Innovative Slip Form Method for the Construction of Tapered Concrete Pylon of Long-Span Cable Bridge

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Summary

The construction of the three-dimensional shaped pylons higher than 400 m requires very high technological degree. It is known that the application of the tapered slip form method for the erection of the concrete pylon of long-span cable bridges offers the advantage of being significantly faster than when applying the auto-climbing system (ACS) form method. Therefore, this study presents the development of an innovative slip form system for pylons with tapered cross-section suing lightweight GFRP panels. Surface wave inspection system is applied on the slip form system for the determination of slip-up time, wireless hydraulic control system is applied for auto rising, and GPS system is used to manage the configuration of pylon. A full-scale test bed was conducted to validate and verify the developed innovative slip form. The full-scale tapered concrete pylon has a hollow shaft and a height of 10 m. The sectional dimension is 4 m × 4 m at the foot and 3.77 m × 3.6 m at the top. The experimental construction of the tapered pylon using the innovative slip form was conducted successfully. This system is the world's first application of GFRP slip form panel.

Keywords: *slip form; concrete pylon; long-span bridge; GPS system; surface wave inspection*

1. Development of the Innovative Tapered Slip Form System

The innovative tapered slip form system (Fig. 1) developed in this study upgrades the conventional slip form technique by adopting the core technologies listed in Table 1. These core technologies comprise the design and fabrication of the system itself, the design and fabrication of the lightweight form system, the automatic slip-up of the slip form system, the precise measurement of the position of the slip form and the shape control of high pylon.

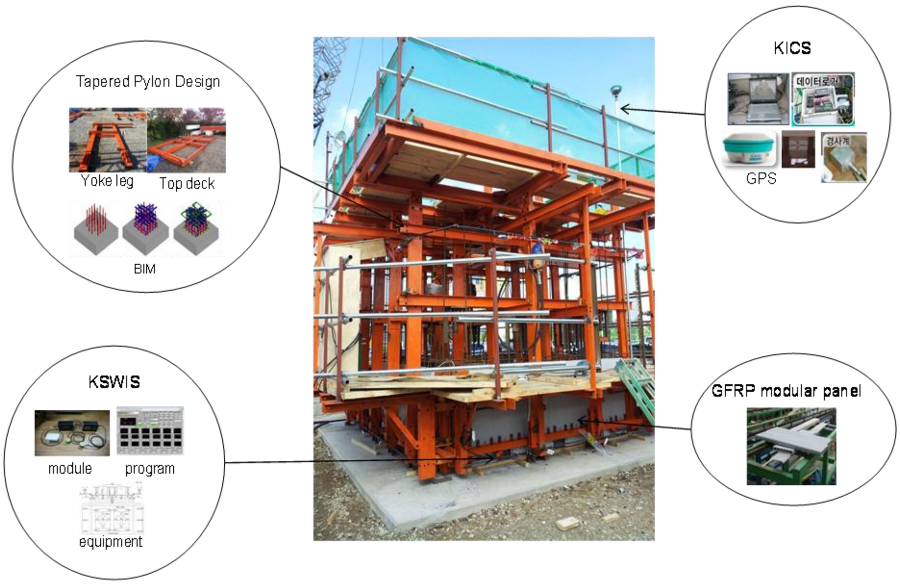


Fig. 1: Layout of the innovative tapered slip form system

https://doi.org/10.2749/222137813815776151

Table 1: Comparison of the core technologies of the innovative and conventional systems

Core technology		Conventional	KICT(*)
Design of tapered slip form system		Design of tapered slip form	Improved design of tapered slip form (application of BIM technology)
Lightening of tapered slip form system		Steel form	Modular GFRP form
Automation of slip form system	Determination of slip-up time	Traditional method using penetration rod	Quantitative method using surface wave inspection system
	Hydraulic system	Manual hydraulic control	Automated and wireless hydraulic control
	Spindle control	Manpower	Automated electric control
Shape and configuration control		Electro-optical instruments, plumb laser	Wireless verticality management (GPS, tiltmeter, image-transmission plumb laser)

(*) KICT: Korea Institute of Construction Technology.

