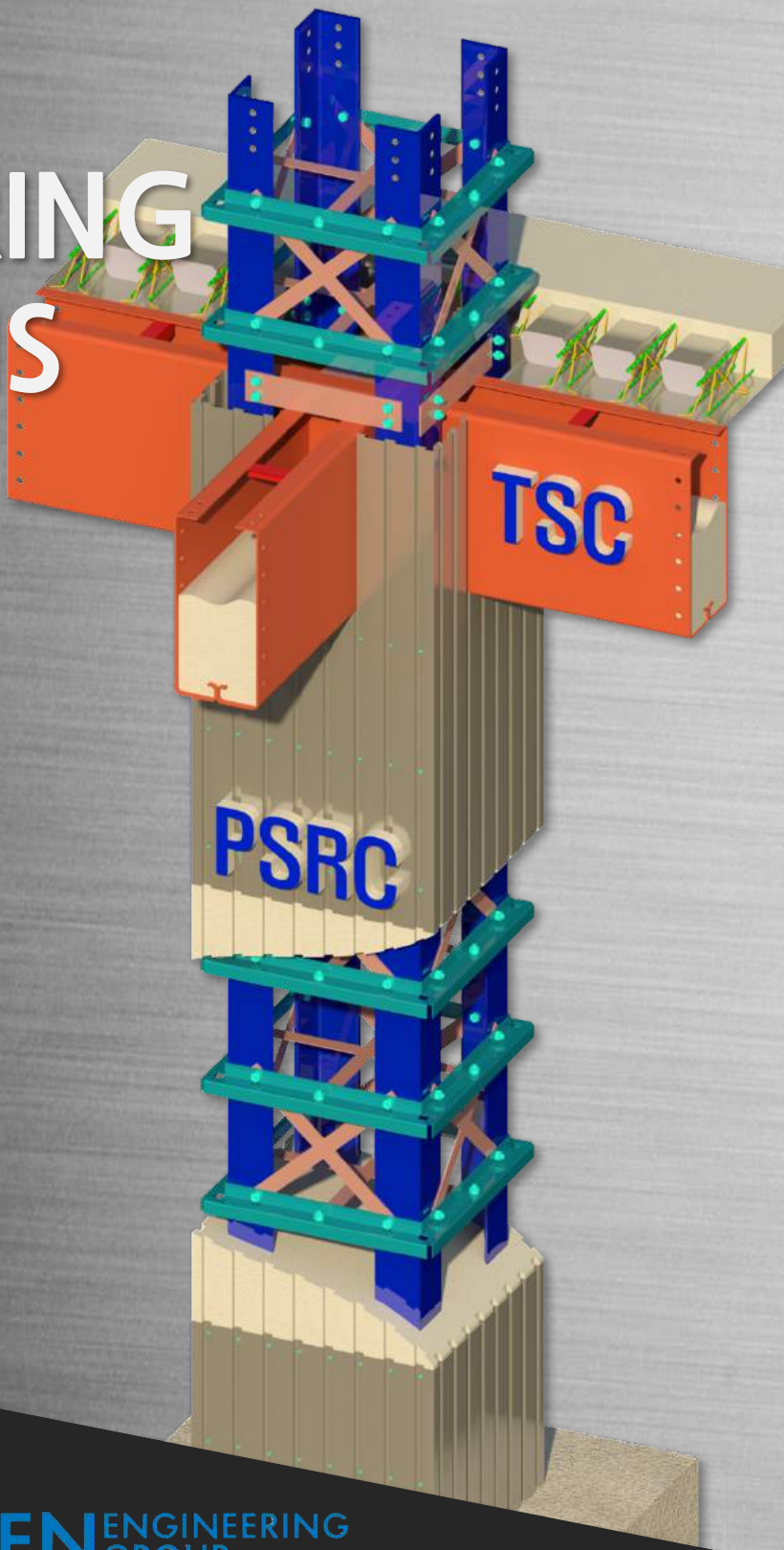
SEN
INNOVATIVE VALUE ENGINEERING SOLUTIONS

October 2016



SEN ENGINEERING GROUP

SEN STRUCTURAL ENGINEERS CO., LTD.
SENVEX CO., LTD.
SEN CORETECH INC.

SEN Structural Engineers Co., Ltd. | SEN Coretech, Inc. | SENVEX Co., Ltd. | Constructive Imagination, Inc.

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CONTENTS

1. SEN ENGINEERING GROUP

SEN Structural Engineers Co., Ltd.

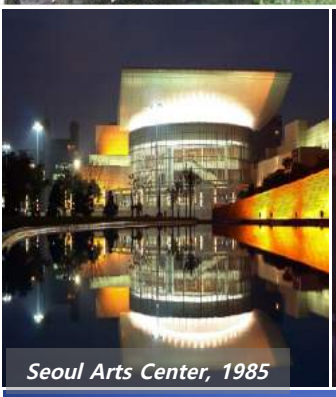
- Premier structural engineering firm of Korea founded in 1973
- No. 1 sales revenue in Korean structural engineering market


Korea World Trade Center
& COEX Exhibition Complex
Seoul, Korea, 1988


Incheon International Airport
Incheon, Korea, 2000


National Museum of Korea
Seoul, Korea, 2003


Posco Center ,2004

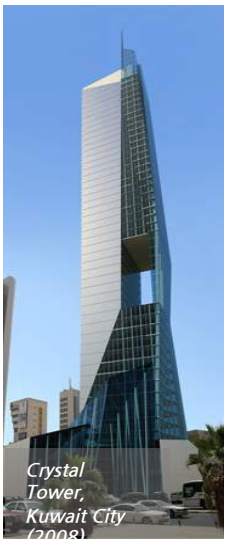

Seoul Arts Center, 1985


D-Cube City, Seoul , 2009


JW Marriott Hotel Seoul, 1997


Korea Development Bank, 1999


Noryangjin Fisheries Wholesale Market (2009)


Crystal Tower, Kuwait City (2008)


Gold Tower 42, Cambodia (2008)


KI Building of KI-KAIST Institute 2008)


Al Reem Island Apartments , Abu Dhabi (2009)

Urban Hive, Seoul (2006)

More than 40 years since its foundation in 1973, SEN Structural Engineers has dedicated to structural design with the aim of

1) raising the safety of building structures,
2) maximizing customer benefits by cutting construction cost and shortening construction period and
3) creatively and effectively utilizing building materials.

Under the goals, we have successfully conducted more than 5,000 projects without any accident. The creativity and challenging spirit have enabled us to think out of the box and consistently come up with new construction methods and development on materials. Unlike any other structural engineers, we have endeavored to pay our clients back the benefits of reducing construction cost and period.

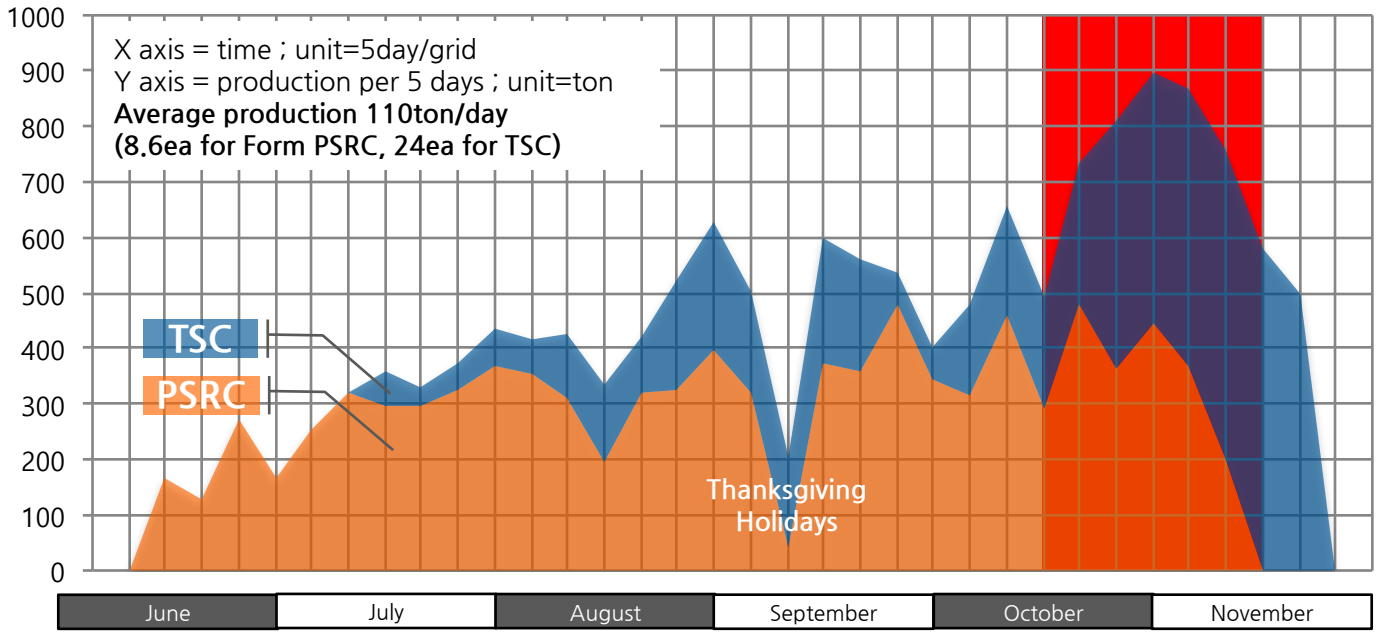
1. SEN ENGINEERING GROUP

SEN CORETECH, INC.

- Founded in 2010, SEN CORETECH has experienced a remarkable growth in manufacturing and constructing steel structure.
- SEN CORETECH mainly produces various patented products of SEN Engineering Group such as PRC, PSRC, TSC V and CRC.
- 10K sqm Main factory in Jincheon, Chungcheong-do (90mins from Seoul).
- Utilizing the advanced production facilities and strong contractor network, SEN CORETECH guarantees timely delivery of prefabricated steel structure for any size and complexity.

Our efficient & flexible production line can handle mega-scale fast track construction works

- Actual production : SK Hynix, 2014

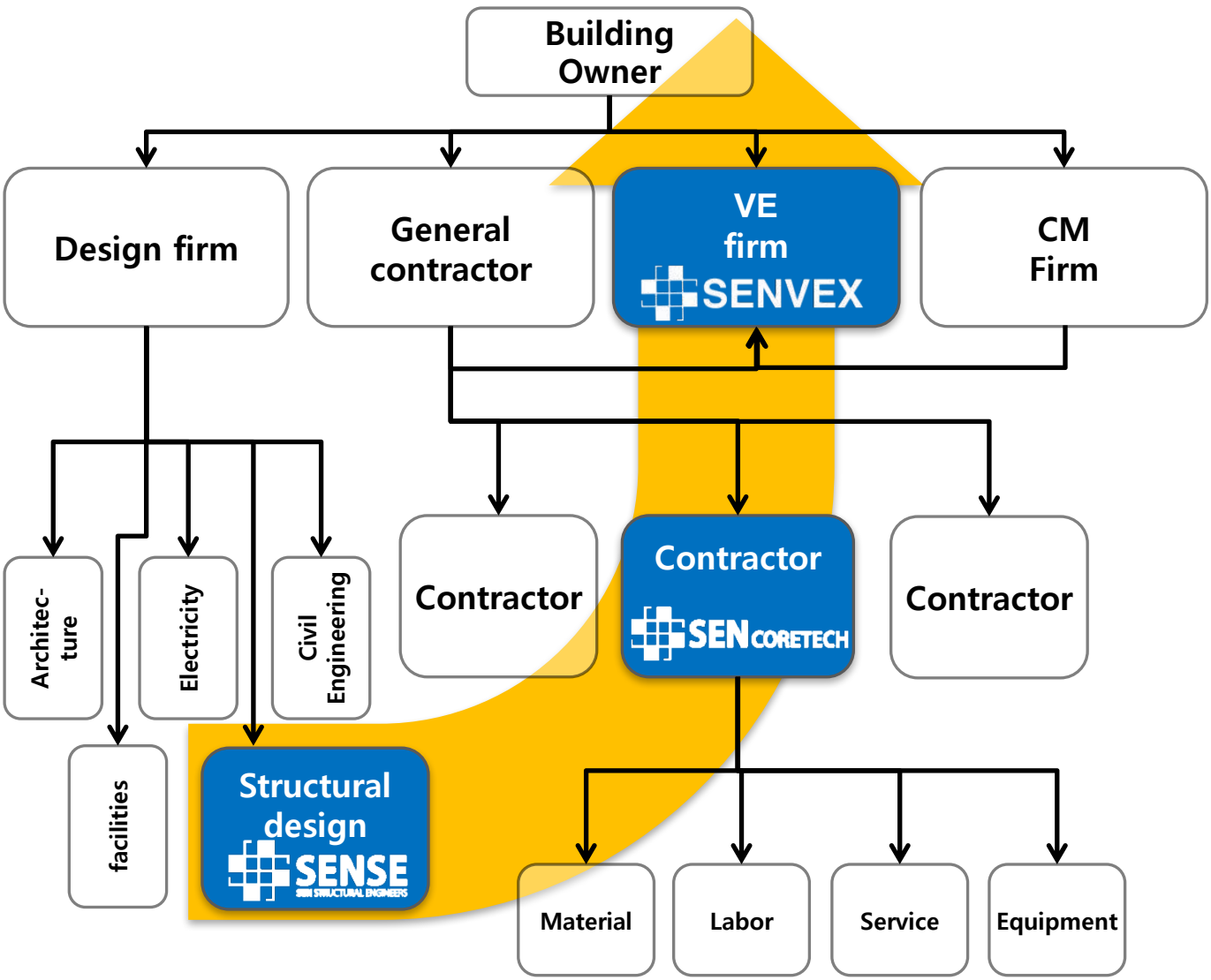


1. SEN ENGINEERING GROUP

Competitive edge of SEN Engineering Group

- Vertical integration of value-engineering firm, special contractor and structural engineering firms
- One-stop VE solution

