World Leading Innovative Composite Deck Technology

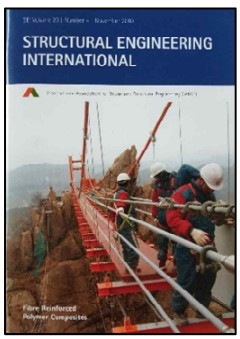
DeltaDeck®

Light and Rapid Installation GFRP Snap-Fit Deck

Best Solution for (Auto)Bikeway/Walkway Expansions and Footbridges





Optimum Solution for Traffic Bridge Deck for Long Service Life, Weight Reduction, Upgrading, Emergency Restoration



EJtech Co., Ltd.
www.ejtech.net

World Leading Composite(FRP) Bridge Deck – DeltaDeck®

GFRP Composite Bridge Deck of Snap-Fit Connection

- **Delta Deck® is glass fiber reinforced plastic(GFRP) composite bridge deck having characteristics of light weight, high strength, high durability and rapid installation.**
- **Snapfit(SF) Delta Deck® is well proven, most economical and fast solution for footbridges and bridge expansions for autobike/bike/walkway with 20-years of extraordinary experiences.**

Patents:

- US Patents (US 7,131,161 B2)
- Korea Patents (10-1991765, 10-0604251, 10-0981348, 10-0981348, 10-0956519, 10-1298581, 10-1118029, 10-0849505, 10-0841716, 10-0625003, 10-0641982, 10-0641981, 10-0620363, 10-0586377, 10-0563718, 10-0421770, 10-0037663)
- Korea Design Patents (30-0991661)
- New Construction Technology Registered to Korean Ministry of Transport (No. 374)

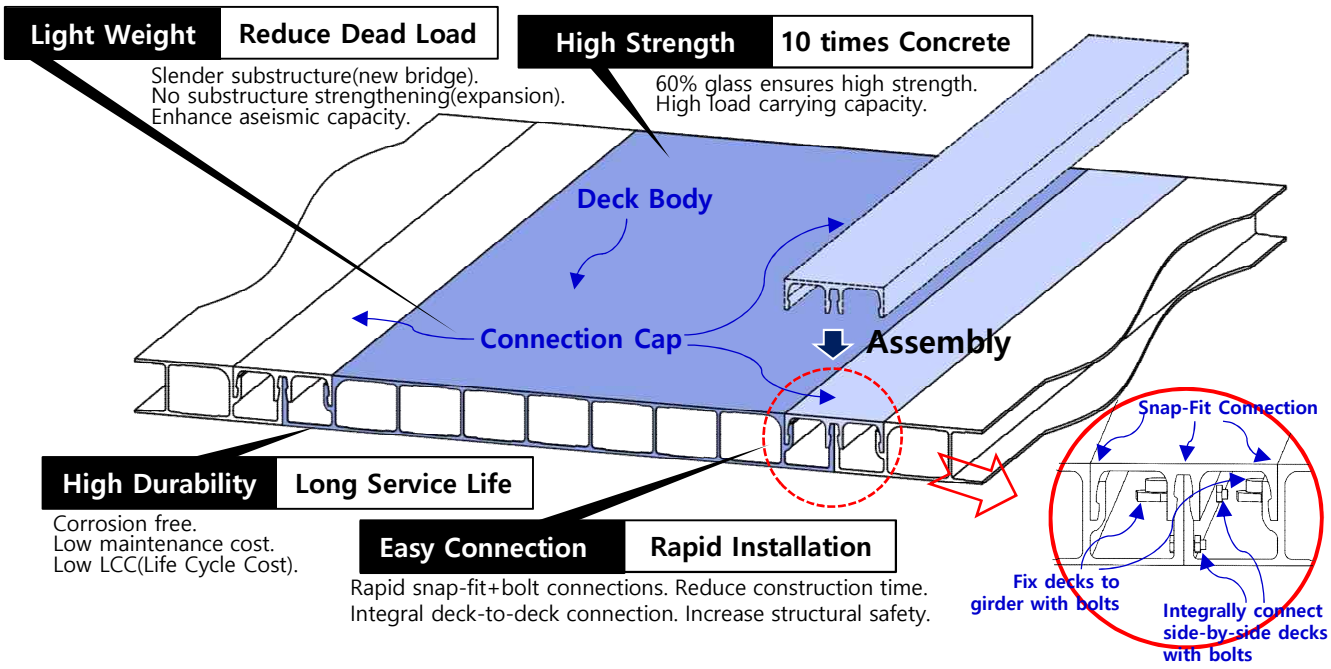
Technology Brief and Advantages

- Delta deck is a modular composite deck panel having Snap-Fit(SF) connections, fabricated by pultrusion with glass fiber and unsaturated polyester.
- Entire bridge deck can be completed by assembling such deck panels together.
- Delta deck of Integral Snap-Fit(ISF) type is newly developed deck, which provides robust and integral connections for deck-to-deck and deck-to-girder with bolts and snap-fit.

NEW

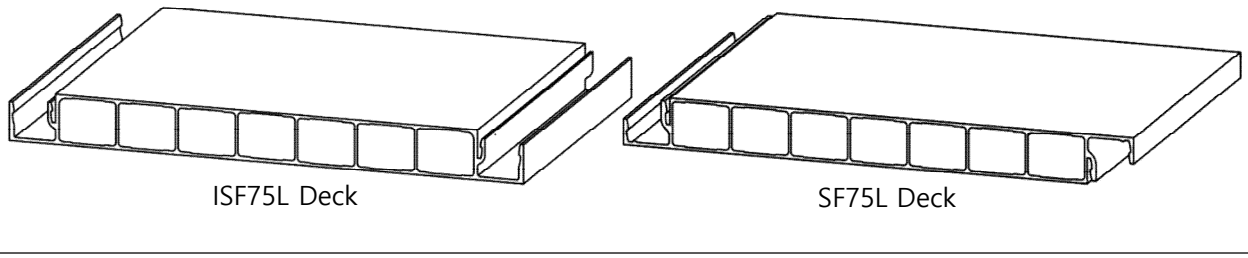
Light Weight, Integrally Connected, Rapid Assembly & Disassembly

