and the countermeasures implemented to ensure the stability of the excavation.

2. HYDRAULIC UPLIFT STUDY

After diluvium sand layer was found below D-wall toe, the pumping test was carried out to estimate the permeability and examine the continuity of the aquifer. **Figure 2** shows the layout plan and groundwater drawdown record of the test. The estimated permeability was $5.7x10^{-4}$ – $9.0x10^{-4}$ m/s and radius of influence was at least 470m. The presence of continuous aquifer was confirmed. The hydraulic uplift failure was checked based on Japanese RTRI DSRSC standard and the risk of failure was confirmed with significantly small counterweight (W) comparing to the uplift pressure (U) (see **Figure 3**).

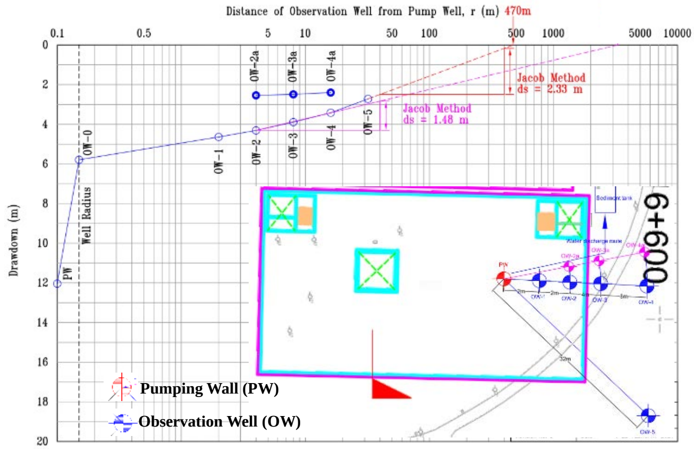

Figure 2 *Layout plan and groundwater drawdown versus distance of observation wells from pump well of pumping test conducted before construction of water cut-off wall*

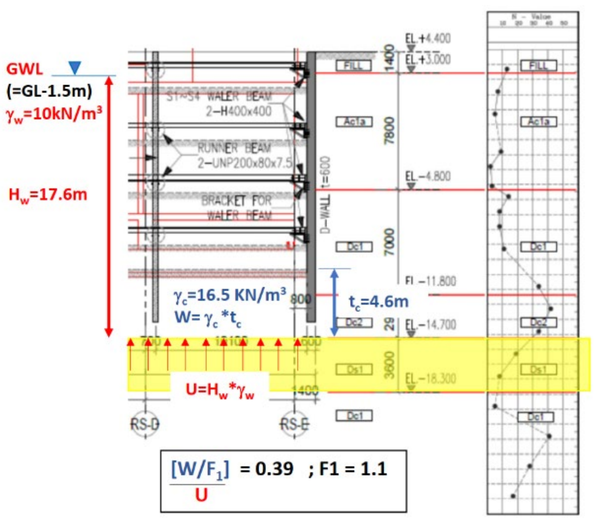

Figure 3 *Base stability checking against hydraulic uplift failure*

Keywords: large excavation, hydraulic uplift, cut-off wall, pressure relief well
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3. PROPOSED PREVENTIVE MEASURES

Due to the contract requirement which prohibits active pumping, installation of water cut-off wall and pressure relief wells was chosen as countermeasure against the hydraulic uplift failure. Based on flow analysis result, minimum 1m thick cut-off wall (coefficient of permeability, $k = 10^{-6}$ m/s) with 1m overlap into D-wall toe and 2m embedded into impermeable layer was required to prevent the uplift failure and excessive settlement due to groundwater drawdown. Pressure relief wells with minimum total flow capacity of 900 litre/min was required according to the estimate flow capacity of the walls from flow analysis result. **Figure 4** shows the design configuration of cut-off wall. The result of flow analysis by 2D FEM is illustrated in **Figure 5**.