➔ **Maximize total profit of building owners and other stakeholders of the project**



Competitive edge of SEN Engineering Group

IDEA

- Over 120 patents
- Over 700 VE Projects experience

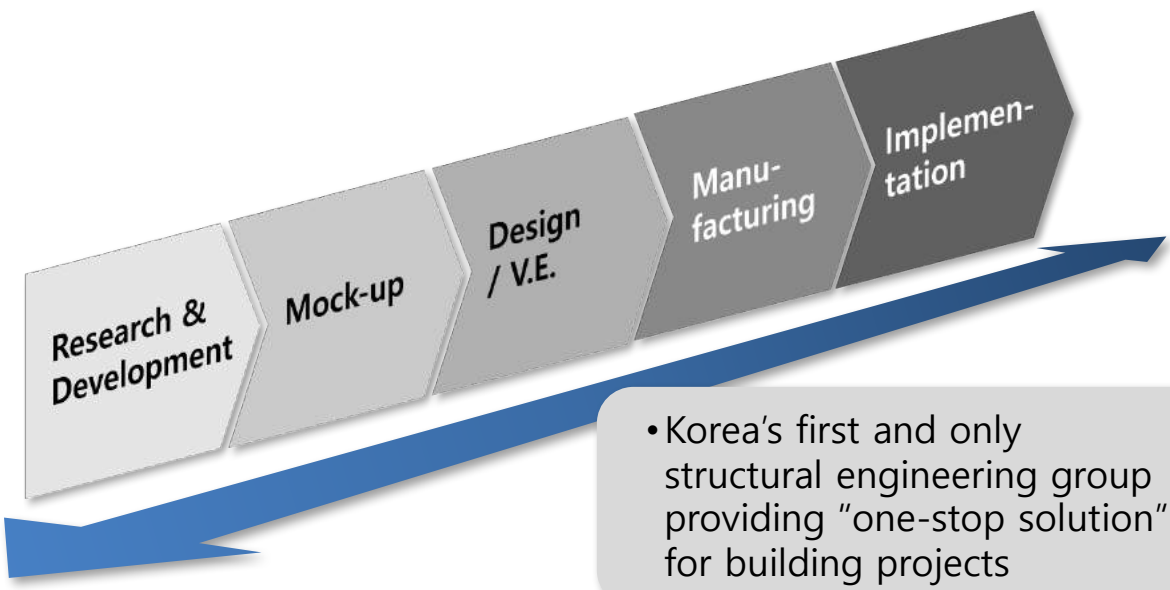
VALUE CREATION

ACTUAL DESIGN

- Premier building structural engineering firm with over 4,000 design projects experience

IMPLEMENTATION

- Directly operating the special steel structure manufacturing and construction company



- Korea's first and only structural engineering group providing "one-stop solution" for building projects

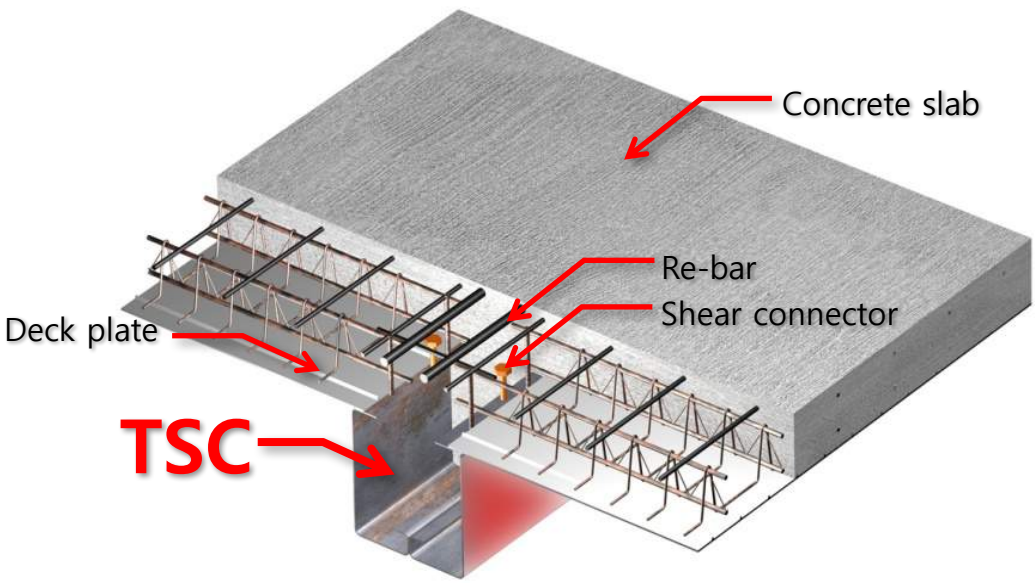
TSC, Korea's leading composite beam system

- TSC is an advanced steel-concrete composite beam system.
- Its unique cold-formed "concrete vessel" design optimizes the arrangement of steel material so that maximizes tensile capacity.
- TSC has been successfully applied on more than 300 domestic and offshore projects since its launch in 2001.

Advantages of TSC (Thin Steel-plate Composite)

Advantages	Economics	High perfor-mance	Eco Friendli-ness
Save up to 30%-40% beam and girder cost compared to conventional steel composite beam	●		●
Up to 70% less fireproofing cost	●	●	●
Save overall construction cost by reducing the story height	●		●
Less vibration compared to conventional steel		●	
Extended life span by preventing concrete crack or neutralization compared to R/C	●	●	●

Overview of the TSC system (Type IV)



Certifications from the Korean Government

- "National New Technology"
  - Ministry of Construction and Transportation (2004, NNT-418)
- "Excellent Quality Product"
  - Public Procurement Service (2005, EQP-2005060)
- "Performance Verification"
  - Architectural Institute of Korea (AIK 06-3)
- "Fire-proofing Performance Verification"
  - Ministry of Construction and Transportation (2009, 09-121 (2 hrs), 09-129 (3 hrs))

Successfully applied to more than 300 projects

Completed projects

1. URBAN HIVE (Seoul)
2. CRYSTAL TOWER (Kuwait City)
3. FINANCIAL SUPERVISORY SERVICE (Seoul)
4. DONGDAEMUN SHOPPING MALL (Seoul)
5. BUCHEON BUS TERMINAL (Bucheon)
6. SCIENCE VALLEY (Seoul)
7. KOREA CHAMBER OF COMMERCE (Seoul)
8. SHINDORIM TECHNOMART (Seoul)
9. SHINSEGAE DEPARTMENT STORE (Seoul)
10. SHINSEGAE DEPARTMENT STORE (Busan)
11. SHINCHON TRAIN STATION (Seoul)
12. AEGYUNG GATEWAY (Seoul)
13. WANGSIMNI STATION (Seoul)
14. TECHNOPARK (Seoul)
15. DIGITAL TOWER (Seoul)
16. LOTTE CASTLE (Seoul)

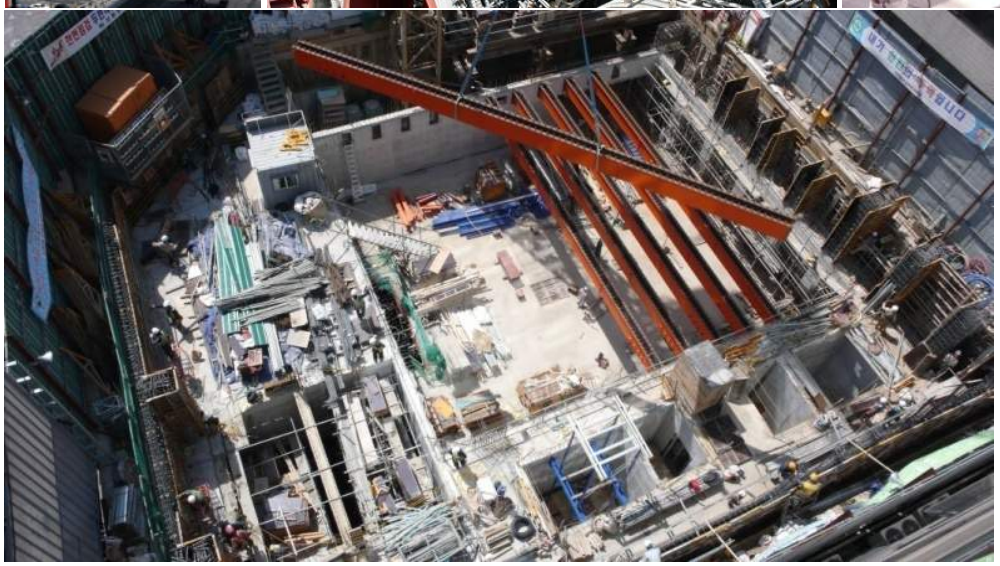
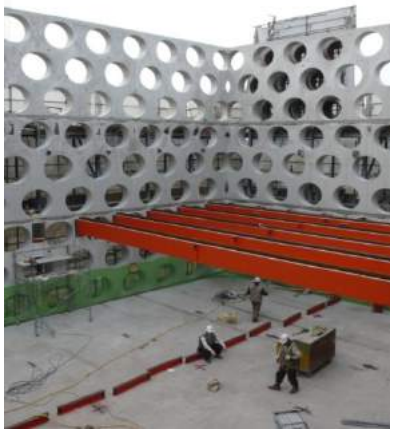
Others

1. DAELIM GRAND HOTEL (Jeju, Constructed by Daerim Industrial)
2. INHA TECHNICAL COLLEGE (Incheon, Constructed by Daerim Industrial)
3. DAESUNG D-CUBE CITY (Seoul, Constructed by Daesung E&C)
4. EXPRESS BUS TERMINAL COMPLEX (Daejeon, Constructed by KSBJ Housing)
5. LG CHEMICAL R&D CENTER (Daejeon, Constructed by LG Serveone
6. SAMSUNG MOBILE DISPLAY FACTORY (Cheonan, Constructed by Samsung Engineering)

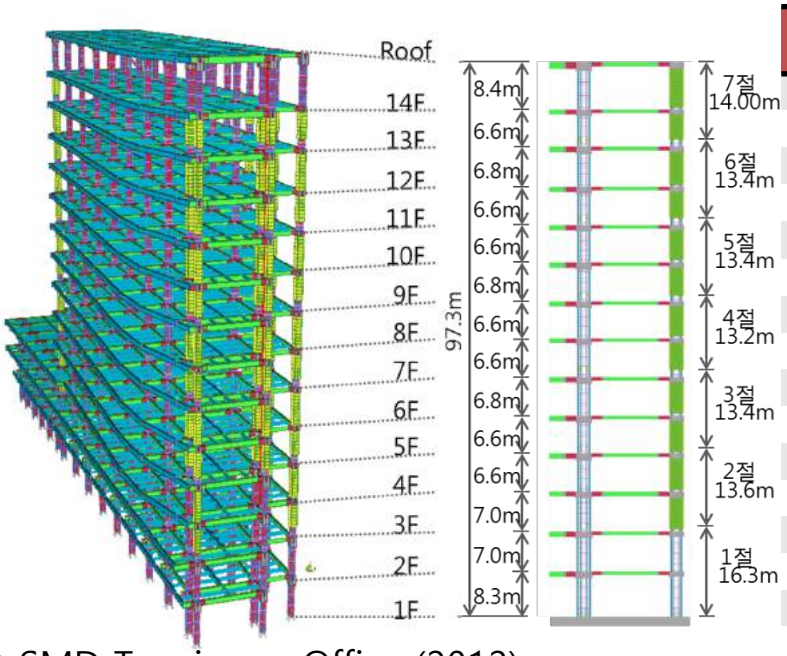
Recent landmark project: Urban Hive

- Applied the TSC composite beam system.
- Awarded Grand Prize of Seoul Architectural Design Competition in 2009.



