Korea 10th Innovative technology

IPC GIRDER®
Incrementally Prestressed Concrete Girder
Incrementally Prestressed Concrete Girder

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For a decade, INTERCONSTECH CO., LTD. (ICT) has forged ahead with a primary principle - the commitment to qualify leading the way. Unlimited endeavors to research and develop top-notch construction technology have, since the firm’s inception, brought us the pride as a construction technology-oriented company, while serving the best satisfaction to customers.

IPC Girder technology, developed as the first item of our company, has achieved a remarkable reputation in the bridge construction field of in Korea due to its superiority in construction feasibility, cost savings and much improved safety. With these leading-edge strength, IPC Girder technology has become one of the most widely used bridge technologies in Korea.

Furthermore, SegBeam has recently been developed as the second item of ICT, which is a spliced segmental prestressed concrete girder. SegBeam has a wide range of advantages such as easy and fast set-in-place and high quality control of segment, environment-friendly construction method as well. Not surprisingly, SegBeam has been evaluated, approved, and started to be used explosively to replace a position of steel bridge in Korea today.

By maintaining a profound respect for our past, and by reaffirming our commitment to quality with each new project, we are certain that our clients and our firm will enjoy a future that is even more exciting, successful and inspiring than our past.

INTERCONSTECH CO., LTD.

CEO Sang Il, Park
Company History

1998
11 Application for IPC Girder patent
12 1st IPC Girder bridge design completion

1999
05 INTERCONSTECH CO., LTD. established
10 Successful loading test of IPC Girder

2000
02 PSC girder design and construction manual set by KCI
03 New technology No.221 by MCT
05 Appointed as a Venture Business Company from SMBA
07 Two IPC Girder bridges accepted in No.42 national road
11 Technology award from KCII (Korean Concrete Institute)

2001
01 Selected as one of “Korea’s 10 Best New Technologies” by MOCIE
04 International patents to 31 countries; USA, China, EU, Vietnam etc.
06 IPC Girder patent registered
06 IPC Girder trademark registered
07 Established R&D Center
12 2nd Korean Construction Prize of the Construction Technique Encouragement

2002
05 IPC Girder Turkey patent registered
08 Prestressing control device patent registered
10 IPC Girder South Africa patent registered
11 1st IPC Girder highway bridge completion-Myohyun bridge

2003
04 Bridge capacity control method patent registered
04 Applied as favorable IPC continuous bridge by Korea Highway Corporation
10 Complementary IPC Girder patent registered
Interconstech is the world-leading bridge engineering company.

2004
01 Appointed alternative military service institute
02 IPC Girder EU patent registered
08 Youngdo bridge constructed in Chunggyeo stream
10 IPC Girder continuous bridge patent registered
10 IPC Girder USA patent registered

2005
03 IPC Girder loading test for railway bridge
04 New technology No.453 by MCT
06 1st Railway bridge construct (Maegok bridge)
08 1st Sea bridge with IPC Girder (Sinsi island bridge)
08 PSC spliced girder 'SegBeam' patent registered
10 Prime minister’s award for application of new construction technology

2006
02 Workshop for construction skill-up and safety
02 Complementary IPC Girder patent registered
06 Selected to INNO-BIZ company as AA grade by SMBA
07 Loading test on actual railway bridge (Maegok bridge)

2007
01 Mahanama bridge constructed in Sri Lanka
03 IPC continuous method awarded Korea construction Vision2007
03 SegBeam loading test
06 AA grade for bidding to public organization by credit evaluation
09 New Technology by KORAIL (No.2007-0001)

2008
03 Extension of technology protection period of No.453 by MLTM
08 AAA grade for credit evaluation by Construction Guarantee
08 Appointed as BK FAMILY enterprise by IBK
09 1st SegBeam bridge, Midang bridge constructed
12 1st place from 2008 new construction technology uses

2009
01 Successful loading test of SegBeam 60m in span length
02 10th anniversary workshop in Jeju island
03 President award for 43th taxpayers’day
05 New & Renewable energy expertise company registered(No.2009-4189)
07 A resolution general meeting for wishing safety & safety precaution
2. Concept of IPC Girder

- Name of IPC Girder
  
  IPC Girder: Incrementally Prestressed Concrete I Girder

- Concept of IPC Girder
  
  Being different from conventional PSC I Beam, IPC Girder has been designed and manufactured to apply tensioning forces incrementally in order to offset imposed loads at the stage of construction.

