Innovation Technology of Bridge in Korea

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1. Overview of bridge in Korea

- Construction Age:
  - - 10yrs: 36%
  - + 10yrs: 44%
  - + 20yrs: 6%
  - + 30yrs: 12%
  - + 40yrs: 2%

- Bridge Grade:
  - Grade 1: 75%
  - Grade 2: 7%
  - Grade 3: 2%
  - etc: 16%

- Bridge Type:
  - RC Bridge: 9,658
  - Steel Bridge: 5,653
  - PSC Bridge: 6,230
  - Others: 3,948
  - One span bridge: 1,408

Grade Design Load:
- Grade 1: DB=24(32,2t)
- Grade 2: DB=18(32.4t) ≡ HS20
- Grade 3: DB=13.5(24.3t)

※ 31 Cable Bridges
- Cable stayed, Suspension bridge

(Unit : number)
I. Overview of bridge in Korea

Transition of bridge technology
(focused on sea-crossing bridge)

Stage 1
1962~1990
- Introduction of Technology

Stage 2
1990s
- Practice of imported technology

Stage 3
2000s
- Independence of technology

Stage 4
2010s
- Leading Core Technology
  (Super-Long Span R&D Project)
II. Upgrade semi integral abutment bridge

- Conceptual Picture

Temperature behavior of Joint Bridge

- Control disp.
- Expansion Joint

Semi Integral Bridge

- Control disp.
- Cyclic Control Joint
- No Expansion Joint
- End Diaphragm

- The length change of superstructure due to temperature change is separated.
- Expansion joint is eliminated.
- Cyclic control joint is installed.
II. Upgrade semi integral abutment bridge

Upgrade Background

- Poor constructing condition
  - Complexity of bar placement with parapet wall and end slab
  - Bad workability of end slab (form, bar placement, concreting)
- Overturning risk of placed girder

Precast girder (girder + parapet + cross beam integration)
II. Upgrade semi integral abutment bridge

New Integrated PSC-I Girder

Unification with end wall and girder

Elimination of overturning risk of girder

Rapid and Optimizing workability of construction
II. Upgrade semi integral abutment bridge

Procedure

- Setting steel form with girder and end wall
- Cure concrete
- Post-tension and concrete end diaphragm
- Partially in-site concrete of end wall
Expected effect

- Save cost up to 15% in comparison with joint bridge
- Workability & Safety improvement
Development of high performance cable systems and steel

- World’s best level high-performance steel wire, strand and cable systems
- Performance certification systems for cables and high strength steel

Long span bridge application of high performance cable and steel

→ The reduction of self-weight in the bridges
### Target products of high-strength steel wire, strand and PPWS

<table>
<thead>
<tr>
<th>Target products</th>
<th>Elements</th>
<th>Technology level (Tensile strength)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel wire</td>
<td>High strength steel wire (φ5.4mm), <em>(Year 2012)</em></td>
<td>Present: 1,960MPa</td>
<td>Target: 2,100MPa</td>
</tr>
<tr>
<td></td>
<td>High strength steel wire (φ7mm), <em>(Year 2013)</em></td>
<td>Present: 1,770MPa</td>
<td>Target: 1,900MPa</td>
</tr>
<tr>
<td>Steel strand</td>
<td>High strength steel strand for MS cable &amp; System (φ15.7mm), <em>(Year 2012)</em></td>
<td>Present: 1,860MPa</td>
<td>Target: 2,200MPa</td>
</tr>
<tr>
<td></td>
<td>High strength steel strand and Systems PT (φ15.2mm), <em>(Year 2011)</em></td>
<td>Present: 2,230MPa</td>
<td>Target: 2,400MPa</td>
</tr>
<tr>
<td>PPWS</td>
<td>2100MPa PPWS Cable System, <em>(Year 2013)</em></td>
<td>Present: 2,060MPa</td>
<td>Target: 2,100MPa</td>
</tr>
</tbody>
</table>