Reducing material amount



Fl	H beam (kg)	TSC beam (kg)	ratio
1F	319,542	203,990	63.84%
2F	329,664	212,409	64.43%
3F	361,392	279,464	77.33%
4F	218,708	134,988	61.72%
5F	217,689	135,009	62.02%
6F	216,050	134,388	62.20%
7F	216,050	134,388	62.20%
8F	216,050	134,388	62.20%
9F	216,050	134,388	62.20%
10F	216,050	134,388	62.20%
11F	216,050	134,388	62.20%
12F	216,050	134,388	62.20%
13F	216,050	134,388	62.20%
14F	216,050	134,388	62.20%
Roof	280,018	180,009	64.28%
sum	**3,671,462 kg**	**2,355,359 kg**	**64.15%**

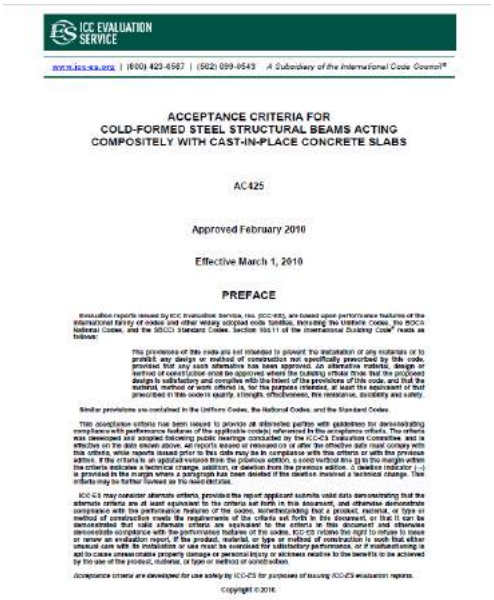
- SMD Tangjeong Office (2012)

Officially listed on ICC-ES Acceptance Criteria

- Officially listed as an Acceptance Criteria of ICC-ES (AC425) in March 2010

http://www.icc-es.org/criteria/dsp.cfm?ac_code=AC425

- Preparing launch in the US market.



ICC EVALUATION SERVICE

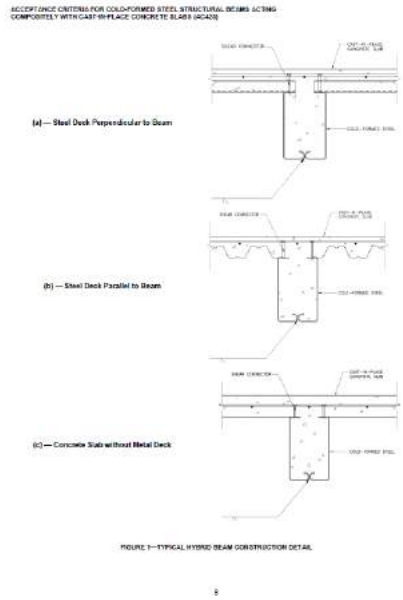
ACCEPTANCE CRITERIA FOR
COLD-FORMED STEEL STRUCTURAL BEAMS ACTING
COMPOSITELY WITH CAST-IN-PLACE CONCRETE SLABS

AC425

Approved February 2010

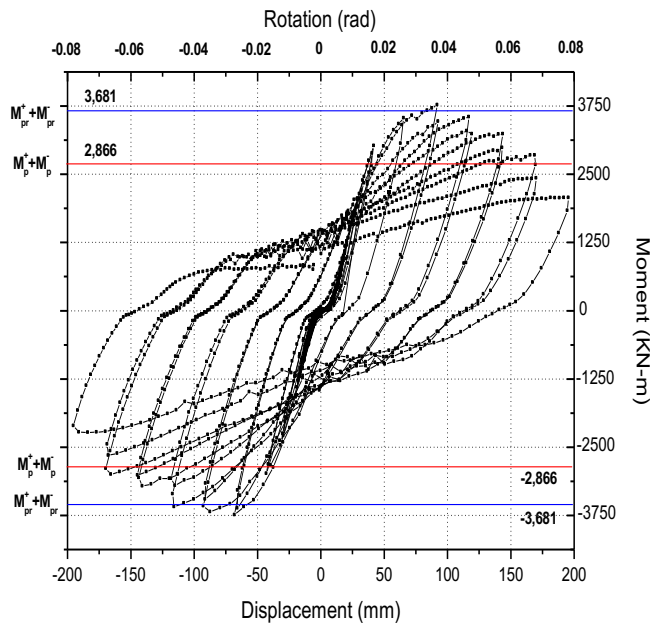
Effective March 1, 2010

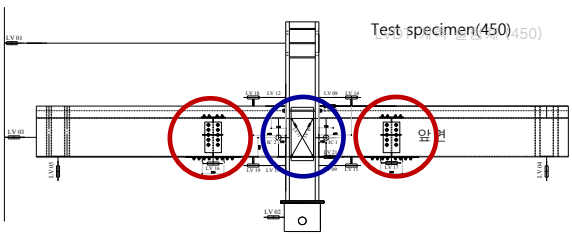
PREFACE



Moment Frame Connection Approval from AISC

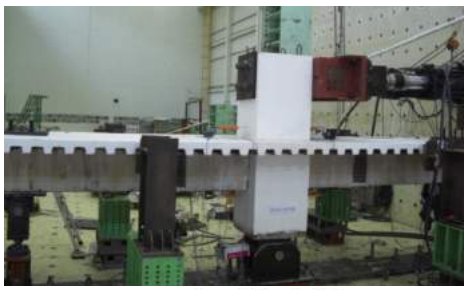
- Papers regarding TSC moment frame connections are officially published in recent issues of ASCE journal
- Running a government-funded project with Seoul National University

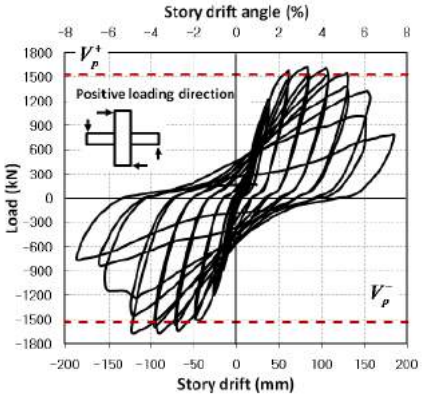


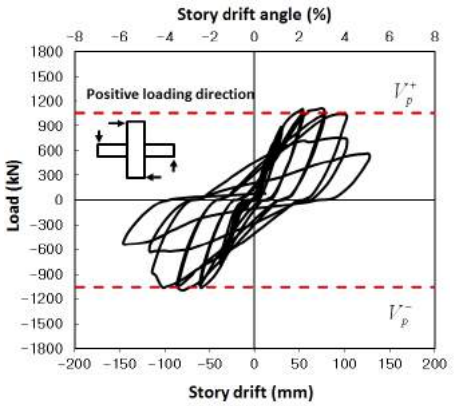


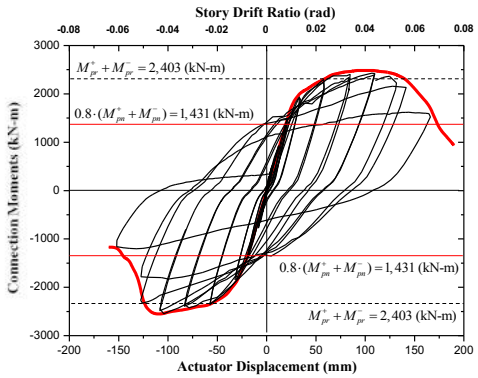
Moment Frame Connection listed on KSSC Paper

- Paper of February 2011 → Special Moment Frame (SMF) recognized: RC column + TSC
- Paper of August 2011 → SMF recognized: H-formed column + TSC









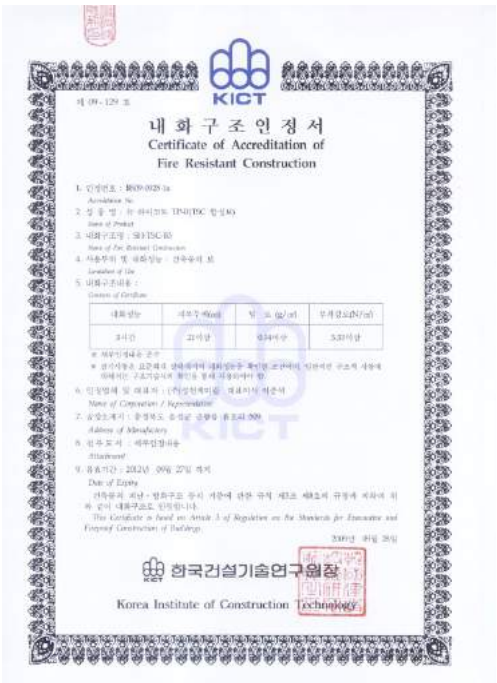
Fire Resistance Structure recognized by KICT

- Enhanced fire resistance efficiency compared to steel frame
  → 2 hrs: 16mm, 3 hrs: 21mm
  (H-shape steel requires more than 38mm of fireproofing for 3 hrs fire resistance.)
- TSC is the first composite beam recognized by KICT for fireproof painting
  → 2 hrs: 1.95mm, 3 hrs: 3.30mm

Comparative experiment for 3 hrs fireproof (KITC, 2008)

- TSC vs. H-shape steel (3 hrs; load(*); fireproofing protection 21mm)

(*) Final recognition of fireproof construction is based on a separate non-load test result.



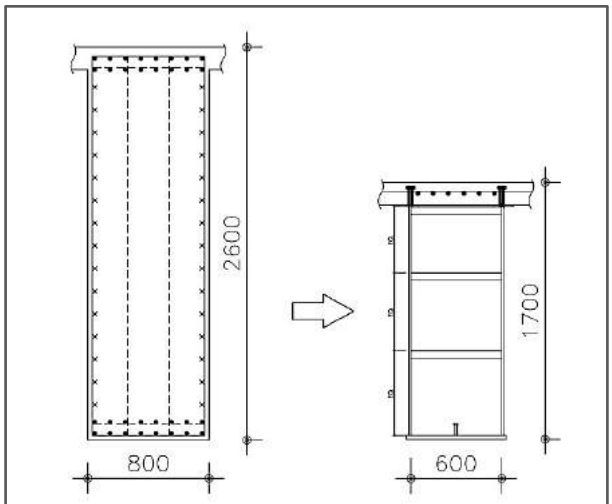
Application of TSC to transfer girder and beam

- Applied TSC instead of conventional RC transfer girder from the original design
- Reduced the beam depth by 900 inch
- Saved more than a month of construction period

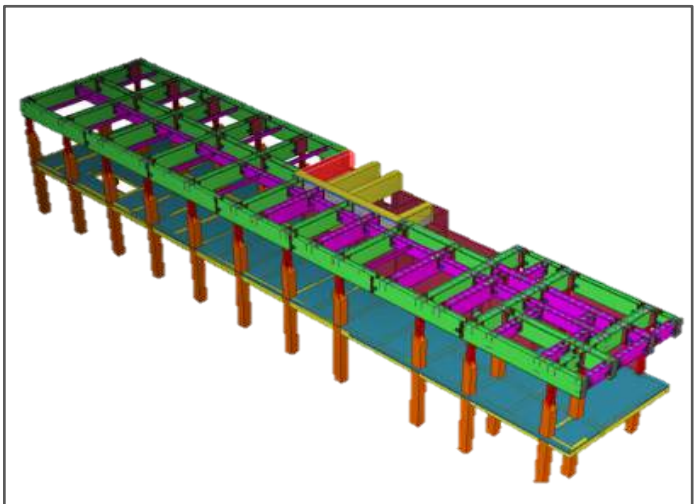
Site located at Gangnam metropolitan area