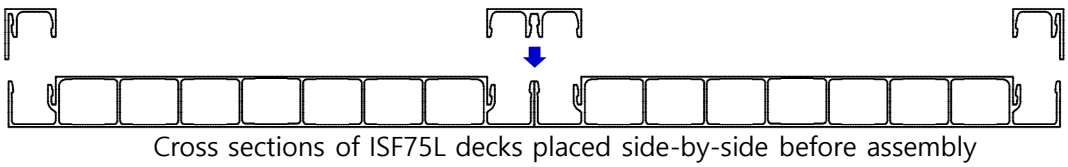
75mm ISF(Integral Snap-Fit) Delta Deck for Bikeway/Walkway

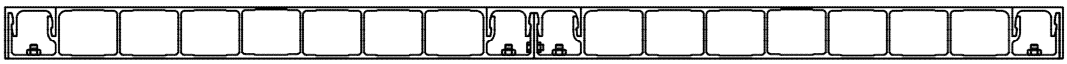


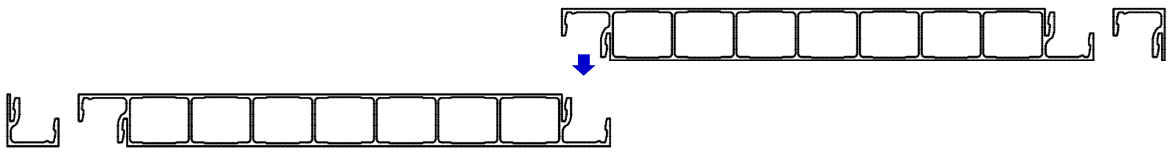
Profiles and Connections of Delta Deck for Footbridge

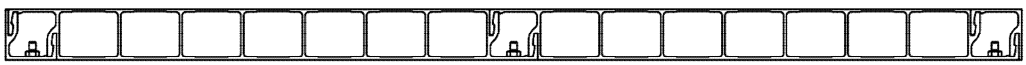
- Snap-fit deck of ISF type, which integrally connects side-by-side decks with snap-fit and bolts in far robust way, is innovatively enhanced previous version of snap-fit deck of SF type, which connects decks with snap-fit and adhesive bonding. Integrally connected ISF decks behave as plate-like 2-way decks, increasing structural safety, and in the later time they can also be easily disassembled for reuse.
- Even though assembled cross section of SF and ISF decks are all the same, structural performance of the later is far better. Therefore field application records of SF decks can be adopted to ISF decks.