- Characteristics of IPC Girder
  
  - Simple construction procedure similar to the conventional PSC I Beam
  
  - New design concept of incremental post-tensioning
    - Simple and continuous long span bridges with a shallow depth
    - Economical construction of long span bridges; medium and long span Preflex and steel-box girder bridges can be replaced by IPC Girder bridges.

  - Design characteristics for maintenance
    - IPC Girder bridge can be strengthened with ease by prestressing the reserved unbonded tendons during use of the bridge.
    - Maintenance cost can be significantly reduced.

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![Certificate of "Korea's Ten Best New Technologies of 2000"](image1.png)

Certificate of technological innovation (awarded by Ministry of Construction and Transportation)
3. Principle of IPC Girder

**Theory of conventional PSC Beam**

- All the prestressing forces are applied once at the early stage in order to keep the stresses for self-weight and final service load within allowable stress range.
  - The conventional PSC Beam is not applicable in long span bridges due to exponentially increasing girder height and self-weight.

<table>
<thead>
<tr>
<th>Non-composite</th>
<th>Composite</th>
<th>Remarks</th>
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<tbody>
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<td><img src="image2" alt="Composite Diagram" /></td>
<td><img src="image3" alt="Remarks Diagram" /></td>
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<tr>
<td>1. $P_1 + M_{dg}$</td>
<td>3. $P_1 + M_{dg} + M_{ds} + M_{d}$</td>
<td>$P_1$: Initial prestressing force</td>
</tr>
<tr>
<td>2. $P_1 + M_{dg} + M_{ds}$</td>
<td>4. $P_1 + M_{dg} + M_{ds} + M_{d} + M_L$</td>
<td>$P_{es}$: Effective prestressing force</td>
</tr>
<tr>
<td></td>
<td>5. $P_1 + M_{dg} + M_{ds} + M_{d} + M_L + M_L$</td>
<td>$M_{dg}$: Weight of girder</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$M_{ds}$: Weight of deck slab</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$M_{d}$: Secondary dead loads (pavement, barrier etc)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$M_L$: Live load</td>
</tr>
</tbody>
</table>

**Theory of IPC Girder**

- The IPC Girder, which has exposed anchors and 2nd tendons, can be post-tensioned separately according to the load change.
  - Thus, at the initial stage, the girder is prestressed as much as to sustain self-weight as well as slab weight while the second prestressing force is applied for sustaining live and secondary dead loads. IPC Girder concept can significantly reduce the depth and cross section area of a girder.

<table>
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<td><img src="image6" alt="Remarks Diagram" /></td>
</tr>
<tr>
<td>1. $P_1 + M_{dg}$</td>
<td>3. $P_1 + M_{dg} + M_{ds} + P_{2}$</td>
<td>$P_1$: Initial prestressing force</td>
</tr>
<tr>
<td>2. $P_1 + M_{dg} + M_{ds}$</td>
<td>4. $P_1 + M_{dg} + M_{ds} + P_{2} + M_{d}$</td>
<td>$P_{es}$: 1st effective prestressing force</td>
</tr>
<tr>
<td></td>
<td>5. $P_1 + M_{dg} + M_{ds} + P_{2} + M_{d} + M_L$</td>
<td>$P_{d}$: Initial 2nd prestressing force</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$P_{d}$: 2nd effective prestressing force</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$M_{d}$: Weight of girder</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$M_{ds}$: Weight of deck slab</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$M_{d}$: Secondary dead loads (pavement, barrier etc)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$M_L$: Live load</td>
</tr>
</tbody>
</table>

**Comparison of IPC Girder with Korean standard PSC Beam (Fck=40MPa)**

- Cross section of KS PSC Beam(L=30m)
- Cross section of IPC Girder(L=30m)
4. Structural advantages of IPC continuous bridges

Contrary to conventional continuous PSC Beam bridges with reinforcing deck slabs, the continuity between IPC Girders is secured by 2nd continuous tendons and additional reinforcement.

- 2nd tendons serve as continuity tendons through girders
  - 2nd tendons serve as continuity tendons through girders
    - 2nd tendons running through girders resist additional dead and live loads imposed after simple superstructure is changed into continuous one.
    - Compression stresses are applied onto girder joints at the time of 2nd Post-tensioning that cope with the negative moment.