TSC installation


TSC connection at the top of column

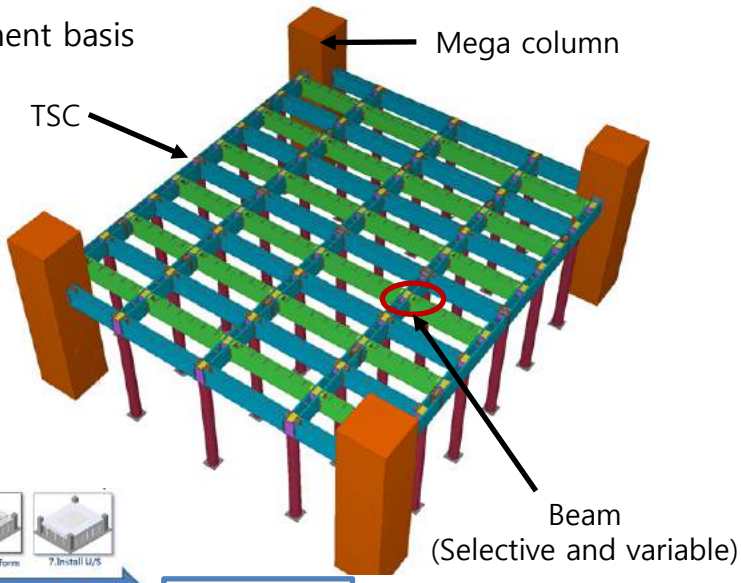


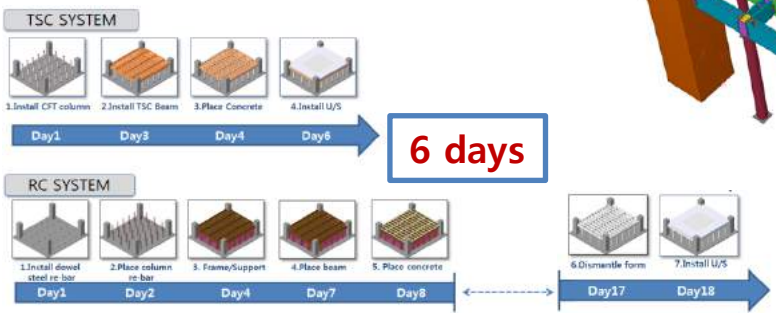
RC cross section TSC Cross section


BIM 3D model

Application to clean room equipment foundation

- Optimized details for clean room equipment basis of semiconductor factory
- Excellent vibration performance
- Reduced construction period





Curing before dismantling form takes 10 days

Reduce vibration and deflection (19%, 30% compared to RC)

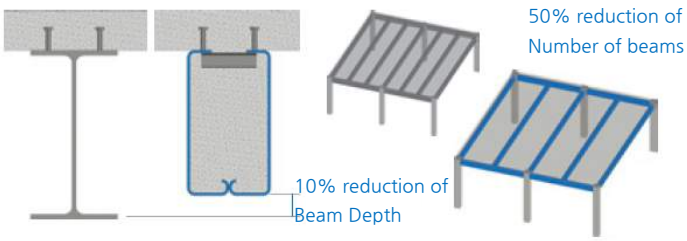
		RC	TSC
Vibration valuation formula		$f_n = 0.18\sqrt{\frac{g}{\Delta_j + \Delta_g}} \geq 3\text{Hz},\ \Delta \propto \frac{1}{EI}$ → $f_n \propto \sqrt{EI}$	
EI		7.098x10⁶ N· mm²	8.478x10⁶ N· mm² (Concrete)
Com-parison	Vibration performance	100%	**119%**
	Deflection (Rigid joint)	100%	**70%**

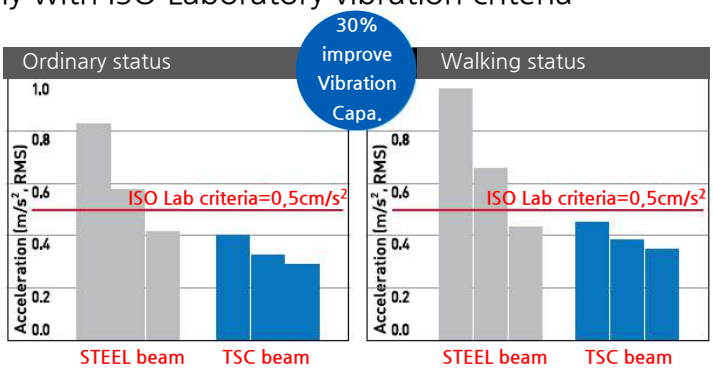
Actual vibration inspection comparison (H vs TSC)

- Client received complaint from occupants of existing building :
  → span 14.7m, built with steel beam (actual survey showed vibration exceeds ISO criteria)
- TSC beams were applied for newly built twin building :

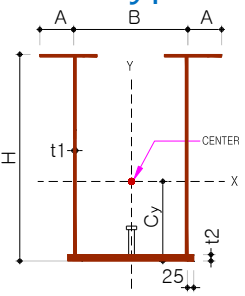
→ Reduced **10% of beam depth** and **50% of number of simple beam** while enhancing 30% of vibration capacity : comply with ISO Laboratory vibration criteria

Comparison of vibration : Steel beam VS TSC beam (twin building)

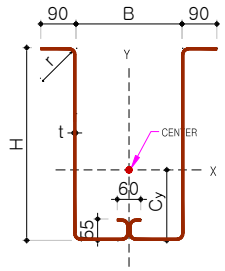




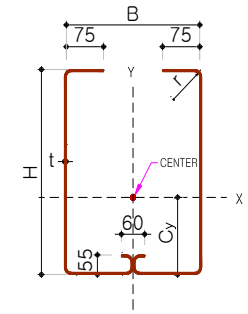
TSC type I



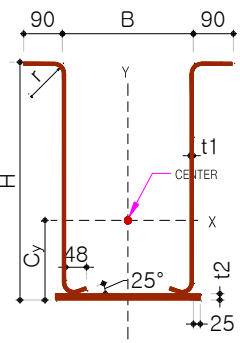
TSC type II



TSC type IV



TSC Type V



TSC IV section profile

Nominal size (mm)		Standard Sectional Dimension (cm)				Sectional Area (cm^2)	Unit Weight (kg/m)	Center of Gravity (cm)	Moment of Inertia $Ix(cm^4)$	Radius of Gyration Ix(cm)	Modulus of Section (cm^3)	
		H	B	t	r	A	W	C_y	I_x	r_x	Z_{x_comp}	Z_{x_tens}
300×270	4.5	29.9	27.0	0.45	1.0	50.12	39.34	12.12	6110.17	11.04	344.7	504.1
	6	30.0	27.0	0.60	1.0	66.47	52.18	12.25	8113.85	11.05	457.1	662.5
350×270	4.5	34.5	27.0	0.45	1.0	54.03	42.42	14.20	8661.91	12.66	427.8	609.9
	6	34.6	27.0	0.60	1.0	71.51	56.13	14.35	11490.38	12.68	567.5	800.5
	7	34.7	27.0	0.70	1.0	83.15	65.27	14.44	13366.32	12.68	659.9	925.4
	8	34.8	27.0	0.80	1.0	94.71	74.34	14.53	15230.92	12.68	751.5	1048.0
	9	34.9	27.0	0.90	1.0	106.19	83.36	14.62	17084.11	12.68	842.6	1168.3
	10	35.0	27.0	1.00	1.0	117.59	92.31	14.71	18925.83	12.69	933.0	1286.2
400×270	6	39.6	27.0	0.60	1.0	77.51	60.84	16.64	16025.65	14.38	698.0	963.1
	7	39.7	27.0	0.70	1.0	90.15	70.77	16.73	18641.08	14.38	811.6	1114.1
	8	39.8	27.0	0.80	1.0	102.71	80.62	16.83	21240.40	14.38	924.6	1262.3
	9	39.9	27.0	0.90	1.0	115.19	90.42	16.92	23823.53	14.38	1036.7	1408.0
	10	40.0	27.0	1.00	1.0	127.59	100.16	17.02	26390.36	14.38	1148.2	1551.0
450×270	6	44.6	27.0	0.60	1.0	83.51	65.55	18.95	21523.63	16.05	839.3	1135.5
	7	44.7	27.0	0.70	1.0	97.15	76.26	19.05	25035.81	16.05	976.1	1314.1
	8	44.8	27.0	0.80	1.0	110.71	86.90	19.15	28526.20	16.05	1112.1	1489.7
	9	44.9	27.0	0.90	1.0	124.19	97.49	19.25	31994.68	16.05	1247.2	1662.3
	10	45.0	27.0	1.00	1.0	137.59	108.01	19.35	35441.11	16.05	1381.5	1832.0
500×270	6	49.6	27.0	0.60	1.0	89.51	70.26	21.30	28060.55	17.71	991.4	1317.7
	7	49.7	27.0	0.70	1.0	104.15	81.76	21.40	32639.39	17.70	1153.2	1525.5
	8	49.8	27.0	0.80	1.0	118.71	93.18	21.50	37189.83	17.70	1314.0	1730.1
	9	49.9	27.0	0.90	1.0	133.19	104.55	21.60	41711.70	17.70	1473.8	1931.4
	10	50.0	27.0	1.00	1.0	147.59	115.86	21.70	46204.83	17.69	1632.6	2129.4
600×270	6	59.6	27.0	0.60	1.0	101.51	79.68	26.03	44554.71	20.95	1327.4	1711.5
	7	59.7	27.0	0.70	1.0	118.15	92.75	26.14	51827.02	20.94	1544.3	1982.8
	8	59.8	27.0	0.80	1.0	134.71	105.74	26.24	59054.86	20.94	1759.9	2250.2
	9	59.9	27.0	0.90	1.0	151.19	118.68	26.35	66237.97	20.93	1974.4	2513.7
	10	60.0	27.0	1.00	1.0	167.59	131.56	26.46	73376.11	20.92	2187.5	2773.4

TSC V section profile

Nominal size (mm)		Standard Sectional Dimension (cm)					Sectional Area (cm^2)	Unit Weight (kg/m)	Center of Gravity (cm)	Moment of Inertia $Ix(cm^4)$	Radius of Gyration Ix(cm)	Modulus of Section (cm^3)	
		H	B	t1	t2*	r	A	W	C_y	I_x	r_x	Z_{x_comp}	Z_{x_tens}
510×300	6x6	51.6	30	0.6	0.6	1.0	98.06	77.24	21.65	36306.88	19.24	1212.4	1676.8
	6x9	51.9	30	0.6	0.9	1.0	108.56	85.49	19.84	40587.96	19.34	1266.2	2045.3
	6x12	52.2	30	0.6	1.2	1.0	119.06	93.73	18.38	44244.30	19.28	1308.3	2407.0
	9x9	51.9	30	0.9	0.9	1.0	146.93	115.87	21.85	54356.29	19.23	1808.9	2487.6
	9x12	52.2	30	0.9	1.2	1.0	157.43	124.11	20.68	58845.80	19.33	1867.1	2845.9
610×300	6x6	61.6	30	0.6	0.6	1.0	110.06	86.66	26.37	56098.32	22.58	1592.1	2127.7
	6x9	61.9	30	0.6	0.9	1.0	120.56	94.91	24.36	62528.38	22.77	1665.5	2567.2
	6x12	62.2	30	0.6	1.2	1.0	131.06	103.15	22.69	68089.69	22.79	1723.5	3000.5
	9x9	61.9	30	0.9	0.9	1.0	164.93	130.00	26.56	84027.87	22.57	2377.9	3163.4
	9x12	62.2	30	0.9	1.2	1.0	175.43	138.24	25.26	90728.40	22.74	2456.3	3591.3
710×300	6x6	71.6	30	0.6	0.6	1.0	122.06	96.08	31.13	81512.54	25.84	2014.4	2618.1
	6x9	71.9	30	0.6	0.9	1.0	132.56	104.33	28.96	90577.82	26.14	2109.2	3128.1
	6x12	72.2	30	0.6	1.2	1.0	143.06	112.57	27.12	98505.66	26.24	2185.1	3632.2
	9x9	71.9	30	0.9	0.9	1.0	182.93	144.13	31.33	122138.43	25.84	3010.6	3898.4
	9x12	72.2	30	0.9	1.2	1.0	193.43	152.37	29.92	131540.18	26.08	3111.3	4396.1
810×300	6x6	81.6	30	0.6	0.6	1.0	134.06	105.50	35.94	113155.09	29.05	2478.5	3148.1
	6x9	81.9	30	0.6	0.9	1.0	144.56	113.75	33.62	125350.93	29.45	2596.5	3728.2
	6x12	82.2	30	0.6	1.2	1.0	155.06	121.99	31.64	136120.35	29.63	2692.0	4302.7
	9x9	81.9	30	0.9	0.9	1.0	200.93	158.26	36.14	169596.51	29.05	3706.3	4692.7
	9x12	82.2	30	0.9	1.2	1.0	211.43	166.50	34.64	182197.97	29.36	3830.8	5260.0

*Thickness of lower flange (t2) can be changed.