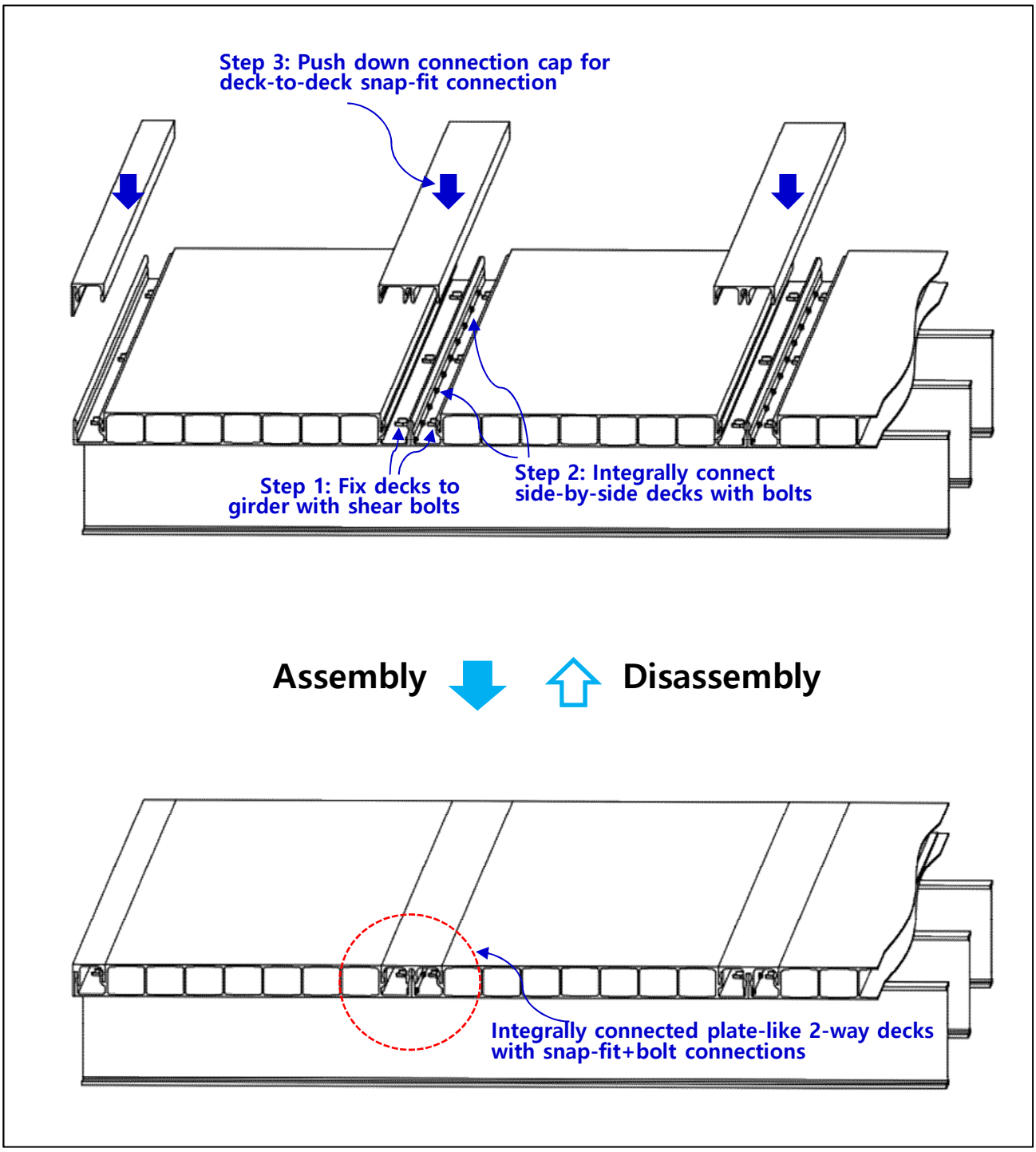

Cross sections of ISF75L decks placed side-by-side before assembly


Cross section of assembled ISF75L decks


Cross sections of SF75L decks before snap-fit assembly


Cross section of assembled SF75L decks

Assembly of ISF75L Delta Deck for Footbridge



Applications of Snap-Fit Composite Bridge Deck

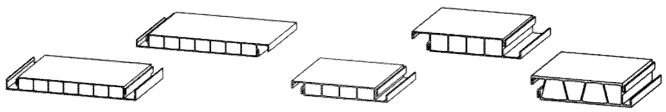
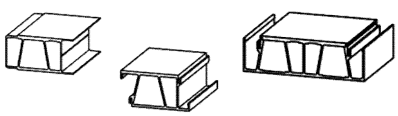
- Walkway/bikeway/auto-bikeway expansions of bridges without strengthening.
- Walkway/bikeway/auto-bikeway in new bridges to reduce self-weight.
- New bridges of waterfront or freezing area of high corrosive environments.
- New bridges at mid. of cities or mountains requiring rapid installation.
- Upgrading bridges without strengthening existing substructure.
- New bridges requiring weight reduction and long service life.
- Restoration or temporary bridges for disaster, construction and military use.

Material Properties and Experimental Verifications

Mech./Physical Properties	Specification	Test Results
Tensile Strength(L/T))	KSF 2241	Over 200/120 Mpa
Compressive Strength(L/T)	ASTM D 695	Over 200/120 Mpa
Shear Strength	KSM 3019	Over 30 Mpa
Young's Modulus	KSF 2241	20 Gpa
Thermal Expansion Coefficient	KSM 3015	$5.0x10^{-6}$(1/°C)
Fiber Weight Fraction	KSF 2244	55~60%
Flammability	KSM 3015	Self Extinguishing
Unit Weight		1.95 ton/m^3

Flexural Test of SF75L Deck (2m-span S.S Beam).
Failure at 6 Times of Footbridge Live Load, 5KN/m^2(F.S.=6).
Deflection: 1/2 of Serviceability Limit.

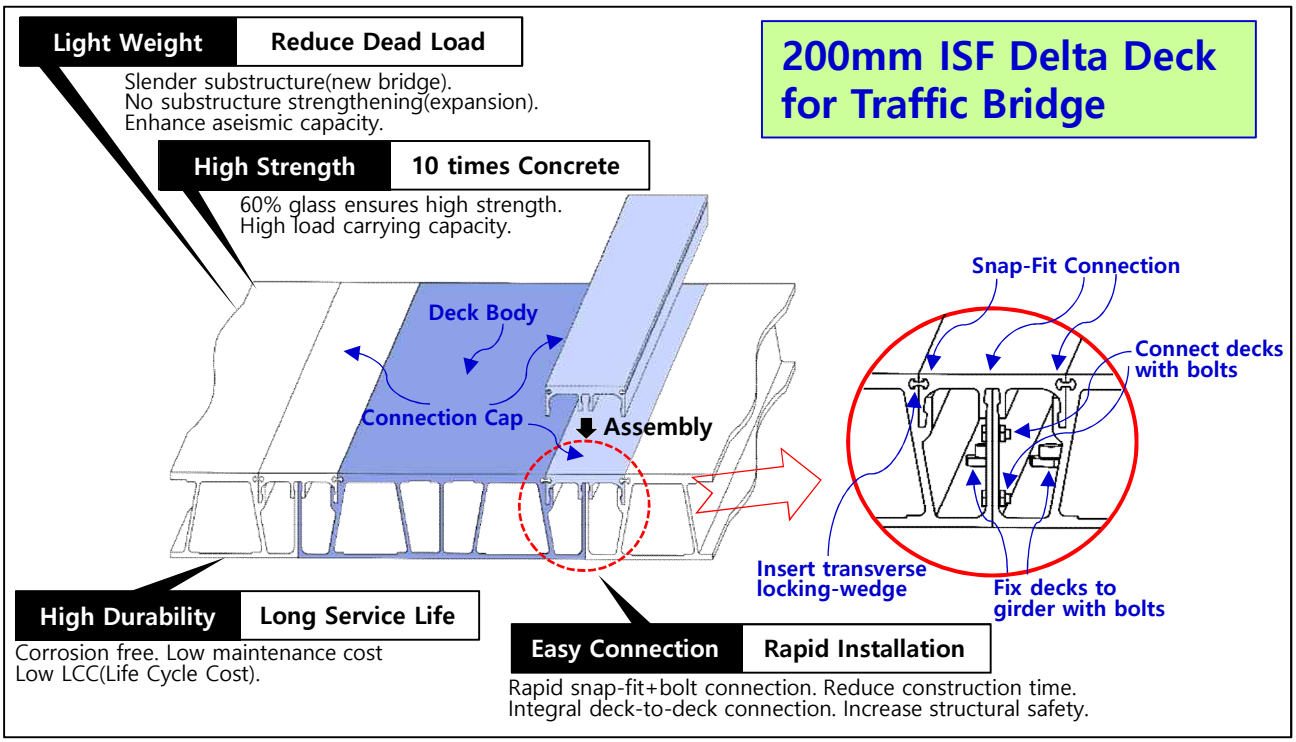
Types of Delta Deck

Description	ISF75L	SF75L	SF75H	SF100	SF125	TG200	SF200	ISF200
	Decks for Footbridge/Bike/Autobike/Light Vehicle					Decks for Traffic Bridge		
Profile								
Height(mm)	75	75	75	100	125	200	200	200
Width(mm)	700	700	470	500	500	330	330	660
Weight(㎏/㎡)	30	30	32	34	57	90	90	180
Max. Span(m)	1.5	1.5	1.8	2.0	3.0	2.5	2.5	2.5

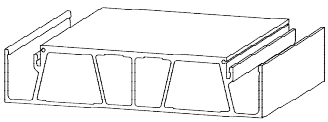
Comparison of Composite Deck with Concrete Deck