- Reinforcing steel between girders
  - Reinforcing steel connected to each girder improves structural safety of the continuous IPC Girder bridge.
  - Reinforcing steel makes individual girders into a monolithic superstructure of the bridge.
  - It will resist the tensile stress which occurs at the bottom of the girders at the time of 2nd tensioning.


Conventional PSC Beam joint

IPC Girder joint

- Reinforcing steel substantially required
- Tendons
- Pier
- Reinforcing steel resists negative moment.

- Reduced reinforcing steel
- 2nd tendon
- Pier
- Continuous tendon and reinforcing steel resist negative moment.

- Protrusive reinforcement for girder joining

- Reinforcements for girder joint and cross beam

- 2nd Tendon in girder joint

- 2nd Tensioning
5. Application of IPC Girder

- **Road bridge**
  - Simple and continuous bridges with span length of 20~35m, which need higher downward clearance.
  - The height of IPC Girder is 70cm lower than conventional PSC Beams.
  - To make a road elevation lower, simple and continuous bridges with span length of 30~35m
  - Lower girder height makes possible to bring down the road elevation.
  - Simple and continuous bridges with span length of 40~50m
  - Alternative to steel-box girder and Preflex girder to construct long span bridges

- **Railway bridge**
  - Appropriate for the railway bridges with span length of 20~25m requiring lower girder height
  - Overall cost advantage due to reduced ground work costs by lowering the road elevation using IPC Girder
  - Applicable up to span length of 35m under the construction costs of about 50% lower than Preflex girder
  - Cost advantage over conventional PSC Beam by reducing the construction costs of lower structure in long multiple-span bridges

※ IPC Girder registered No.1 in KRNA integrated information system in Oct. 2007

- **Minimum radius of curve of IPC Girder**

<table>
<thead>
<tr>
<th>Span length(L)</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>45</th>
<th>50</th>
<th>비고</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum radius of curve(R)</td>
<td>250</td>
<td>350</td>
<td>500</td>
<td>650</td>
<td>800</td>
<td></td>
</tr>
</tbody>
</table>

Amnok br(6@30=180m, R=500m)  
Sagimak br(4@42=168m, R=600m)
6. Construction scheme

**Simple span bridge**

1. Manufacturing IPC Girder on a casing bed

2. Concrete curing followed by 1st tensioning and grouting

3. Erection of IPC Girders on piers

4. Casing deck slab and diaphragm

5. Concrete hardening followed by 2nd tensioning and grouting

6. Added dead loads (pavement, barrier etc)

7. Live load
Continuous bridge

(1) Manufacturing IPC Girder on a casing bed

(2) Concrete curing followed by 1st tensioning and grouting

(3) Erection of IPC Girders on piers

(4) Casing deck slab and diaphragm

(5) Concrete hardening followed by 2nd tensioning and grouting

(6) Added dead loads (pavement, barrier etc)

(7) Live load
7. Work flow

- Bending reinforcing steel
- Installing casing bed
- Fabricating reinforcing steel
- Placing sheath
- Fabricating steel form
- Casting concrete
- Steam curing
- Releasing steel form
- 1st tendons inserting
- Tensioning 1st tendons
- Erect girders
- 2nd tendons inserting
- Casting deck slab concrete
- Tensioning 2nd tendons
- Construction completion

Simple span bridge
2nd Tensioning and grouting of IPC Girder

- 2nd tendons inserting
- Setting anchor head and wedges
- Installing a wedge plate
- Setting up jacking device
- Installing wedge for jacking
- Setting up hydraulic gauge
- Elongation Step 1
- Elongation Step 2
- Cutting off strands
- Maintenance tendons
- Supporting device for 2nd tensioning
- Hydraulic pump for 2nd tensioning
- Grouting
- Urethane filling
- Installation protection cap
8. Economical advantage

**Girder height**

[L=25m]

- [AASHTO Type IV]
- [NEBT Girder: ‘97]
- [IPC Girder: ‘00]

**Construction cost**

- **P.C Box girder → IPC Girder + Launching Truss**

<table>
<thead>
<tr>
<th>ILM</th>
<th>FCM</th>
<th>MSS</th>
<th>FSM</th>
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</thead>
<tbody>
<tr>
<td>174</td>
<td>290</td>
<td>290</td>
<td>172</td>
</tr>
</tbody>
</table>

IPC Girder + Launching Truss
100

- **Steel girder → IPC Girder + Launching Truss**

<table>
<thead>
<tr>
<th>Steel Plate girder</th>
<th>Steel Box girder</th>
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<tbody>
<tr>
<td>174</td>
<td>208</td>
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</tbody>
</table>