3. PRC

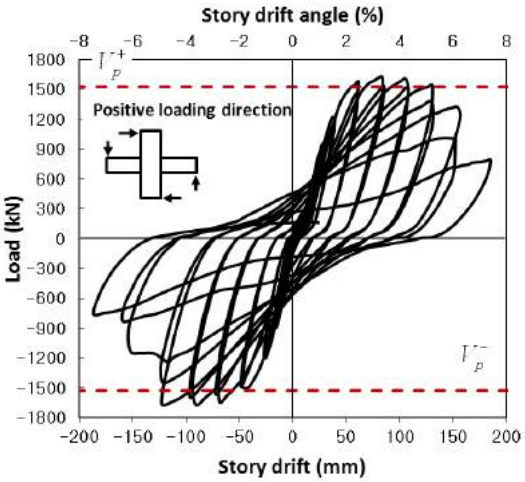
Time-saving as steel, low cost as RC

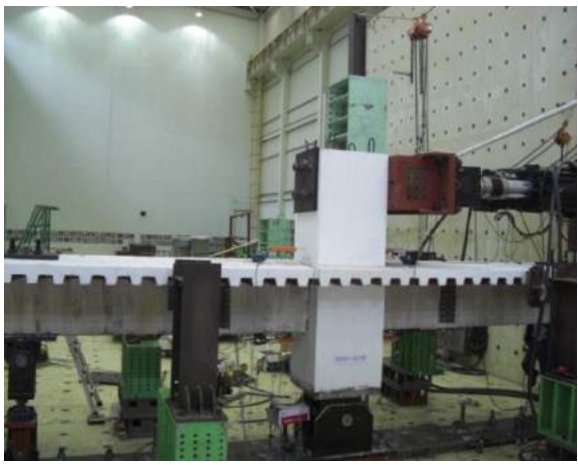
- PRC: Prefabricated Reinforced Concrete
- Field erection of re-bar cages prefabricated in factory

Cooperative research with Seoul National University

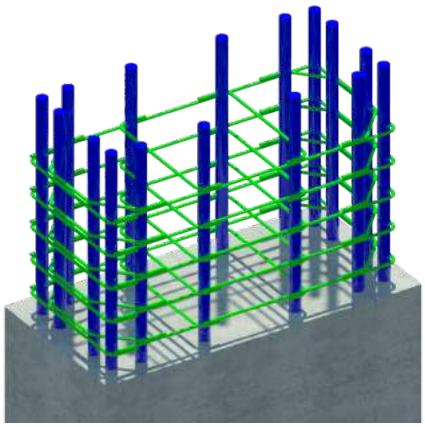
- Verified as Special Moment Frame (SMF) at Hyundai E&C Test Laboratory in June 2010

- Cyclic test result on PRC column + TSC connection

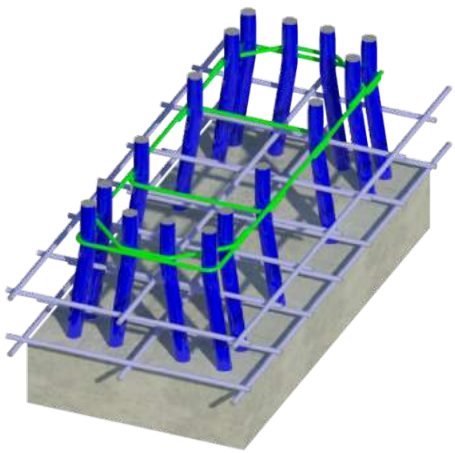




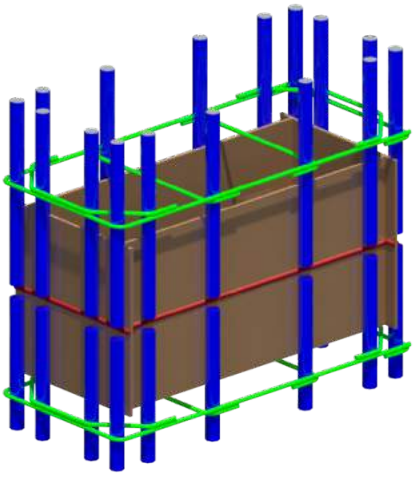
Details of PRC



Bar arrangement



Column size reduction



Column splice

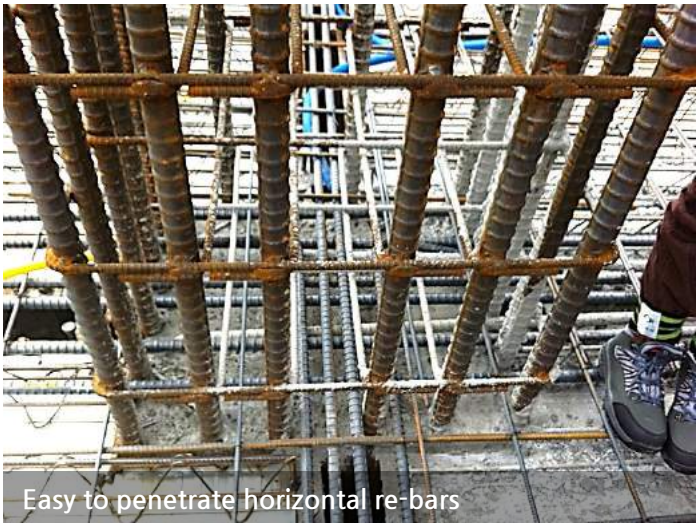
Application examples


PRC column stock


PRC column + TSC girder connection


PRC column + TSC girder connection


PRC column erection


Easy to penetrate horizontal re-bars


PRC column + TSC girder connection

Application of PRC columns to high-rise building

- Applied PRC columns to the belt truss of 63-stories building for BIFC in Busan.
- Ensured construction quality and shortened construction period by prefabricating a special sheer wall system—an optimized system for high-rise buildings of reinforced concrete.
- Aired on SBS-CNBC Creative Economy TV news show in August 2013.

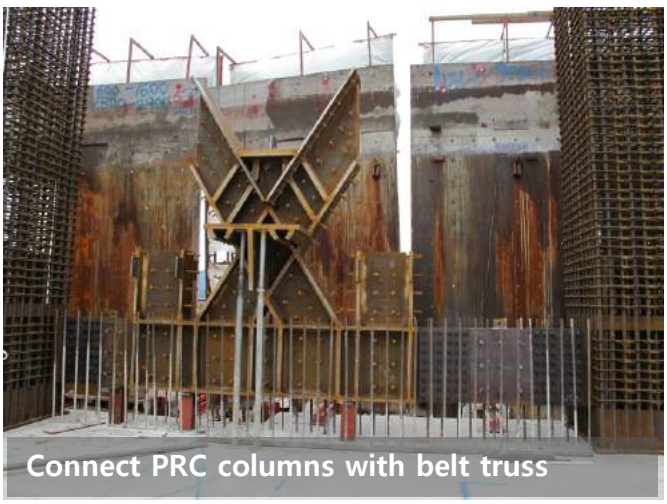

Aerial view of the project


Prefabricate PRC columns

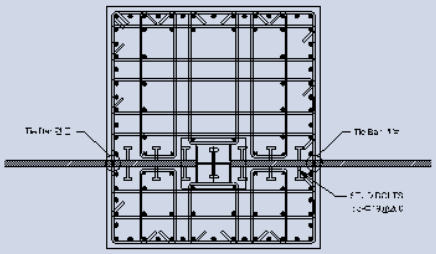
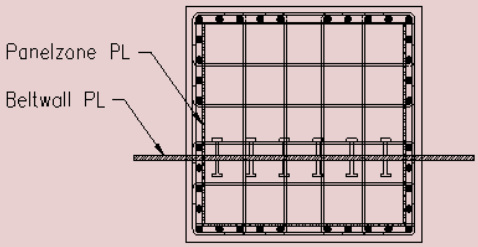
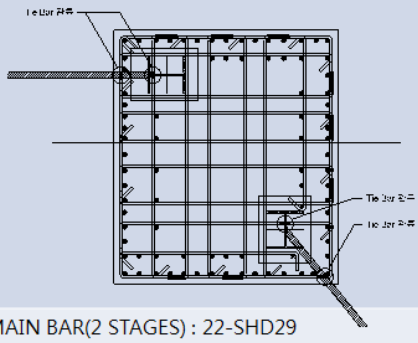
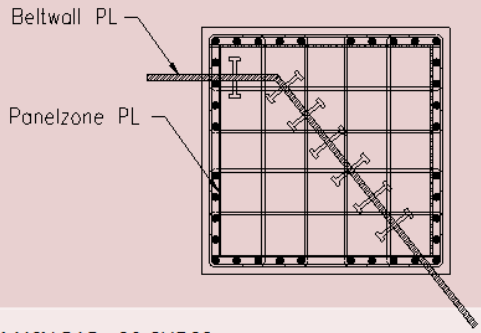

Bring PRC columns to the site

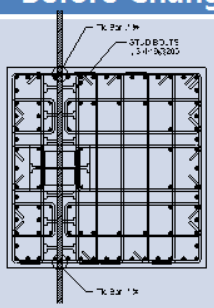
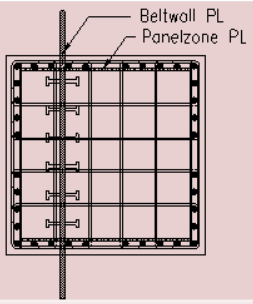
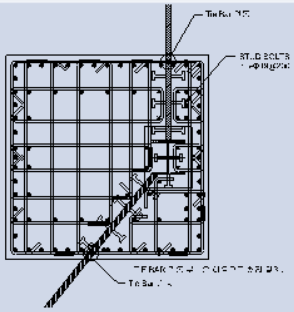
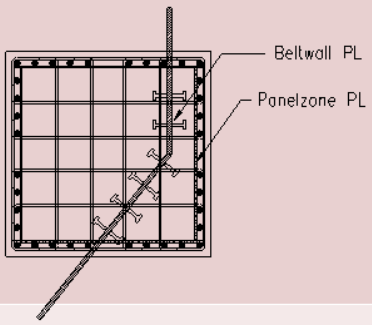