Description	Composite Delta Deck®	In-situ Concrete Deck
Technology Brief	Assemble and install prefabricated composite deck over the girders.	Concrete decking work consists of false work, form work, rebar installation, concrete placing and curing.
Materials Used	Fiber Reinforced Composites (Glass fiber +Unsaturated polyester)	Reinforced Concrete (Rebar+Aggregate+Cement+Water)
Cost Comparison	• Shorten construction time due to rapid installation. Reduce costs. • Long service life(over 75 years) due to high durability. Reduce Life Cycle Cost(LCC). • Slender substructure for new bridge due to light weight deck. Reduce costs. • No strengthening substructure for upgrading or expansion of bridge due to light weight deck. Reduce costs. • Corrosion free. Reduce maintenance cost.	• Complicated field works require high labor costs. • Higher substructure costs due to heavy weight concrete deck. • Mid service life(20~30 years). Require higher repair and maintenance costs. Increase LCC. • Redecking after service life requires high costs. Also increase indirect costs. due to long-period traffic congestion. • Advantage of low initial costs.
Structural Performance	• High strength(8-10 times of concrete strength). High load carrying capacity. • Light weight. Reduce self-weight. Better structural performance. Enhance aseismic capacity.	• Far higher dead load due to heavy weight concrete. Reduce aseismic capacity. • Shorten service life due to fatigue, concrete deterioration. • Reduce load carrying capacity due to rebar corrosion.
Constructability	• Excellent constructability. Easy transportation and installation. • Good quality control. • Minimize traffic blocking during construction. • Minimize misc. works.	• Abundant construction experiences. • Good constructability. • Difficulties in quality control at field. • Concerns for defective construction.
Maintenance	• Minimum maintenance due to high durable materials. • Easy to repair and reinforcing.	• Long maintenance experiences. Established maintenance rules. • Uncertain performances after repair and reinforcement.
Environmental Friendliness	• Not induce pollution due to chemical resistant materials. • Good appearance due to cleanly maintained surface.	• Induce acidic materials and dust due to rebar corrosion and concrete deterioration. • Bad appearance for aged concrete.
Remark	**Composite bridge decking is considered cost-effective method considering better structural performance, non-strengthening for upgrading and expansion, longer service life, good constructability, shortening construction time, lowering maintenance costs and reducing life cycle costs.**	

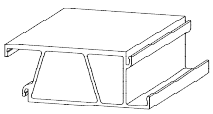
Profile and Connection of Delta Deck for Traffic Bridge



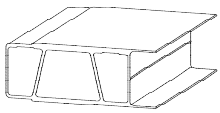
- 3 types of delta deck profiles are available for traffic bridges; TG(Tongue and Groove), SF(Snap-Fit) and ISF(Integral Snap-Fit).
- Snap-fit deck of ISF type, which integrally connects side-by-side decks with snap-fit and bolts in far robust way, is innovatively enhanced previous deck of TG type, which connects adjacent decks with only adhesive bonding. Integrally connected ISF decks. behaves as plate-like 2-way decks, increasing structural safety, and in the later time they can also be easily disassembled for reuse.
- Even though cross sections of assembled delta decks of 3 types(TG, SF and ISF) are all the same, structural performance of ISF decks are far better. Therefore field application records of TG decks can be adopted to ISF decks.



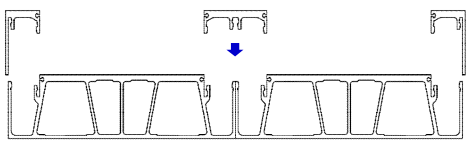
ISF200 Deck



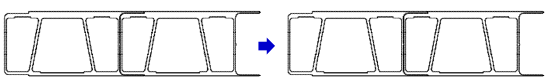
SF200 Deck



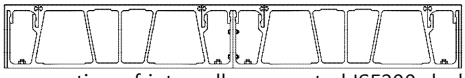
TG200 Deck



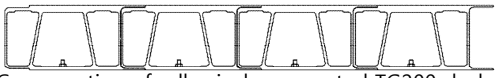
ISF200 decks placed side-by-side before connection



