A design case of deep excavation with steel pipe strut method

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ABSTRACT: The steel pipe strut method replaces the existing method using H beams as earth retaining structures in large-scale deep excavation carried out for the construction of railway, subway, underground road. Steel pipes have an excellent cross section function that changes the overall retaining structure, allowing the characteristics of the existing method to be maintained while improving convenience. The larger scale of the retaining structure accounts for 6.76% of Korea's GDP. As such, if the method is applied nationwide in public construction projects, significant economic benefits are expected.

Keywords: Steel pipe, earth retaining structure, strut, H-Beam

1 INTRODUCTION

At present, the construction market faces complex difficulty due to an imbalance in the supply of demand in reinforcement materials and a rise in raw materials. The steel pipe strut materials used in this study feature a variety of forms (○, □), types (SPS 41, SPS 50, SMA 50, SMA 58, STKT 590), standards (D406, D508, D609-D2,000) and thickness to fit the conditions of the site and budget. By applying the steep pipe strut method to the site for the private investment project for Seoul Jemulpo Terminal in Korea, we sought to secure stability of the nearby buildings in an urban environment and shorten the construction period to minimize traffic disruptions, which in turn save costs.

2 OVERVIEW AND CHARACTERISTICS OF THE STEEL PIPE STRUT METHOD

During a deep excavation to construct a large-scale structure underground (railway, subway, underground roads, underground parking lots), the weight of the nearby buildings, soil pressure and water pressure must take into account. As such, an H-pile+ earth flow wall need to be installed. Depending on the depth of the excavation, multiple struts on top, bottom, left and right need to be installed to support the pressure from the soil and water delivered through the walls structures to prevent the easing or collapse of the areas near the excavation site. In order for this new method to be widely applied, it must be more economical and easier to apply compared to the existing method. The implementation must also be done systematically to shorten the construction period. Most importantly, since most of the construction sites are in urban areas and for larger structures, the safety of the struts must be taken into account. The SP-STRUT method that meet these criteria have the following characteristics.

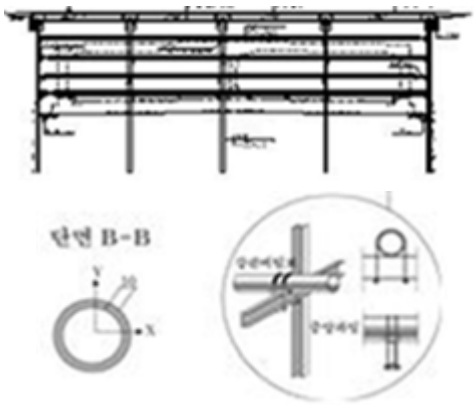
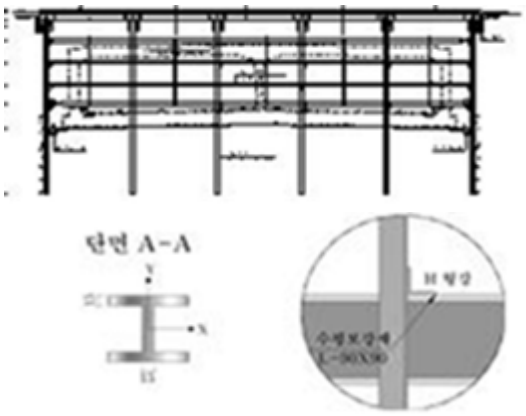
Table 1. Characteristics of the steel pipe strut

	Characteristics
Economic aspect	· 10-20% reduction in construction costs · Increase in strength means wider intervals at which struts are installed. No need in horizontal or vertical reinforcements.
Constructability	· Increased work efficiency for transportation of tools and materials by securing sufficient work area. · Easy to assemble the connecting parts (waling+steel pipe, steel pipe+steel pipe) : Easy to construct in a shorter time
Safety	· Since there is no reinforcement work, safety incidents can be prevented when installing or removing the structures (Trucks can be used) · Disfiguration of the ground base when removing reinforcement does not occur
Structural aspect	· Isotropic cross section leaves no distinction between strong and weak axises. · Allowances for buckling weight is greater as it withstands buckling, twisting or bending better

3 COMPARISON OF STEEL PIPE STRUTS AND H-BEAMS

Table 2 shows a comparison of steel pipe struts and H-beams.

Table 2. Comparison of steel pipe struts and H-Beams

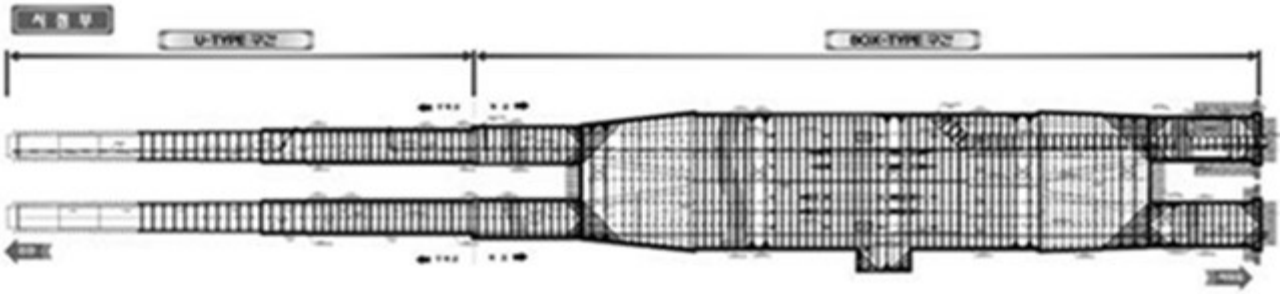
Application cases	Steel pipe Strut (Φ406.4x9t)	H-Beam Strut (H-300x300x10x15)
Cross section		
Structural stability	· Cross section 2nd moment (for 7t) Iv=22,000cm4 Iz=22,200com4(The direction of the weak axis is stronger) · Unit weight High structural stability · Isotropic structure makes it more favorable for structure ⇒Greater resistance to buckling or twisting · Horizontal interval of struts: 4-6m · Available maximum span is 13m	· Cross section 2nd moment Iy = 20.400cm4 Iz = 6.750cm4 (The direction of the weak axis is stronger) · Unit weight 94kgf/m(H-300X300X10X15) · Average structural stability · Cross section of the weak axis ⇒Vulnerable to buckling or twisting · Horizontal interval of struts: 2-3m · Available maximum span is 9m