Lift and Erect PRC columns


Complete installation

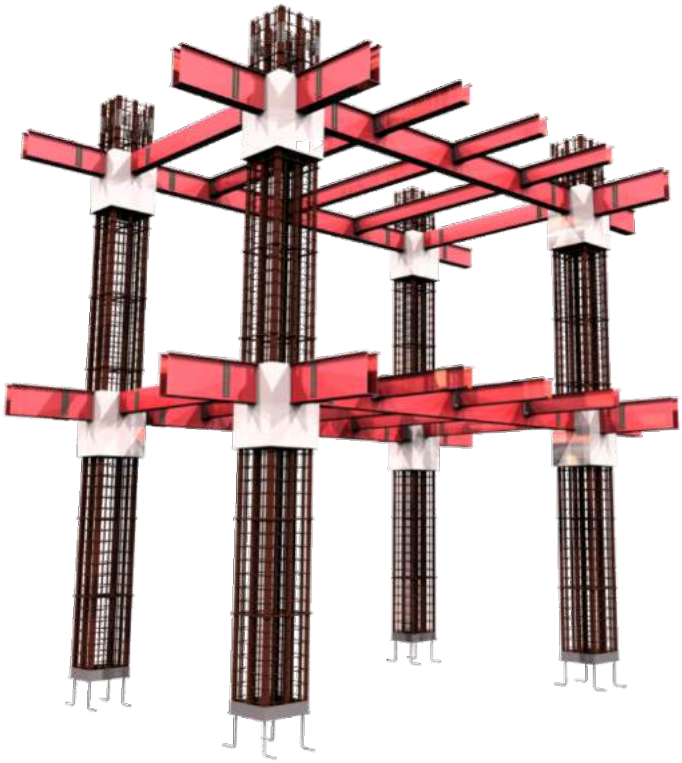

Connect PRC columns with belt truss

Changes in column design of BIFC

	Before Change	After Change
OC1 (6/C,E 1/C,E 6/D 1/D)		
	MAIN BAR(2 STAGES) : 22-SHD29 MAIN BAR(1 STAGE) : 60-SHD29 TIE BAR : HD16@100	MAIN BAR : 36-SHD38 TIE BAR : HD16@100
OC1 (6/B,F 1/B,F)		
	MAIN BAR(2 STAGES) : 22-SHD29 MAIN BAR(1 STAGE) : 60-SHD29 TIE BAR : HD16@100	MAIN BAR : 36-SHD38 TIE BAR : HD16@100

	Before Change	After Change
OC2 (G/3,4) OC3 (A/3,4)		
	MAIN BAR(2 STAGES) : 20-SHD29 MAIN BAR(1 STAGE) : 56-SHD29 TIE BAR : HD16@100	MAIN BAR : 36-SHD38 TIE BAR : HD16@100
OC2A OC2B OC3 (G/5 G/2 A/2,5)		
	MAIN BAR(2 STAGES) : 22-SHD29 MAIN BAR(1 STAGE) : 60-SHD29 TIE BAR : HD16@100	MAIN BAR : 36-SHD38 TIE BAR : HD16@100

2nd-Gen. PRC optimized for mega and mini columns



- PSRC: Prefabricated SRC
- Prefabricate the column structure by welding and/or bolting large-diameter re-bars, angles and steel plates (practically same as steel structure)
- Eliminate field fabrication process → Higher quality and shorter construction period
- Suitable for wide range of size : from smaller columns to mega columns (~700mm or 1,500mm~ width of cross section)

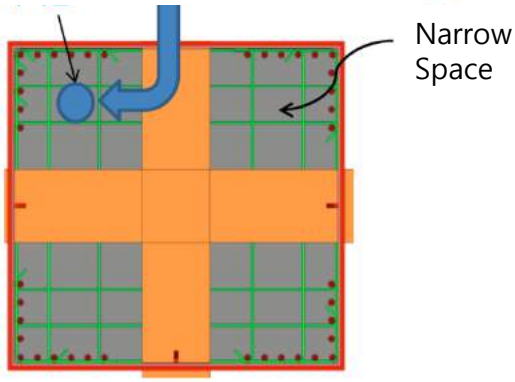
Advantages of PSRC

Product description	Advantages	
	Advantages over RC	Advantages over SRC
Share all the advantages of PRC	• Ensure quality and reduce construction period by prefabricating all members • Self-standing during construction	• Cut back more than 20% of construction cost
Distribute structural steel to the most outer part of column	• Higher allowable load during construction compare to PRC • Ease in securing consistency in thickness of covering concrete during form installation	• Excellent flexural strength than SRC, where structural steel is centered at the core of column → Possible to reduce the volume and cross sectional area of steel frame
Apply "ㄱ"-shape angle to the edge of column section	• Excellent self-standing and erection than PRC → Ease in securing erection of mini column of which width of cross section of less than 700mm • Easy bolt attachment to every joint • Advantageous to apply modular design, where multiple number of mini columns are placed in parallel → Effective for forming mega column	
Secure enough room at the center of column section	• Minimize the penetration of concrete hose by complementary re-bar belt	• No web interference of structural steel during concrete pouring → Minimize side pressure

Excellent workability in concrete pouring
→ enhance quality and reduce construction period

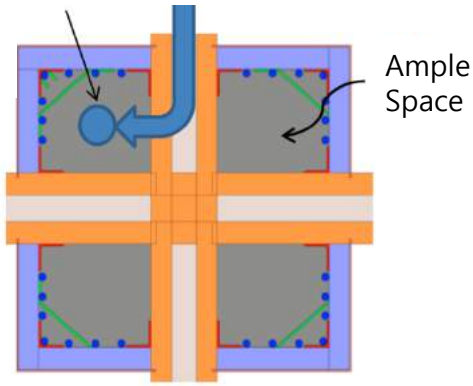
- Comparison with RC

Pouring hose is prone to be interfered



RC

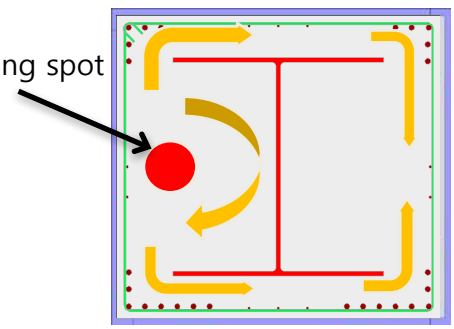
No interference



PSRC

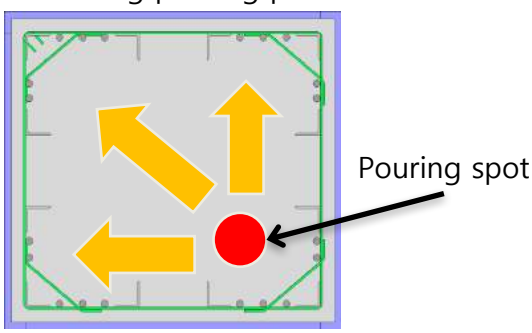
- Comparison with SRC

Structural steel webs interfere concrete flow and generate excessive side pressure during pouring process.



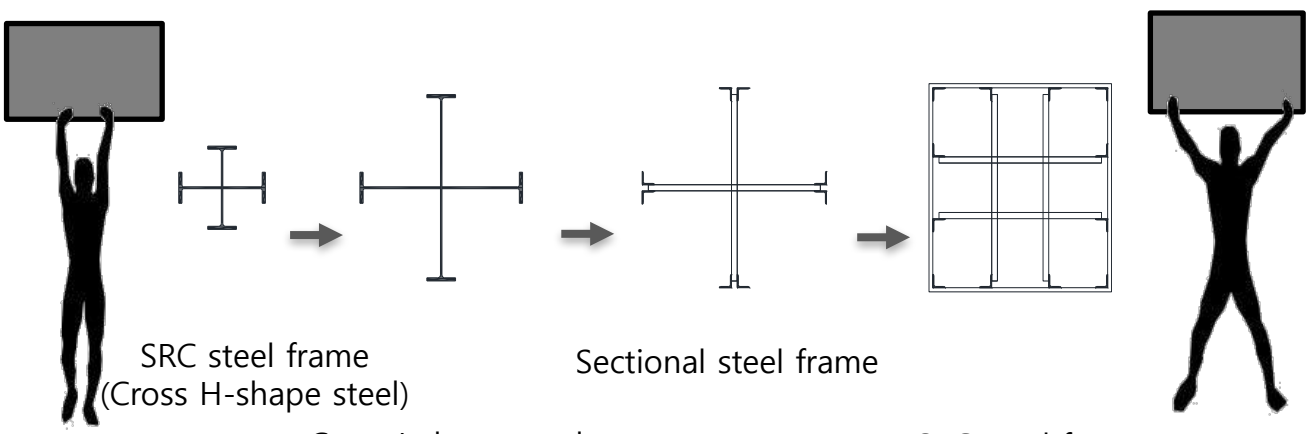
SRC

No large webs → No significant interference, therefore no excessive side pressure during pouring process



PSRC

Optimal Distribution of steel material
→ Minimize the amount of steel



SRC steel frame
(Cross H-shape steel)

Cross I-shape steel

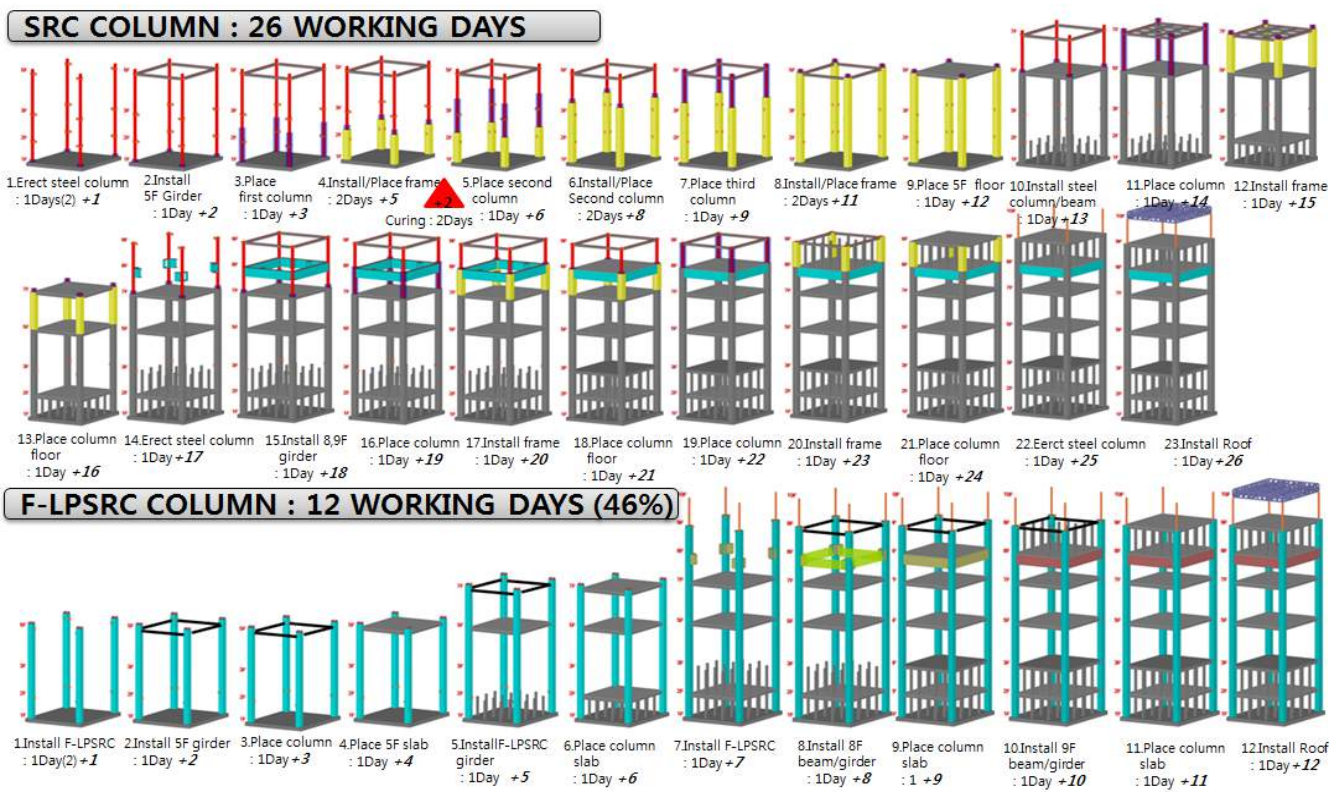
Sectional steel frame

PSRC steel frame

Application of PSRC mega column

- Factory project: 2.1m in width of column; 7 to 18m in height; 6 to 13t in weight
- Over 800 PSRC mega columns