TG200 deck panels before connection with adhesives

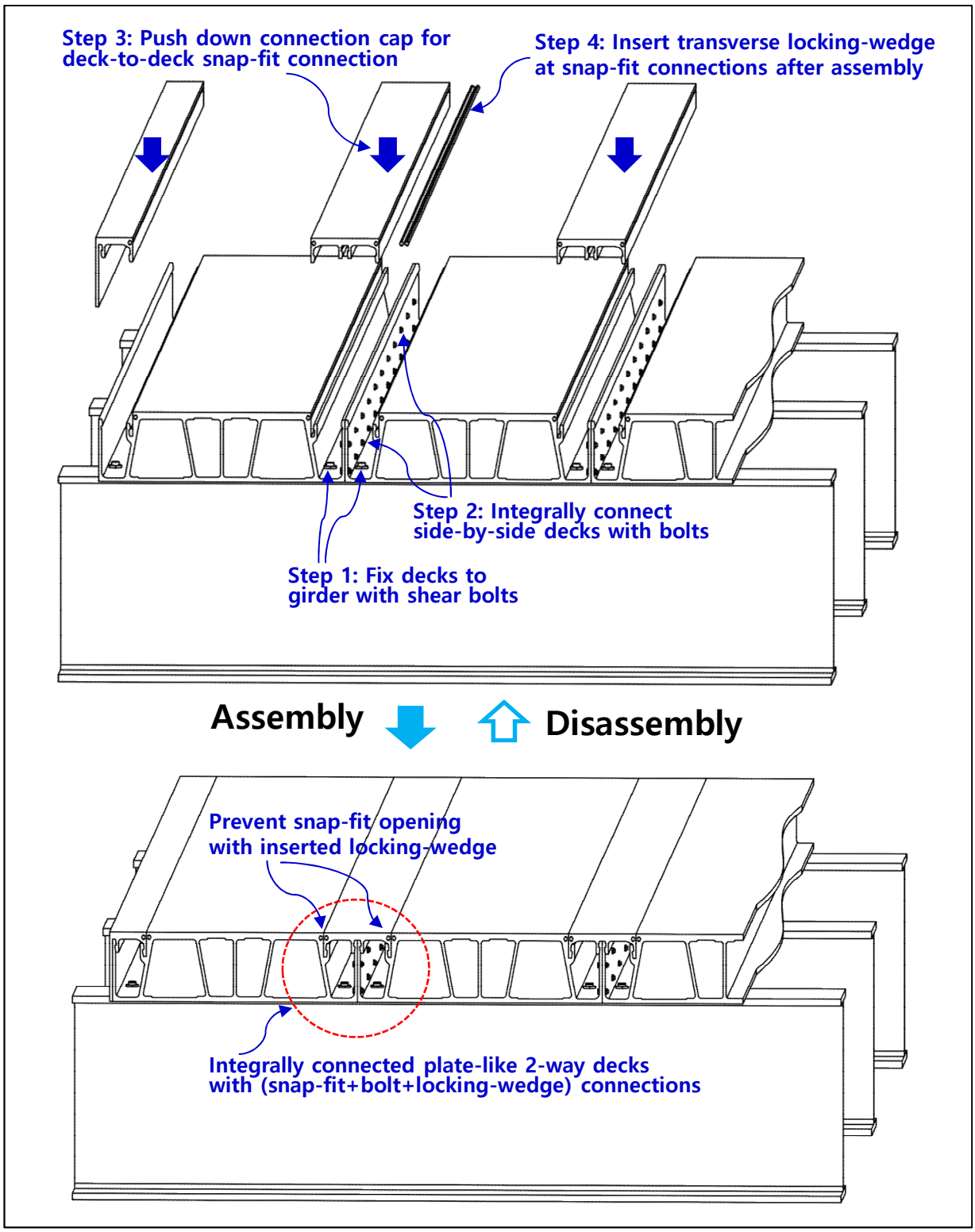


Cross section of integrally connected ISF200 decks



Cross section of adhesively connected TG200 decks

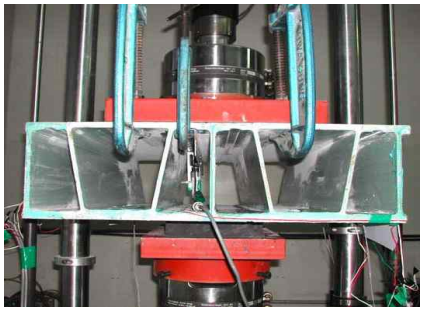
Assembly of ISF200 Delta Deck for Traffic Bridge



Fabrication, Experiments and Evaluation of Traffic Deck

Pultrusion of TG200 Deck

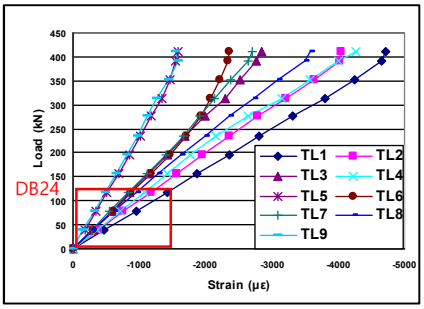
Pultrusion of SF200 Deck

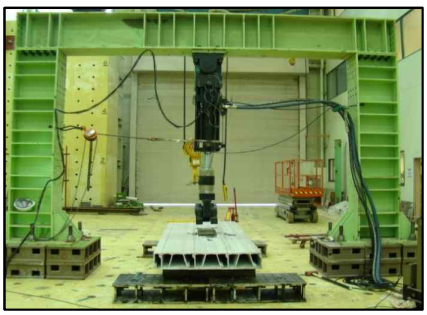


Fatigue Test of TG200 Deck

3-Point Flexural Test of TG200.

Failure at 412kN [F.S.=3.4 for DB24 Axle Load(122kN, 1.33xASSHTO_H20)].

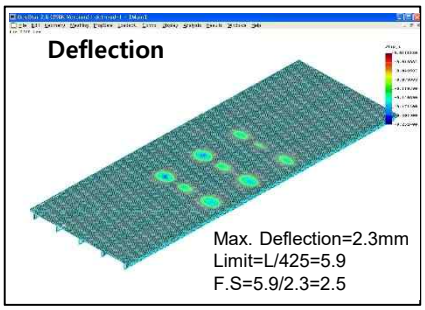




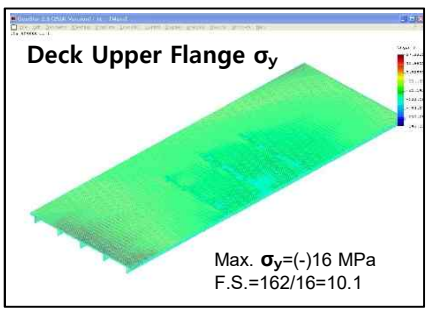
Test of SF200(Results similar to TG200)

Field Load Test(Girder composite action)

Field Load Test(Non-composite action)



Structural Analysis for DB24 Load



Structural Analysis(σ_y stress contour)

Description			F.S.
3-Point Flexural Test			6.5
Fatigue Test			13.1
Shear Test(Deck-Girder Connection)			3.7
Plate Girder Bridge DB24 Load	Field Load Test	Serviceability(δ)	3.0
		Max. Stress	13.6
	Structural Analysis (L=30m, 5-girder@2.5)	Serviceability(δ)	2.5
		Max. Stress	10.1
		Failure Index	10.4
		Buckling	10.7

Structural Capacity Evaluation

Cost Comparison for Traffic Decks(Concrete vs. Composite)

■ Cost Comparison for New Bridge (Total Construction Costs)

PSC Girder Bridge(L: 180.0m, W: 20.9m, 4 Lanes)

Description		Concrete Slab(S. Life: 30 y)		Composite Decks(S. Life: 75 y)		Composite/ Concrete (%)
		Cost(M. US$)	Portion(%)	Cost(Mil. US$)	Portion(%)	
Earth Works		1.31	25.0	0.98	18.6	74.8
Substructure/Pier		1.42	27.2	1.07	20.3	75.4
Bridge Shoes		0.19	3.6	0.15	2.8	78.9
PSC Girder		1.07	20.5	0.83	15.7	77.6
Deck(Slab)		0.74	14.1	1.85	35.0	250.0
Misc.		0.50	9.6	0.40	7.6	80.0
Initial Costs		5.23	100.0	5.28	100.0	101.0
Life Cycle Cost(LCC)	Redecking	2.27	22.0	-	-	-
	Maintenance	2.80	27.2	0.56	9.6	20.0
	Total	10.30	-	5.84	-	56.7 (▽43.3%)