2. Mock-up Test of Pylon

A slip form system applying all the developed core technologies was fabricated, and field test on a full-scale tapered concrete pylon was executed in the site of KICT. The pylon mock-up presents a hollow shaft with cross-sectional dimensions of 4 m × 4 m at the bottom and 3.77 m × 3.6 m at the top. The height of the pylon was planned to be 10 m (Fig. 2). The erection of the pylon mock-up started on November 5, 2012. After placing of concrete in the slip form, the final height of 10 m was achieved within 5 days on November 10, 2012. The test was conducted by adjusting the slip-up speed of the slip form using the surface wave measurement system in order to simulate various conditions. The slip-up was executed by wireless hydraulic control using the KICS after real-time measurement by RTK-GPS. The field test demonstrated that the tapered concrete pylon could be successfully erected by using the lightweight GFRP slip form system developed in this study.

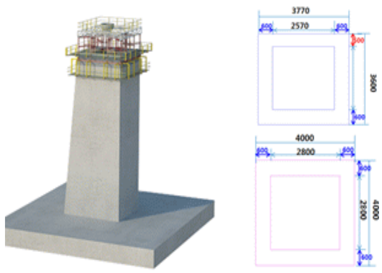
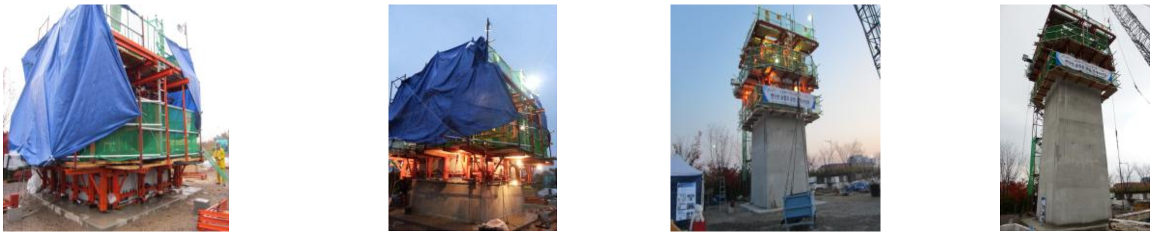


Fig. 2: Shape of pylon mock-up (height: 10 m)



(a) Completed assembling of slip form *(b) Slip-up: first day (1.5 m)* *(c) Slip-up: third day (5 m)* *(d) Slip-up: fifth day (10 m)*

Fig. 3: Pylon mock-up erection

3. Conclusions

A slip form system enabling to construct tapered concrete pylons has been developed. This tapered slip form system is faster than other conventional construction systems and offers significant improvement through the application of the latest IT technology for the configuration control. Through this study, the design technology of tapered slip form system was secured, GFRP form panels were applied for the first time in the world, and an automated rising system using surface wave (KSWIS) was established. This innovative system called the KICS (KICT Integrated Configuration control System) and the KSWIS were applied for the mock-up test of a concrete pylon and enabled to achieve successfully the configuration control and slip-up during the erection using the tapered slip form. A period of 5 days was sufficient to erect a 10 m-high pylon in the mock-up test, which means that the erection was executed at a rate of 2 m per day. This test will demonstrate the efficiency and adaptability of the tapered slip form system under diversified site conditions and will help us to secure our independent construction technology in the field of the pylons of super long-span bridges. The applicability of this tapered slip form technology is not limited to the construction of bridge’s pylon but can be extended to all kinds of high-rise structures like bridge piers, the chimney of thermoelectric power plants, and wind power towers. This research allowed us to acquire the advanced core technology related to tapered slip form systems, which will strengthen our international competitiveness in the long-span bridge market.