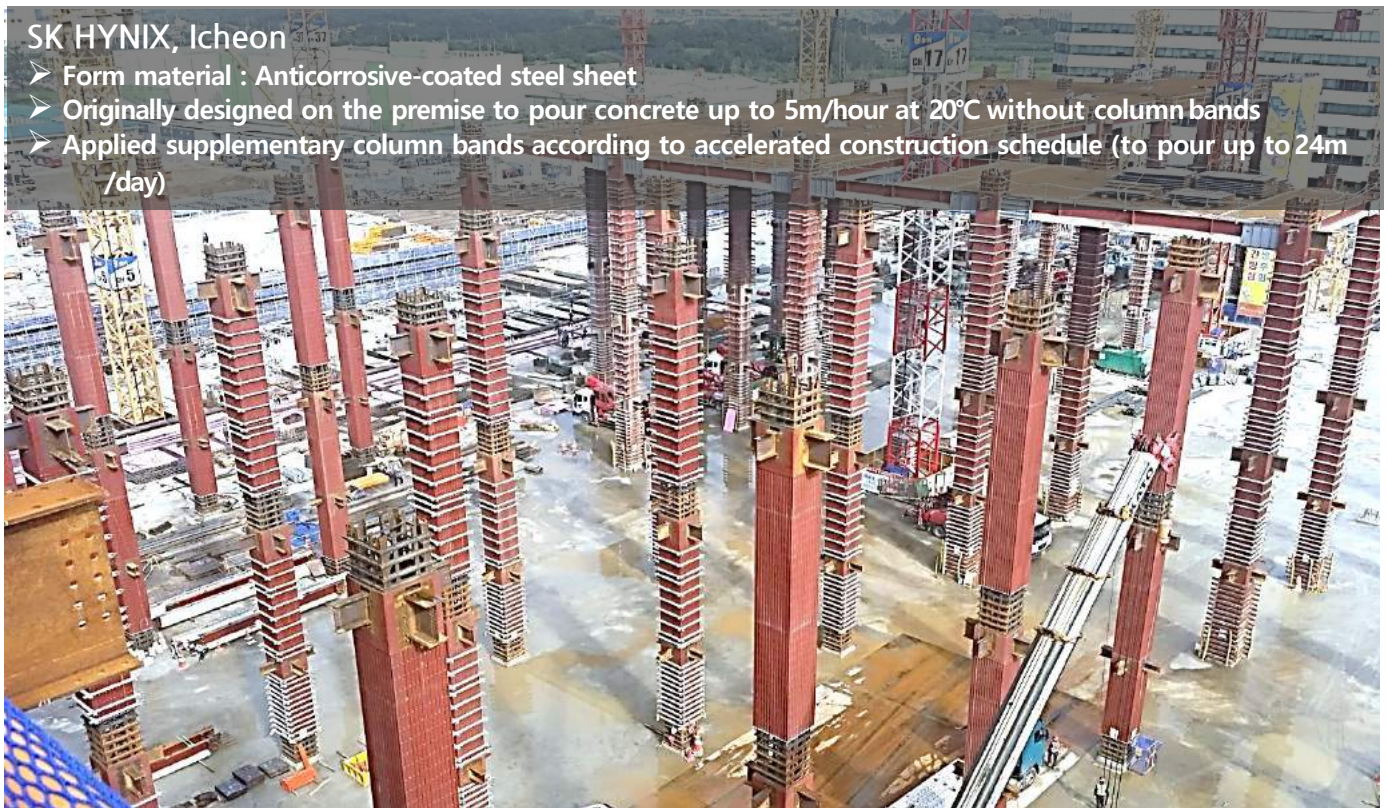
Form PSRC reduces construction period significantly



Form PSRC Construction case

- PSRC integrated with prefabricated permanent form which is made of cold-formed thin(1.6T) steel sheet
- Eliminated on-site formwork and lateral support

→ Safer and cleaner site environment in reduced construction period



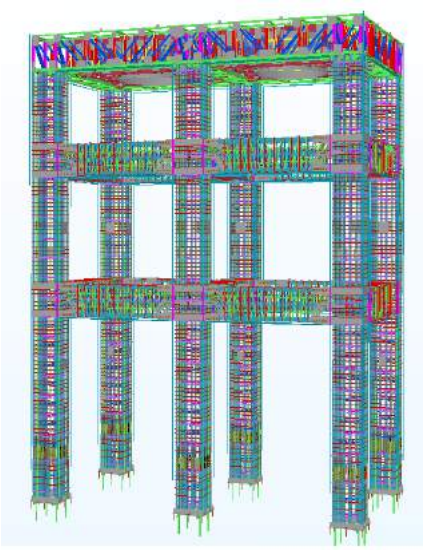
4. PSRC

Form PSRC Construction case

Oil Refinery, Seosan

- Concrete mount for oil reactor
- Height 24m, Slab depth 2m
- Shortened construction period by 50% (compared with generic R/C method)

- Good example of Integrated E-P-C total service
- Applied BIM on all E-P-C process, from proposal to construction



SCI Journal Articles

- Cyclic Loading Test for Concrete-Filled U-Shaped Steel Beam-RC Column Connections *(Engineering Structures, December 2011)*
- Cyclic Loading Test for Beam-Column Connection with Prefabricated Re-Bar Details *(ACI Structural Journal, May 2013)*
- Flexural Test for Steel-Concrete Composite Members Using Prefabricated Steel Angles *(ASCE journal of Structural Engineering, May-June 2013)*
- Cyclic Loading Test for Beam-Column Connections of Concrete-Filled U-Shaped Steel Beams and Concrete-Encased Steel Angle Columns *(ASCE journal of Structural Engineering, February 2015)*

Domestic Journals

- Earthquake Resistance of Prefabricated Reinforced Concrete Beam-Column Connection *(Architectural Institute of Korea, October 2011)*
- Seismic Resistance of Concrete-filled U-shaped Steel Beam-to-RC Column Connections *(Korea Society of Steel Construction, February 2011)*
- Seismic Performance Test of Concrete-filled U-shaped Steel Beam-to-Prefabricated Column Connections *(Architectural Institute of Korea, April 2012)*
- Compression Test for Prefabricated Composite Columns Using High-Strength Steel Angles *(Korea Society of Steel Construction, August 2012)*
- Flexural Test for Prefabricated Composite Columns Using Steel Angle and Reinforcing Bar *(Korea Society of Steel Construction, October 2012)*
- Cyclic Loading Tests for Prefabricated Composite Columns Using Steel Angle and Reinforcing Bar *(Korea Society of Steel Construction, December 2013)*
- Construction Application of a Newly Developed Form-Latticed Prefabricated Steel Reinforced Concrete Column *(Korea Institute of Building Construction, October 2014)*
- Method of Integrity Form-Latticed Prefabricated Steel Reinforced Concrete Columns (Form-LPSRC) *(Korea Concrete Institute, July 2014)*
- Case of Super Fast Construction Using Composite Structure System *(Korea Concrete Institute, November 2014)*

Awards

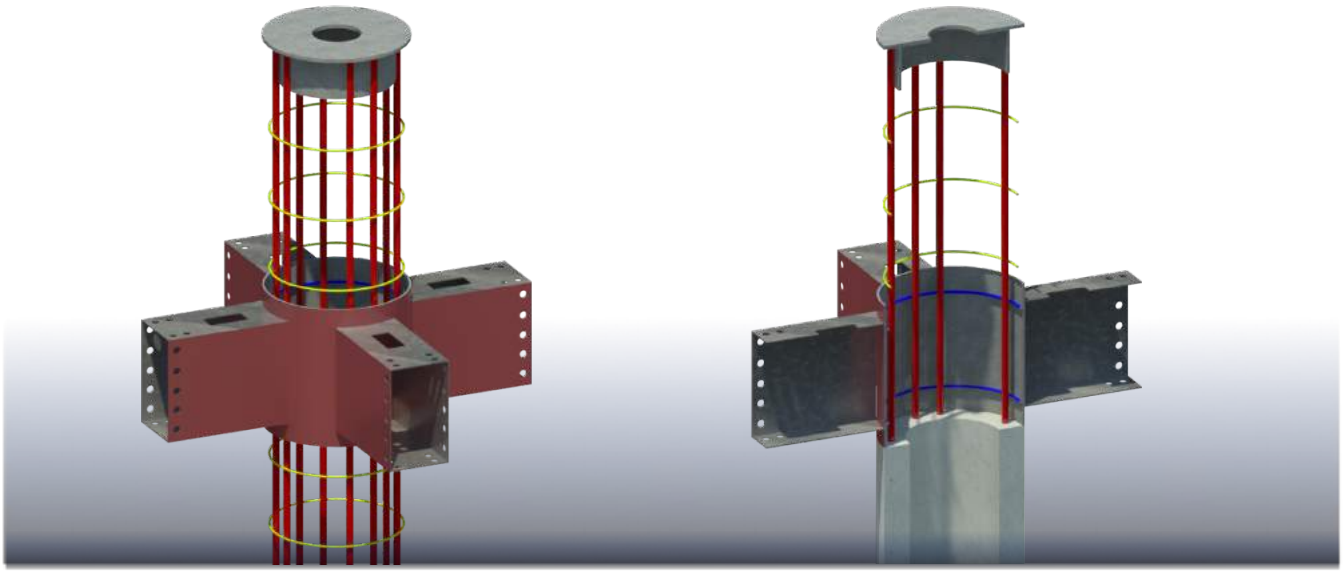
Ministry of Knowledge Economy
(June 2012)

Korea Concrete Institute
(November2012)

5. CRC

Super-high strength pile column

- CRC: Centrifugal Reinforced Concrete
- Super-high strength pile column using high strength re-bar cages and centrifugal concrete
- High strength centrifugal concrete pile (≥80MPa)
- Utilize large-diameter high-strength re-bar (PRC)
- High quality by factory manufacturing
- Enhanced axial force → buckling-resistant



CRC manufacturing facility: SEN CORETECH and IS Dongseo

- Re-bar cages: SEN CORETECH
- Centrifugal concrete pile: IS Dongseo (No. 1 PHC pile supplier of Korea)