■ Cost Comparison for Bridge Upgrading (per m²)

Steel Plate Girder Bridge(L: 916.0m, W: 51.0m, DB18 ➧ DB24). Note: DB18 is Equivalent to AASHTO HS20. DB24=1.33HS20

Description	Concrete Slab(US$/㎡)		Composite Deck(US$/㎡)		Composite/ Concrete (%)
Deck Cost (w/ demolition)	400	Demolish existing concrete Slab. Place new concrete slab.	890	Demolish existing concrete slab. Install composite decks.	68
Strengthening	900	Strengthen pier, substructure.	-	-	
Initial Costs	1,300		890	Reduce 32% of initial costs.	
Redecking	800	2 times x 40	-	-	0
Maintenance	750	30 years x (2.5/year)	150	75 years x (0.2/year)	20
LCC	2,850		1,040	Reduce LCC 64%	36
Service Life	30 years		75 years		-
Const. time	2 years		6 months		-
Remarks	Congestion in long time. Redecking with concrete slab. Strengthening of pier and substructure is inevitable for upgrading load carrying capacity. High costs for relatively short service life. Increase social costs due to long construction time. Induce inconveniency for citizens.		Rapid construction. Minimize congestion. Shorten construction time. Minimize citizen's inconveniency. Increase load carrying capacity. Upgrade bridge only with composite redecking. Unnecessary to strengthen pier and substructure. Increase service life. Reduce LCC. Increase aseismic capacity. Early traffic opening. Reduce construction cost.		

Construction Records of Delta Deck for Walkway/Bikeway and Footbridges

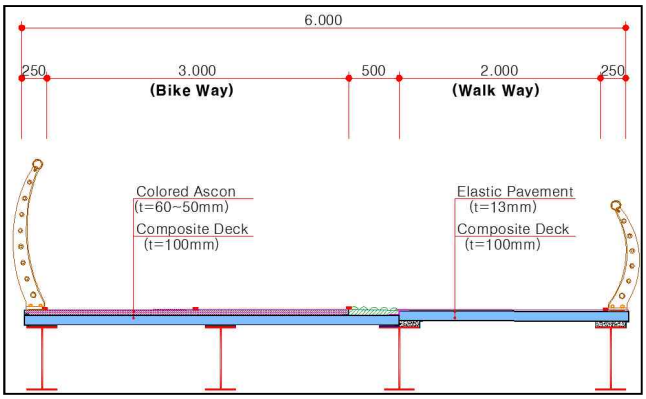
Construction Records of SF Delta Deck for Footbridges

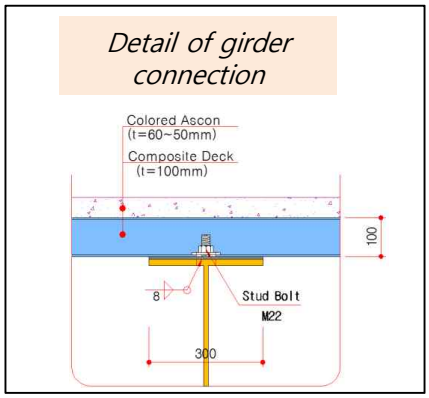
Bridge Name	Bridge Owner	Construction Year	Bridge Type	Length (m)	Width (m)
Biwoodang Bridge, Walkway	Seoul Metropolitan City	2004	Arch + St. Plate Girder	44.5	9.0
Wulchulsan Footbridge	Wulchulsan National Park	2006	Suspension	53.1	1.0
Osanchun Footbridge	Ministry of Transport	2006	Arch/ St. Box	140.0	5.0
Ponam Footbridge	Kangneoung City	2007	St. Plate Girder	50.0	5.0
Giheung Lake Footbridge (Phase 1 & 2)	Yongin City	2007 2010	St. Plate Girder	772.0 892.0	3.5 3.5
Sangju Footbridge	Sangju City	2007	Suspension	30.0	2.0
Bonghwa Footbridge	Bonghwa-gun	2007	Suspension	90.0	2.2
Samsung Shipyard Catwalk	Samsung Heavy Industries	2008	St. Plate Girder	82.0	5.0
Hangang Bridge (Walkway Expansion)	Seoul Metropolitan City	2008	Arch, St. Plate Girder	1,681.8	4.5
Shinchun Footbridge	Dongducheon City	2009	St. Plate Girder	70.0	5.0
Gwangju Jeungsim Footbridge	Gwangju City	2009	St. Plate Girder	18.0	3.0
Yongin Dodam Footbridge	Yongin City	2009	St. Plate Girder	32.0	3.0
Gunsan Seonyoo-do Road Mat	Gunsan City	2009	Road Mat Use	92.0	3.0
Jukdosan Park Footbridge	Yeongdeok-gun	2009	Cable Stayed	140.0	1.5
Sinjeom Bridge (Walkway Expansion)	Yangpyung-gun	2009	RC Slab	47.0	2.2
Johyun Bridge (Walkway Expansion)	Yangpyung-gun	2009	RC Rahmen	41.5	2.5
Geumchun Bridge (Walkway Expansion)	Korea Land & Housing Corp.	2009	PSC Girder	197.5	3.3
Paju-Wunjung Footbridge	Paju City	2009	St. Plate Girder	190.0	4.5
Saewul Bridge (Walkway Expansion)	Haeundae-gu, Busan City	2009	St. Plate Girder	77.0	3.0
Onchun-chun Bridge (Walkway Expansion)	Dongnae-gu, Busan City	2009	FRP Bracket	144.0	3.0
Youngdo Julyoung-ro (Walkway Expansion)	Youngdo-gu, Busan City	2010	FRP Bracket	830.0	2.0
Sinchun Bridge	Gimpo City	2011	St. Plate Girder	232.0	2.0
Gyulhyun Bridge, Walkway	K-Water Corp.	2011	Concrete Box Girder	585.0	4.0
Joadong Bridge	Haeundae-gu, Busan City	2011	St. Plate Girder	45.0	2.3
Sejong Haknarae Bridge, Walkway	Korea Land & Housing Corp.	2011	Cable Stayed	700.0	9.0
Swinging Footbridge	Suwan Kwangju City	2011	Cable Stayed	67.1	4.0
Bonap-Neupsan Footbridge	Gapyung-gun	2011	Suspension	55.4	2.3
Dojang Port Footbridge	Ministry of Transport	2011	Cable Stayed	41.0	2.1
Sasang-gu Riverside (Walkway Expansion)	Sasang-gu, Busan City	2012	St. Plate Girder	50.7	4.8
Busan North Port Haedoji Footbridge	Busan Port Corp.	2012	Cable Stayed	76.4	7.0
Busan North Port Noyeul Footbridge	Busan Port Corp.	2012	Cable Stayed	145.0	10.0
Daedunsan Park Footbridge	Geumsan-gun	2012	Suspension	58.0	1.5
Gochuk Bridge (Walkway Expansion)	Seoul Metropolitan City	2015	St. Plate Girder	406.0	5.6
Gochuk Skydome Baseball St. (Expansion & Footbridge)	Seoul Metropolitan City	2015	St. Plate Girder	410.0	7.4