Constructability	· No or minimal need for bracing ⇒Safer for the worker during installation and dismantling · Work space for heavy equipment can be secured ⇒Shortened construction time · Reinforcement of minimal number of slabs with interim posts ⇒ Better quality · Many design and construction cases in Korea	· Multiple horizontal and vertical bracing are needed. ⇒Potential for multiple safety incidents during work · Limits work space ⇒Extends construction period · Reinforcement of multiple number of slabs with interim posts ⇒Undermined quality · Widely used method in Korea and Japan
Economical aspect	· Rough construction costs: 85%(Compared to H-beam strut)	· Rough construction costs : 100%
Application	· Higher structural stability and better economics can help save costs during project plan ing and implementation. · Appropriate to prevent resident complaints in the area and for complex structures · Better fit for when there are many underground obstacles near construction site. · Better for shortening the construction period if there are struts	

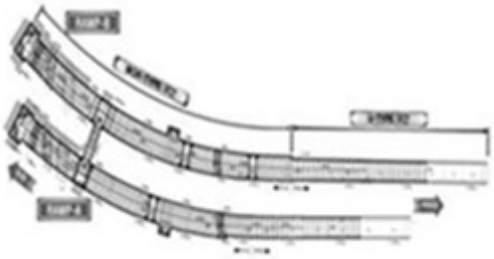
4 APLICATION CASES

If the ground is excavated from the surface, an increase in soil pressure and lowering of underground waters lead to loss of soil and vibration in the ground, as well as decreased cohesion of nearby grounds. This can damage nearby structures, roads and underground facilities. In order to secure stability of nearby buildings and shorten the construction period to minimize traffic disruption, this steel pipe strut method was applied to the site of the "Design and Implementation of the Private Investment Project for Seoul Jemulpo Terminal." The method was applied at the starting point and end point as follows.

○ Starting point



○ Ramp-A,B



○Ramp-C,D

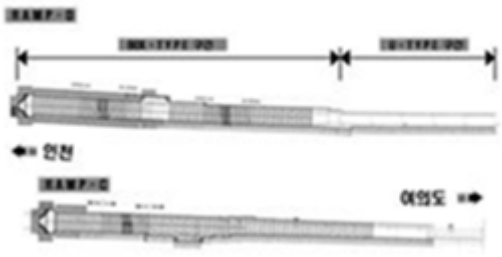


Figure 1. Sections where the steel pipe strut method was applied

Table 3. Sections where the steel pipe strut method was applied.

		Scale of temporary facilities	Layout plan for temporary facilities
Starting point	U-TYPE	L=171.5m, B=11.0-12.1m, H=0.857-8.184m	1-3 rows of struts
	BOX	L=40.0m, B=14.1m, H=8.184-10.441m	2-3 rows of struts
	Business office	L=210.0m, B=43.01-52.37m, H=10.44-19.18m	4 rows of struts, 1-5 rows of anchors
	Work section	L=41.21m, B=16.25m, H=19.181-20.882m	5-8 rows of struts, 4 rows of rose, 4 rows of lock bolt, 2-4 rows of anchors
End point	Ramp-A, B	L=144.02-231.17m B=11.0-15.4m H=0.830-28.958m	1-13 rows of struts, 1 row of anchor
	Ramp-C, D	L=100.0-207.0m B=9.2-12.8m H=5.81-21.77m	1-7 rows of struts, 1-5 rows of anchor

5 CONCLUSION

By applying this new method, the connecting parts are turned into modules when the struts are installed or dismantled, leading to greater convenience and faster implementation of tasks. This in turn shortens the construction period, helps save steel pipes used and increase the interval at which struts are installed, leading to greater efficiency in trench work, mold work, steel and concrete work to make the construction of the main structure to be more efficient and costs of the overall construction to be saved. The saved costs and shortened construction period makes it favorable for bidding where the lowest budget often wins the bid for SOC projects, T/K constructions or alternative constructions (that apply new technologies or methods). Stability is secured for nearby buildings and the construction period is shortened to minimize traffic disruptions and reduce resident complaints. The SP-Strut method is expected to quickly replace constructions for struts and earth retaining structures in large-scale excavation projects. With the construction for temporary structures becoming bigger in scale, constructions account for 6.76% of Korea's GDP (as of 2006; statistics from Bank of Korea). As such, wider application of the method to construction projects in the public and private sector is expected to bring significant economic benefits.

ACKNOWLEDGEMENTS

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