Attachment “1”

Achievement from Professional Construction Supervision

- All risk factors during construction were identified prior to commencement of any works, and appropriate preventive measures were taken. Especially, as there are numerous risk factors in the installation of large blocks, safety of all processes involved from loading, transport, lifting, setting in place, to connection welding, etc. were thoroughly reviewed and inspected at site so that works can be carried out in safe and accurate manners.

- In order to minimize noise and vibration, PC House was produced on land and moved out to sea. As a result, seawater pollution and complaints from fish farmers were kept to a minimum.

- Through close and rigorous program management, he project was completed eight months earlier than scheduled.

-Through VE and design modification considering site conditions, construction cost was reduced by 0.77%.

Attachment “2”

Geogeum Bridge, Golden Light in Asia

1. Project Overview

Geogeum Bridge, also called as Golden Light Bridge, links Geogeum Island to Sorok Island both in the South Sea of Korea. The project was launched by Iksan Regional Construction Management Administration of the Ministry of Land, Infrastructure and Transport with the aim to link the Korea's 10th-largest island Geogeum-do, having an area of 62.08 square kilometers and a population of 4,720 (as of 2001), to the fawn-shaped Sorok-do, with an area of 3.79 square kilometers and a population of 890 (as of 2001). It is an extension to National Highway No. 27 and part of a broader scheme of MLIT to facilitate the traffic flow between islands and to improve the living environment for island residents.

The marine bridge is 2,028m long, with the main bridge of 1,116m and the approach bridge of 912m.

This project was kicked off in December 2002 and completed in April 2012 at a total project cost of KRW 271.8 billion. It was constructed by Hyundai Engineering & Construction Co., Ltd., while Soosung Engineering Co., Ltd. participated as the Project Management Consultant (Construction Supervision Consultant?).

2. Bridge Plan

Geogeum Bridge is the world's first “bundle type 5 span continuous cable-stayed bridge”, which can be differentiated from the adjacent Sorok Bridge (suspension bridge), and is a unique “double composite Warren Truss bridge with one central plane of bundle-type cable.”

Geogeum Bridge is the only double deck bridge in Korea, with the upper deck being designed for 2 lane motorways and the lower deck for pedestrians and bicycle riders. This bridge attracts popular attention as one of the most beautiful hiking and marathon course on which people can cross the sea.

- Functional Aspect: 480m main span in consideration of the passage of 5,000DWT cargo vessel in case of emergency
- Structural Aspect: Verification of wind resistance through wind tunnel test, minimization of field joints and improvement of quality through installation of large blocks with marine equipment.
- Environmental and Construction Aspect: In consideration of construction efficiency, economic feasibility and environmental effect, application of the bell type steel caisson with in-situ concrete pile method for pylons, which is suitable for deep areas, and application of the pile cap with in-situ concrete pile method for the approach bridge section that offers outstanding adaptability to the variation of the stratum, excellent constructability through system management and minimum environmental impact.

3. Plan and Construction of Pylon and Foundation

- As the pylon is a structure with a large slenderness ratio, a cross-sectional design enabling mechanized construction was required to secure sufficient safety, not only against vertical forces but also against lateral load from wind and earthquake, as well as to secure constructability when working at sea. Further, as a symbolic structure representing the region, the pylon takes the form of a diamond symbolizing the praying hands for the bright future.
- The bell type steel caisson with in-situ concrete pile method was adopted for the foundation of the pylon to enable construction without blasting, thus to minimize underwater works and environmental impact. In addition, marine equipment such as jack up barge and jig jacket was used to maintain accuracy when performing the foundation work
- Construction of the pylon was performed using ACS (auto climbing form system), and structural review for each section was done and reflected on the construction to ensure safer construction. Operations such as installation and dismantling of formworks, fabrication of reinforcing bars, concreting, etc. were carried out

using tower cranes.

- Through structural review, construction of 4 meters per section was adopted. As the pylon has curves and bends, the process of disassembling and reinstalling the formworks was repeated for each section. The height of the pylon is 167.5 meters, which is equivalent to a 60-story building. When construction of the main pylon is completed, the anchorage box is installed to anchor cables to the pylon. The anchorage box was installed using heavy lifting equipment and non-shrinkage concrete was placed.

High damping rubber bearings were used for piers and the pylon to reduce the lateral seismic force by the damping effect.

- Items reviewed with focus to ensure safe construction of the pylon include the structure of the formworks, temporary strut on the pylon, anchorage box lifting equipment, temporary facilities for anchorage box installation and the scaffolding for the pylon, etc.

4. Span Configuration and Plan and Construction of Superstructure

- In order to secure the safety and comfort of plying vessels in the future, the span length and the vertical clearance of Geogeum Bridge were set at 480m and 38.5m, respectively. For the span length, minimum clearance from piers of 100m was considered.