Total 37,779 m^2 of composite decks on walkway/bikeway expansions and footbridges (35 bridges) are installed till 2019

New Footbridge and Walkway

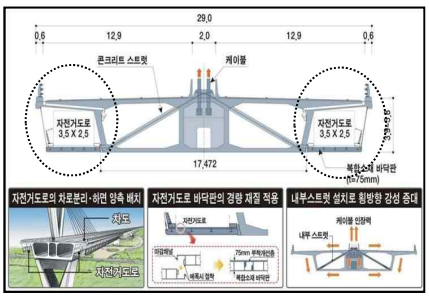
Typical Section of Plate Girder Bridge (Giheung Lake Footbridge)





Typical Applications

Giheung Lake Footbridge (Steel Plate Girder Bridge. L=1664.0m, W=3.5m. 2007)

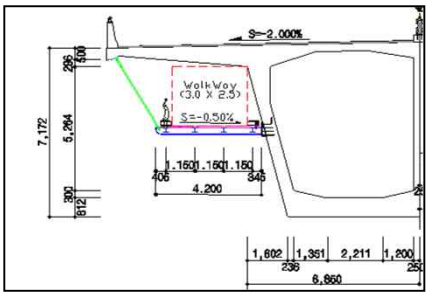


Sejong Haknarae Bridge, Walkway (Cable Stayed Bridge. Under Concrete Box. L=700.0m, W=9.0m. 2011)

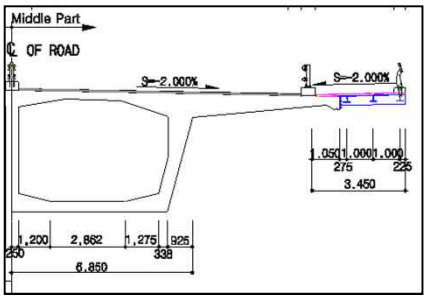
Sejong Haknarae Bridge, Walkway [(L) Deck Installation. (M) Pavement. (R) Underneath View)]

New Footbridge and Walkway

Typical Applications




Gyulhyun Bridge, Walkway (Concrete Box Girder Bridge. Under Box Girder. L=293.0m, W=4.0m. 2011)




Gyulhyun Bridge, Walkway (Concrete Box Girder Bridge. Above Box Girder. L=292.0m, W=4.0m. 2011)



Gochuk Skydome Baseball Stadium, Walkway (Plate Girder. Walkway+Footbridge: L=410.0m, W=7.4m. 2015)



Gochuk Skydome Baseball Stadium, Footbridge [(L) Deck Installation. (M, R) Underneath View)]

New Footbridge and Walkway

Typical Applications



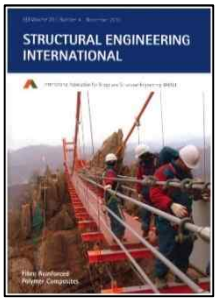
Osanshun Footbridge (Arch + Steel Box Girder Bridge. L=140.0m, W=5.0m. 2006)



Samsung Shipyard Catwalk (Steel Plate Girder Bridge. L=82.0m, W=5.0m. 2008)



Biwoodang Bridge, Walkway (Arch + Steel Plate Girder Bridge. L=44.5m, W=9.0m. 2004)

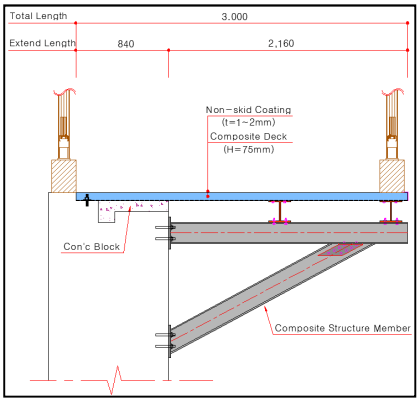


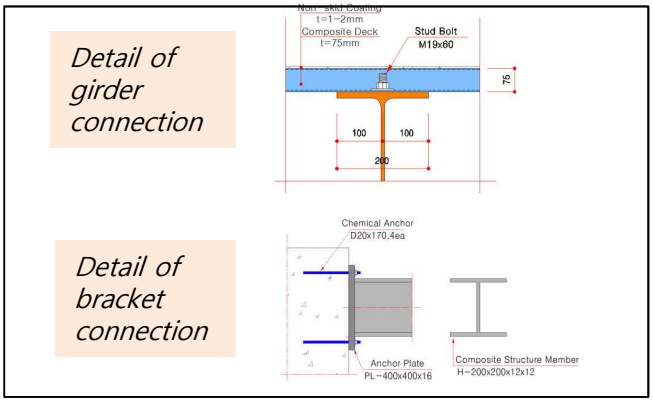

Wulchulsan Footbridge (Suspension Bridge. L=53.1m, W=1.0m. 2006).
Cover of Structural Eng. International[2010.11. IABSE(Int. Ass. For Bridge and Structural Eng.)]

