Simultaneous Installation of Two Caissons

— Caisson Work at the Senjusekiya Pumping Station —

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1. Introduction

Senjusekiya Pumping Station located at the north-east of Tokyo, is a rainwater pumping station designed to cope with the increased rain runoff due to the recent climb of localized heavy rains.

Fig. 1

2. Outline of Construction

This was the first project in the world to simultaneously install two large pneumatic caissons for more than 50 meters underground. The two caissons, namely the west caisson ($2,614m^2$) and the east caisson ($2,289m^2$) were only apart for a distance of 2.0m.

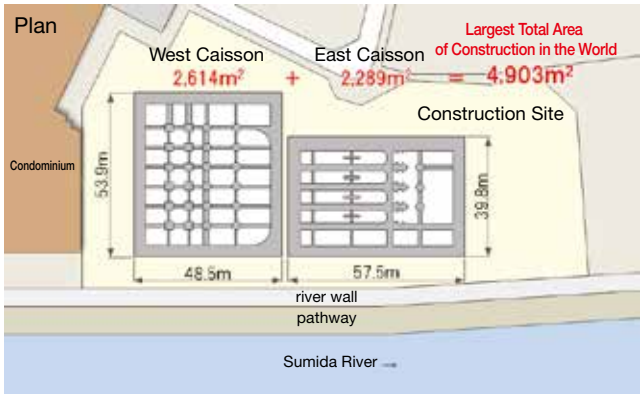

Fig. 2

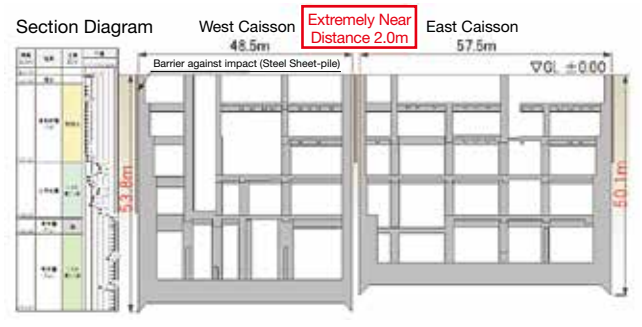

Fig. 3

3. Features of Construction

As this was an urban project, there were restrictions on the usage of land, which in place required to install the caissons in great depth. Also, the construction period had to be as short as possible, considering the burden causing to those living nearby. Pneumatic Caisson method was the resolution for these challenges.

The ground surrounding the pumping station is not rectangular, but heterotypic. Heterotypic caissons might get twisted, or have other problems when installed underground, so the two separate caissons were designed, as the drilling area had become larger than any similar project before.

4. Technical Issues and Resolutions Regarding the Two Caissons

Ground pressure and surface friction increased between the walls of the two caissons, as the soil changed from soft cohesive soil to over-consolidated cohesive soil, and then to gravel and sand layers. It was anticipated that the repeated shearing while installing the caissons had caused the volume of the ground to expand (positive dilatancy). The Drucker-Prager fracture criterion (a nonlinear dynamics model considering the dilatancy of the ground) was adopted to conduct a reproductive analysis of ground pressure. This revealed the fact that the dilatancy was larger than expected due to various factors: fast shearing speed during installation of caissons, adjacent face being wide (about 40m x 50m) and near (2m), and the ground being rigid.

Resistance to install becomes larger as the surface friction increases. The project came to a yellow sign during the last phase of installment deeper than GL-45m, as 669,300kN more was necessary to complete installment.

There were two options: increase power to install or reduce resistance. In this project, approximately $57,000m^3$ of water was poured into the caisson first to make it heavier. Secondly, the ground between the caissons was drilled using a high-pressure drill, and the friction was reduced using 40MPa high-pressure water. As a result, the surface friction was reduced by 242,800kN, making the power to install larger than the resistance.

5. Final Results of Construction Accuracy

Various measurements and figures from the GPS automatic displacement measurement system showed that the final inclination was 1/2,000 (34mm). The simultaneous installment of two caissons was highly accurate.

6. Conclusion

The fifth phase of the Senjusekiya Pumping Station construction is currently ongoing. This is to connect the two caissons by drilling the 2.0m distance between them.