IPC Girder + Launching Truss
100

※Comparative bridge construction cost per square meter when IPC Girder bridge costs 100.
Comparison LCC (Life cycle cost) of IPC continuous bridges with conventional PSC Beam bridges

**Bridge composition**

<table>
<thead>
<tr>
<th>Span length</th>
<th>Conventional PSC I Beam</th>
<th>IPC continuous bridge</th>
</tr>
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<tbody>
<tr>
<td>30m</td>
<td>2@30 + 2@30 = 120m</td>
<td>2@30 + 2@30 = 120m</td>
</tr>
<tr>
<td>40m</td>
<td>3@30 + 2@35 + 2@35 + 3@30 = 320m</td>
<td>3@40 + 2@40 + 3@40 = 320m</td>
</tr>
<tr>
<td>45m</td>
<td>3@35 + 2@30 + 3@30 + 3@35 = 360m</td>
<td>3@45 + 2@45 + 3@45 = 360m</td>
</tr>
<tr>
<td>50m</td>
<td>3@35 + 4@30 + 4@30 + 3@35 = 450m</td>
<td>3@50 + 3@50 + 3@50 = 450m</td>
</tr>
</tbody>
</table>

**Life Cycle Cost**

[Unit: mil. US$-1US$=1,300KRW]

<table>
<thead>
<tr>
<th>Span length</th>
<th>Conventional</th>
<th>IPC Girder</th>
<th>LCC index</th>
</tr>
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<tbody>
<tr>
<td>30m</td>
<td>4.468</td>
<td>4.417</td>
<td>0.9886</td>
</tr>
<tr>
<td>40m</td>
<td>15.732</td>
<td>14.403</td>
<td>0.9155</td>
</tr>
<tr>
<td>45m</td>
<td>17.905</td>
<td>16.190</td>
<td>0.9041</td>
</tr>
<tr>
<td>50m</td>
<td>22.381</td>
<td>20.210</td>
<td>0.9030</td>
</tr>
</tbody>
</table>
9. Project gallery

Shinchundaero (9@43=387m)  
Sinsido br. (6@40=240m)

Amnok br. (6@30=180m, R=500m)

South Kimchun IC br. (2@40=80m)  
Youngdo br. (30m)  
Gongse br. (3@40=120m)

Hwangryong br. (8@37.5=300m)  
Bulgokchun br. (4@30=120m)
Gisung br. (8@45=360m)
Susan br. (8@37.5=300m)
Gurey 1 br. (6@45=270m)
Jinyang br. (13@20=260m)
Macha br. (5@40=200m)
Mangsung br. (6@30=180m)
Maegok railway br. (7@25=175m)
Bangchuk overpass br. (2@35=70m)
Sunmun br. (25m, railway br.)
10. Achievements

**Design achievement**

<table>
<thead>
<tr>
<th>Project type</th>
<th>No. of bridge</th>
</tr>
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<tbody>
<tr>
<td>Highway</td>
<td>417</td>
</tr>
<tr>
<td>National road</td>
<td>597</td>
</tr>
<tr>
<td>Provincial road</td>
<td>885</td>
</tr>
<tr>
<td>Railway bridge</td>
<td>38</td>
</tr>
<tr>
<td>Sum</td>
<td>1,937</td>
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**Construction achievement**

<table>
<thead>
<tr>
<th>Project type</th>
<th>No. of bridge</th>
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<tbody>
<tr>
<td>Highway</td>
<td>203</td>
</tr>
<tr>
<td>National road</td>
<td>189</td>
</tr>
<tr>
<td>Provincial road</td>
<td>380</td>
</tr>
<tr>
<td>Railway bridge</td>
<td>10</td>
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<tr>
<td>Sum</td>
<td>782</td>
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</table>

**Single girder span length**

<table>
<thead>
<tr>
<th>No. of bridge</th>
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<tbody>
<tr>
<td>Over 45m</td>
</tr>
<tr>
<td>35m~45m</td>
</tr>
<tr>
<td>Under 35m</td>
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</table>

**Bridge type**

<table>
<thead>
<tr>
<th>No. of bridge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple</td>
</tr>
<tr>
<td>Continuous</td>
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</tbody>
</table>
Maritime erection work of IPC Girder bridge: Sinsido bridge