Bongwha Footbridge (L=90.0m, 2007)

Walkway/Bikeway Expansions for Existing Bridge

Typical Section of Expansion (Onchuncun Walkway Expansion)





Typical Applications

Onchun-chun Bridge, Walkway Expansion (FRP Bracket. L=144.0m, W=3.0m. 2009)

Gochuk Bridge, Walkway Expansion (Steel Plate Girder Bridge. L=406.0m, W=5.6m. 2009)

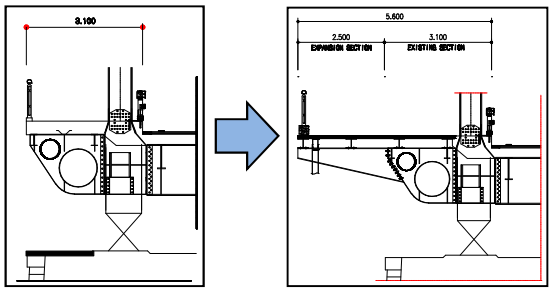
Geumchun Bridge, Walkway Expansion (PSC Girder Bridge. L=197.5m, W=3.3m. 2009)

Walkway/Bikeway Expansions for Existing Bridge

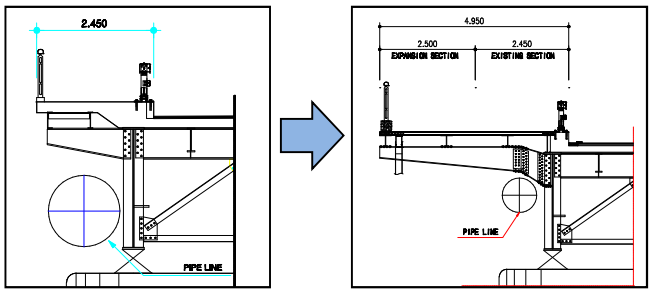
Typical Applications

Walkaway Expansion of Hangang Bridge with Light Weight Composite Deck

- Expand 2.5m walkway(conc., 11.3kN/m) to 4.5m composite one(SF75L deck,1.4kN/m) at both side of Arch/Plate Girder Bridge
- Significant cost savings by avoiding strengthening substructure due to reduced self-weight, despite doubly expanded walkway
- Compared with 4-month removal time, considerably shorten construction period by rapid installation of prefab decks in 2 weeks
- By the benefit of such advantages, composite decks of snap-fit type proved to be highly cost-effective for bridge expansions



Expansion of Arch Bridge Side



Expansion of Plate Girder Bridge Side

Walkway/Bikeway Expansion(Both Side) of Hangang Bridge(Arch Bridge) (L=840m, W= 4.5m)

Walkway/Bikeway Expansion(Both Side) of Hangang Bridge(Plate Girder Bridge) (L=840m, W= 4.5m)

Construction Records of Delta Deck for Traffic Bridges

Construction Records of TG200 Deck for Traffic Bridges

Bridge Name	Bridge Owner	Construction Year	Bridge Type	Length (m)	Width (m)
Bunchun Bridge (Temporary Bridge)	Jungbu Expressway(Hail-Hobup Expansion), Korea Expressway Corp.	2001	St. Plate Girder	6.0	4.0
Hyungju Bridge	Kyungbu Expressway(Busan-Unyang Expansion), Korea Expressway Corp.	2002	St. Plate Girder	11.0	4.3
Gwangyang Temporary Dike Access Bridge (Temporary Bridge)	Kwangyang Dredging Dike, Ministry of Maritime Affairs	2004	St. Plate Girder	150.0	10.0
Gaejung Bridge	Jansu-gun, Ministry of Transport	2004	St. Plate Girder	25.0	11.0
Pyeongtaek Port Access Bridge	Pyeongtaek Port, Ministry of Maritime Affairs	2005	PSC Girder	70.0	11.9
Bongsan 3-Bridge	Gangwon-do	2007	St. Plate Girder	35.9	7.0
Bongsan 9-Bridge	Gangwon-do	2008	St. Plate Girder	30.0	7.0
Gohan Bridge	Jeongseon-gun, Gangwon-do	2008	St. Plate Girder	29.9	12.0
Siheung Farmroad Bridge	Siheung City, Gyunggi-do	2008	St. Plate Girder	25.0	3.5
Baedoon Bridge	Masan City, Gyeongsangnam-do	2009	St. Box Girder	47.0	10.0
Yerim Bridge	Gijang-gun, Busan City	2009	IPC Girder	70.0	20.0
Gajaewul 2-Bridge	Cheoin-gu Yongin City	2010	St. Plate Girder	20.2	5.5
Malmoo Bridge	Busan New Port North Container Terminal, Busan City Development Corp.	2013	St. Box Girder	120.0	35.0

Total 9,768 m^2 of composite decks on traffic bridges(13 bridges) are installed till 2019

TG200 Composite Delta Deck for Traffic Bridges

Typical Applications



Hyungju Bridge (Steel Plate Girder Bridge. L=11.0m, W=4.3m, 2002)



Gwangyang Bridge (Steel Plate Girder Bridge of Non-Composite Action. L=150.0m, W=10.0m. 2004)



Gaejung Bridge (Steel Plate Girder Bridge. L=25.0m, W=11.0m. 2004)



Bongsan 3-Bridge (Steel Plate Girder Bridge. L=35.9m, W=7.0m. 2007)

TG200 Composite Delta Deck for Traffic Bridges

Typical Applications



Baedoon Bridge (Steel Box Girder Bridge. L=47.0m, W=10.0m. 2009)



Malmoo Bridge (Steel Box Girder Bridge. L=120.0m, W=35.0m. 2013)



Pyungtaek Port Access Bridge (PSC Girder Bridge. L=70.0m, W=11.9m. 2008)



Yerim Bridge (IPC Girder Bridge. L=70.0m, W=20.0m. 2009)

Bridge Deck Technology for 4th Industrial Revolutuion

DeltaDeck®

Light and Rapid Installation GFRP Snap-Fit Deck

Applications to Footbridges and Bike/Autobike/Walkway Expansions

Applications to Traffic Bridges

EJtech

www.ejtech.net

EJtech Co., Ltd.

10, Migeum-ro, 33beon-gil, Bundang-gu,
Sungnam-si, Gyeonggi-do, 13625, Korea
Phone: +82.31.711.4880
Email: ejtech@ejtech.net