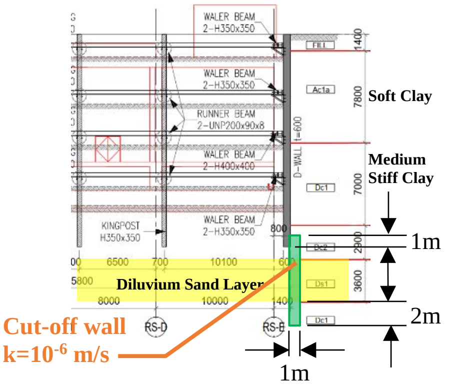

Figure 4 *Design configuration of cut-off wall.*

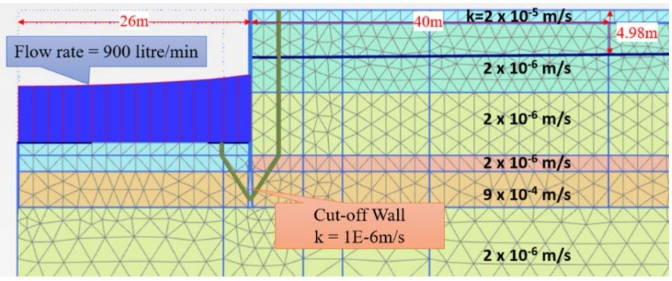

Figure 5 *Water ingress and groundwater drawdown according to flow analysis by 2D FEM*

4. CONSTRUCTION ISSUES AND THE COUNTERMEASURES

The jet grouting and chemical injection were selected as construction methods for the cut-off wall, based on result of confirmation pumping tests. The jet grouting was to ensure the strength of wall. While the chemical injection, which was injected between jet grouting columns on the back side, was to enhance the watertightness of the wall. **Figure 6** shows the layout plan of jet grouting and chemical injection and pressure relief wells (PRW). Another pumping test was conducted to confirm the efficiency of the cut-off wall after completion of chemical injection. **Figure 7** presents the layout plan and the result of the pumping test. The result shows sufficient effectiveness with obvious distinction of groundwater drawdown between outside and inside cut-off wall area.

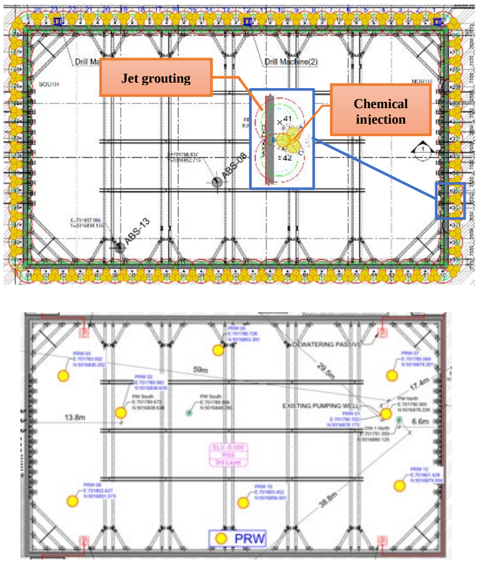

Figure 6 *Layout plan of jet grouting and chemical injection and pressure relief wells (PRW)*

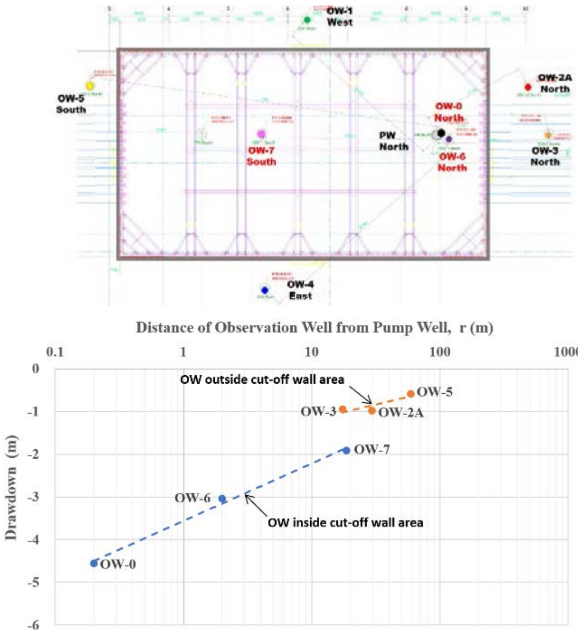

Figure 7 *Layout plan and the results of confirmation pumping test conducted after completion of cut-off wall*

The excavation reached the final excavation level safety. The water ingress rate at this stage was 660 litre/min, which is within manageable capacity of PRW. This proves the effectiveness of the water cut-off wall. No excessive wall movement observed during excavation.

5. CONCLUSION AND LESSONS LEARNED

The risk of hydraulic uplift failure was found through additional soil investigation and confirmed by pumping test conducted during detail design stage. The geotechnical investigation and proper interpretation are necessary to be done to identify the risk and to plan for appropriate preventive measures. Moreover, confirmation of the effectiveness of the preventive measures by the field tests and duly decision on corrective measures are also crucial. Finally, the close monitoring and observation during excavation is the key to ensure the safe construction.