Applicable vessels	5,000DWT level cargo vessels	
Facilities limit	350m x 38.5m (channel width x vertical clearance)	
Span configur-ation	- Cable-stayed bridge: double composite Warren Truss (120m+198m+480m+198m+120m) - Approach bridge: double compound Warren Truss (72m+7@120m)	
Design speed	80km/h (road classification: National Highway No. 27)	
Cross-sectional configuration	2-lane (cable stayed bridge: 15.3m/Access bridge: 12.7m)	

- For the deck of the cable-stayed bridge, double composite Warren Truss was adopted, which have outstanding structural stability through increase of wind resistance and torsional rigidity, and fairing (wind nose) was installed as a measure against vortex vibration. For the approach bridge, double composite Warren Truss was also adopted and the girders were made pre-cast and installed using a marine crane.

- Using ACS (Auto Climbing Form System), the pylon was constructed on the pylon foundation which was formed by placing in-situ concrete piles, installing bell type steel caissons and then making the two into a monolithic structure by concrete.

After construction of the pylon, the anchorage box is installed on the pylon and after safety review of the pier table, central span and side span in a phased manner, the deck is constructed and the cables are anchored using marine cranes and jack up barges in accordance with the camber adjustment plan for the bridge profile. At this time, to secure the camber of the deck, it is adjusted using the cable tension. For installation of Key Seg the set back device is installed on the cross beam of the pylon to secure space. After the installation of the KEY SEG, the tension is finally adjusted to complete the longitudinal alignment.

5. Type, Arrangement and Installation of Cables

- The bridge is a bundled cable-stayed bridge with one central plane, which means that there is comparatively small number of cables, that as a result it is subject to deflection during construction and that therefore adaptability to the change of installation environment is important. For this reason, PSW (Parallel Strand Wire) type was adopted. For the longitudinal arrangement of cables in Geogeum Bridge, a single plane arrangement was adopted for both the central span and the side span.
- As a 4-fold anti-corrosion measure for the cable, the strands are galvanized, waxed, HDPE coated and then covered by HDPE duct. As a measure against rainy wind induced vibration, helical fillet (spiral projection) is installed on the exterior of the duct.
- Cables are installed using the MS method, in which tension is applied to each cable individually to facilitate the replacement of the cable at the time of maintenance. The anchorage is installed on the girder and the anchorage box. As the accuracy of installation needs to be ensured first, cables were cut to be longer than the design length in consideration of the construction errors. Cables are comprised of 55 strands, 61 strands or 71 strands, and 71 strands-cables are installed as a bundle in the middle part of the main span, which is farthest from the pylon. As the HDPF duct needs to be produced in facilities designed to ensure a constant temperature and less effect from the wind, a dedicated production space was prepared separately. To ensure safety when installing the anchorage box and anchoring the cables, a safety footstep was mounted on the outside.
- To adjust the tension of the cable, a dead anchorage was installed in the anchorage box and a live anchorage was installed on the girder to facilitate maintenance. The strand inside the anchorage whose wedge and coating was removed was sealed with wax and protection cap for protection from corrosion.

- As the cables of a cable-stayed bridge are subject to vibrations from the live load, rainy wind and vortex etc., dampers and deviators were installed to reduce such vibrations. (Internal dampers were also installed.) IHD (Internal Hydraulic Damper) and IRD (Internal Radial Damper), the latter of which is known to have good damping effect when the cable is longer than 250m, have been used for this bridge.
- IHD has a circular shape and is operated by viscid friction absorbing the energy. IHD is installed in the guide tube and uses the viscosity of silicon injected inside the damper. IRD is operated by the piston action.

6. Effects of the Opening of Geogeum Bridge

- Sorok-do and Geogeum-do are in the South Sea, which is so beautiful as to be designated as the Da dohaehaesang (archipelago) National Park.

By connecting Sorok-do, an island harboring the painful wounds of lepers, with Geogeum-do, the 10th l argest island in Korea, the following effects and benefits are expected:

- Improved welfare for residents in the islands (medical service, leisure activities)
- Increased incomes (21% reduction in logistics costs, increased tourism income)
- Related development effects (aerospace center, industrial complex, historical experience center), fordable seaway, high efficiency and versatility of Korea's only double floor sidewalk convertible driveway bridge, long distance double compound marine bridge with less vibrations and deflection that would be suitable for hiking activities and tourist attraction. The launch of Geogeum bridge, which is golden like the morning sunshine, brings happiness to residents and a feeling of pride to constructors.

7 Awards

- Structure of the Year Prize in the Structure Contest held by Korean Society of Civil Engineers (March 30, 2013)
- Minister of Land, Transport and Maritime Affairs Prize in the Construction Supervision Contest (November 2012)
- Prime Minister Commendation for the construction of Geogeum Bridge (June 2012)