- **Completion of performance certification test**

**NOTE**) MS: Multi Strand, PT: Post Tensioning, PPWS: Prefabricated Parallel Wire Strand
### Target products level of high-performance steel

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<th>Technology level</th>
<th>remarks</th>
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</table>
| Present High Strength and High Toughness Steel (HSB®800L) and Welding Consumable (Year 2012) | Present: <BHS700 - Japan>  
- Toughness  
  - BM: over 100J @ -40°C  
| Target: <HSB®800L>  
- Toughness: over 47J @ -40°C | World Best |
| Present High Strength Weathering Steel (HSB®800W) and Welding Consumable (Year 2012) | Present: <HPS690W - USA>  
- Toughness: over 48J @ -34°C  
- Weathering Steel  
| Target: <HSB®800W>  
- Toughness: over 47J @ -20°C  
- Weathering Steel | World Best |

### Performance certification system for the cables (test standard & machines)

- **Cable Fatigue Testing Machine : CFTM**
  - 30 MN CFTM
  - Fatigue and static strength of cable system

- **Cable Leak Testing Machine : CLTM**
  - 15 MN CLTM
  - Leak tightness of cable system
The final goal of long span cable bridge maintenance is integrated operation system.

Global Navigational Satellite System (GNSS) based bridge monitoring system

System layout

- Dynamic Properties
  - Natural Frequencies
  - Ductility Ratios
  - Mode Shapes

- Dynamic Data

- Post Processing Mod.
  - RMS
  - F-ratio
  - Sky plot
  - DOPs
  - Satellite number
  - Satellite Elevation

- GNSS: GPS in USA, Galileo project in Euro
  - RINEX: Receiver Independent Exchange Format (RINEX) is data interchange format for raw satellite navigation system data
  - NMEA: combined electrical and data specification for communication between marine electronic devices
  - DOP: Dilution Of Precision

GNSS monitoring system is more stable substitution with existing gauges
(displacement measuring equipments and accelerometer)
IV. IT-based maintenance technology

- Vision-based monitoring system
  - Processing

The acquisition of the dynamic property of cables in the bridge.

→ Accurately predict the tension of the cable
→ Ensure the safety of the cable bridges

Field Testing and Results in Gwangan bridge in KOREA

<table>
<thead>
<tr>
<th>Accelerometer (A)</th>
<th>Accelerometer (B)</th>
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<tr>
<td>Cable Shape (A)</td>
<td>Cable Shape (B)</td>
</tr>
<tr>
<td>Hanger Cable (A)</td>
<td>Hanger Cable (B)</td>
</tr>
</tbody>
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<table>
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<tr>
<th>Power Amplitude</th>
<th>Frequency [Hz]</th>
</tr>
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<tbody>
<tr>
<td>2.95</td>
<td>5.87</td>
</tr>
<tr>
<td>8.75</td>
<td>11.48</td>
</tr>
<tr>
<td>14.09</td>
<td>17.02</td>
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<tr>
<th>Cable Shape (A)</th>
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<tr>
<td>Power Amplitude</td>
</tr>
<tr>
<td>5.86</td>
</tr>
<tr>
<td>8.71</td>
</tr>
<tr>
<td>11.47</td>
</tr>
<tr>
<td>14.08</td>
</tr>
<tr>
<td>16.96</td>
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</tbody>
</table>

Estimated Tension: 349.43kN
Estimated Tension: 349.02kN
IV. IT-based maintenance technology

Inspection Robot System

Smart inspection system of IT-based disaster mitigation & Target members are stay cables and hangers

1. Vision-based surface damage detection of cable exterior
2. Non-destructive Test for internal damage detection

Verification of damage detection using sensor

※ Developed Robot System can be used reasonably
V. Conclusion

1. Semi-integral abutment bridge
   - save cost up to 15% in comparison with joint bridge
   - workability and safety improvement

2. High performance materials
   - save cost about 10 to 15%
   - cable-stayed bridge and suspension bridge

3. Proposed maintenance tools of long span cable bridges
   - more reasonable and safer than existing method
Thank you