Overview of CRC construction

- "O" Church, Gyeonggi-do

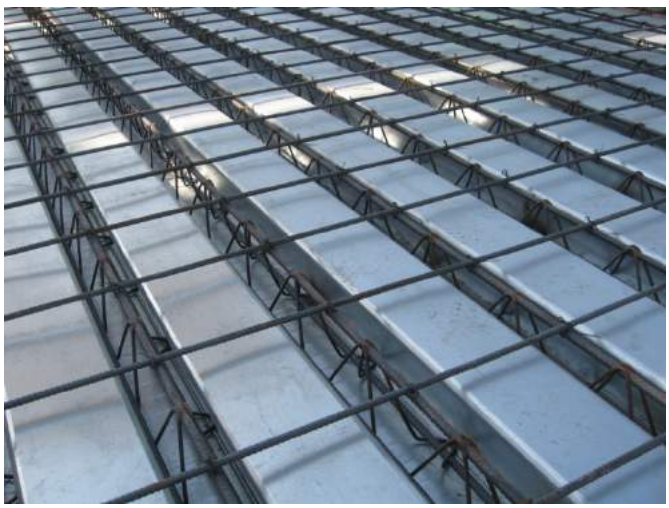

- "I" High-rise factory building, Seoul




6. Omega Deck

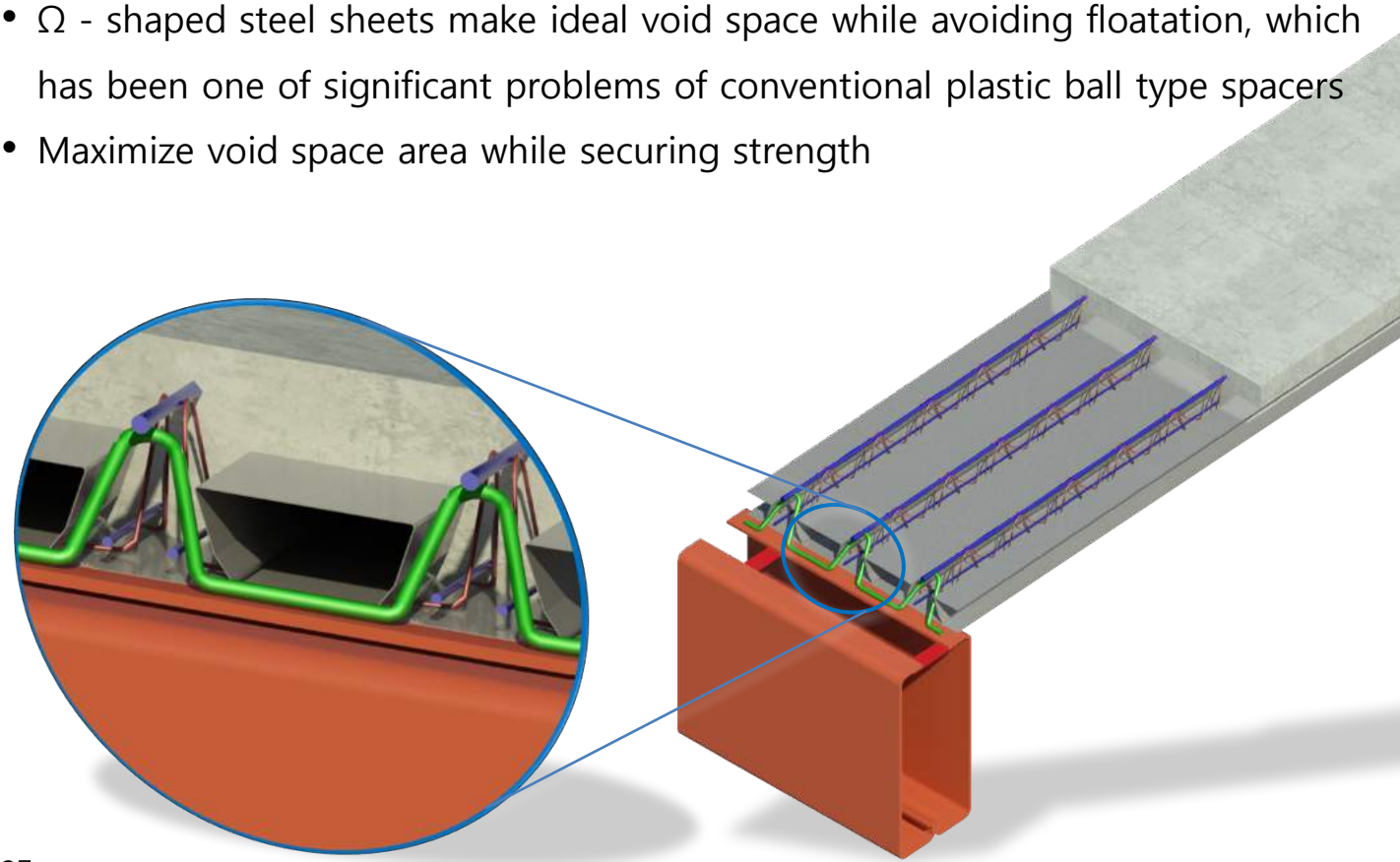
Revolution of voided slab, Omega Deck

- Self-weight reduction by "Omega-section" void
- Korean patent no. 2009-0064359 pending
  - "Manufacturing Method of Light Weight Truss Deck"
- "Fire-proofing Performance Verification"
  - Ministry of Construction and Transportation (2009, 09-864 ; 2 hrs fire proof)



Advantage of Omega Deck

- Ω - shaped steel sheets make ideal void space while avoiding floatation, which has been one of significant problems of conventional plastic ball type spacers
- Maximize void space area while securing strength



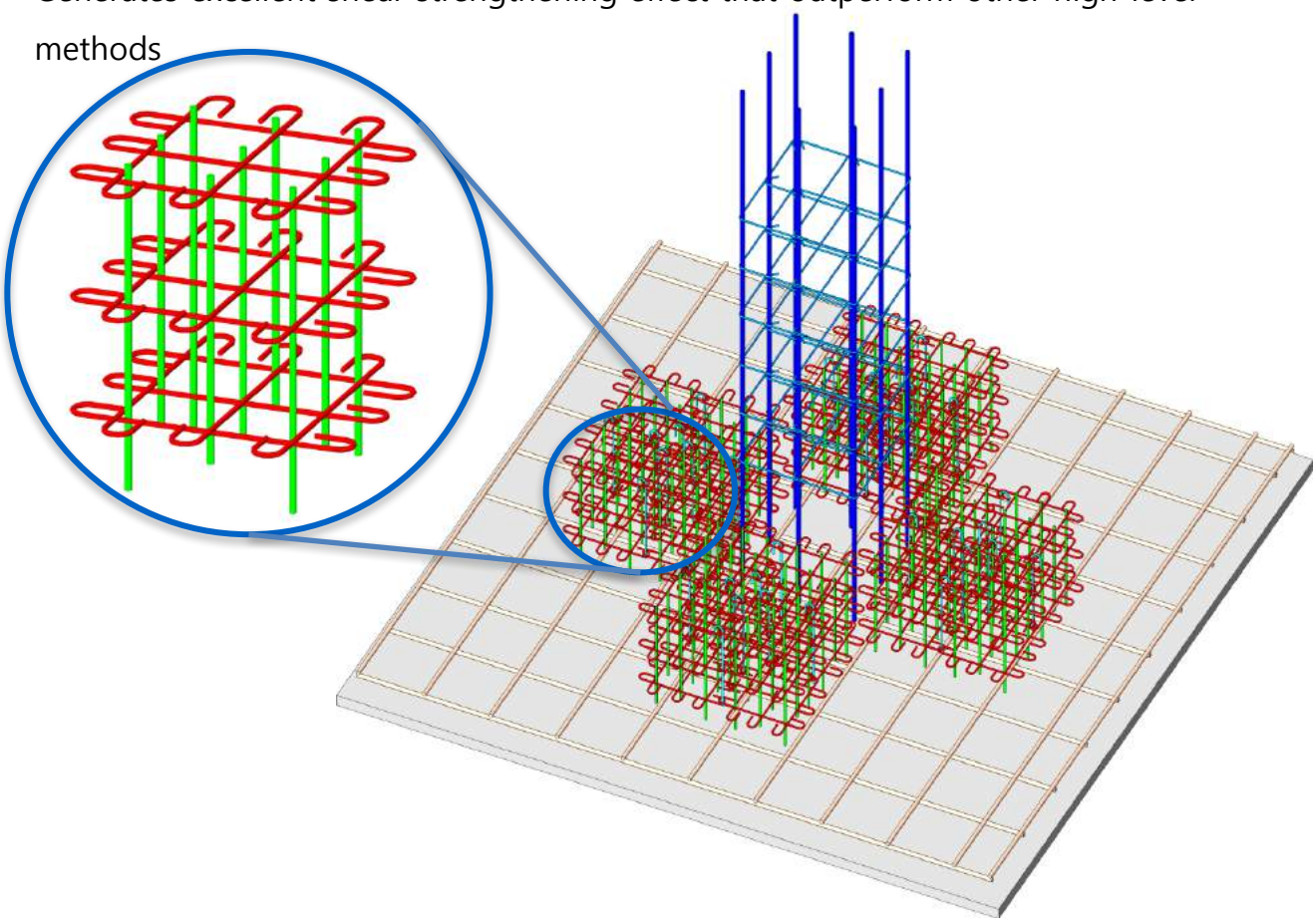
7. SSG

Simple and effective shear strengthening for mat foundation and flat slab

- Patent-pending construction method designed for shear strengthening effect by placing SSG cube, welded square column-shape re-bar block unit of 30cm on a side, around column and bearing beam during concrete placement on mat foundation and flat plate

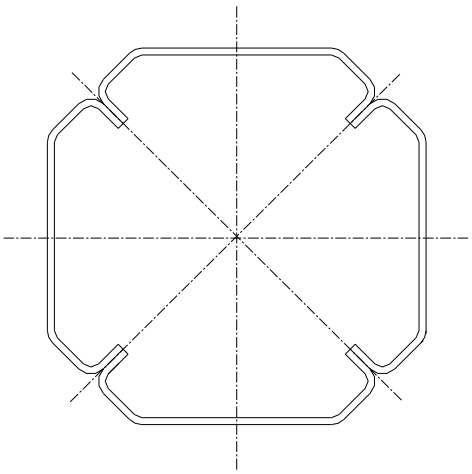
Advantages of SSG shear strengthening method

- Enhances construction quality and shortened construction period by easy and simple field processing
- Reduces construction cost by cutting foundation volume to the half
- Simplifies shear strengthening design by allowing flexibility in extension and multi-dimensional arrangement of standardized SSG cube
- SEN Engineering Group produces SSG cubes through a welding method under stringent quality control and ensures stiffness and quality equivalent to CRC prefabricated re-bar net and PRC/PSRC.
- Generates excellent shear strengthening effect that outperform other high-level methods

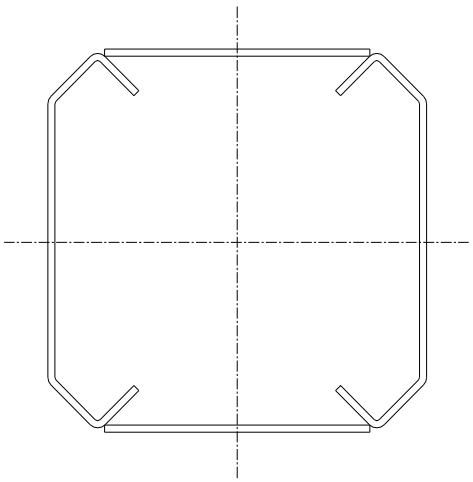


8. OCFT(Octagonal CFT) Column

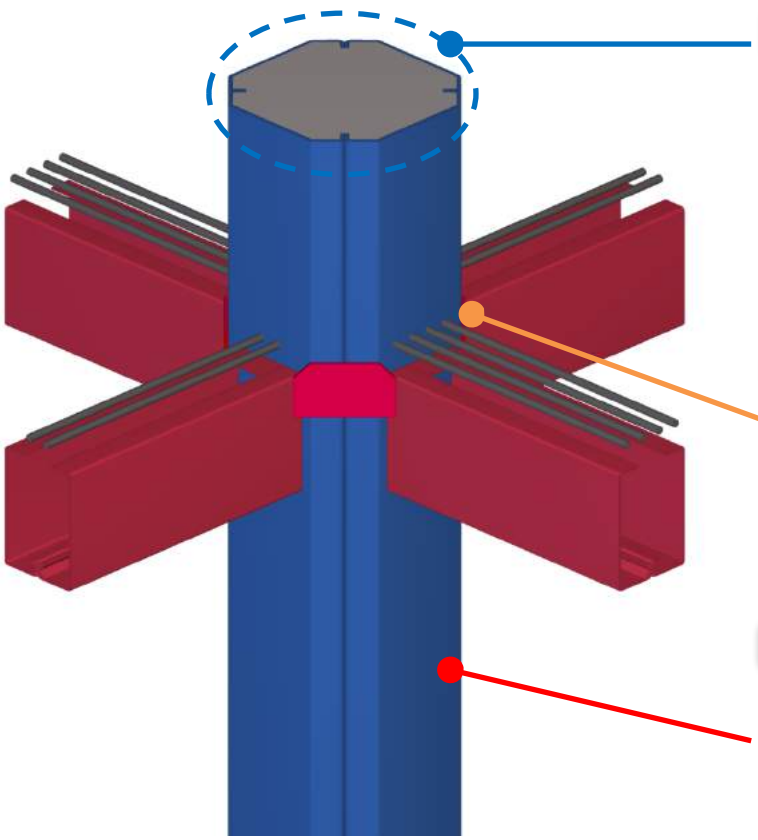
New octagonal CFT only takes merits of conventional Square CFT and Round CFT



Q-TYPE
(Quadrant axis type)



T-TYPE
(Twin Axis type)



Octagonal Column Section

- Increase section capacity
- Relax limitation of width-to-thickness ratio
- Decrease bulging
- Enhanced confinement effect
- Also suitable as pile

Beam to Column Connection

- Easier to connect
- Smoother stress transfer
- Easy to attach exterior diaphragm

Unit Steel Sheet

- Produce by bending method : more customizable than cold forming
- Two-line welding : faster production
- Capable of applying different thickness for strong axis and weak axis
- Also work as permanent form

OCFT Manufacturing

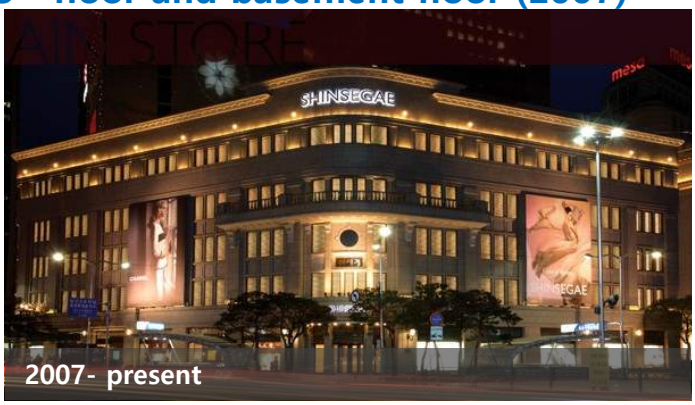
OCFT Application

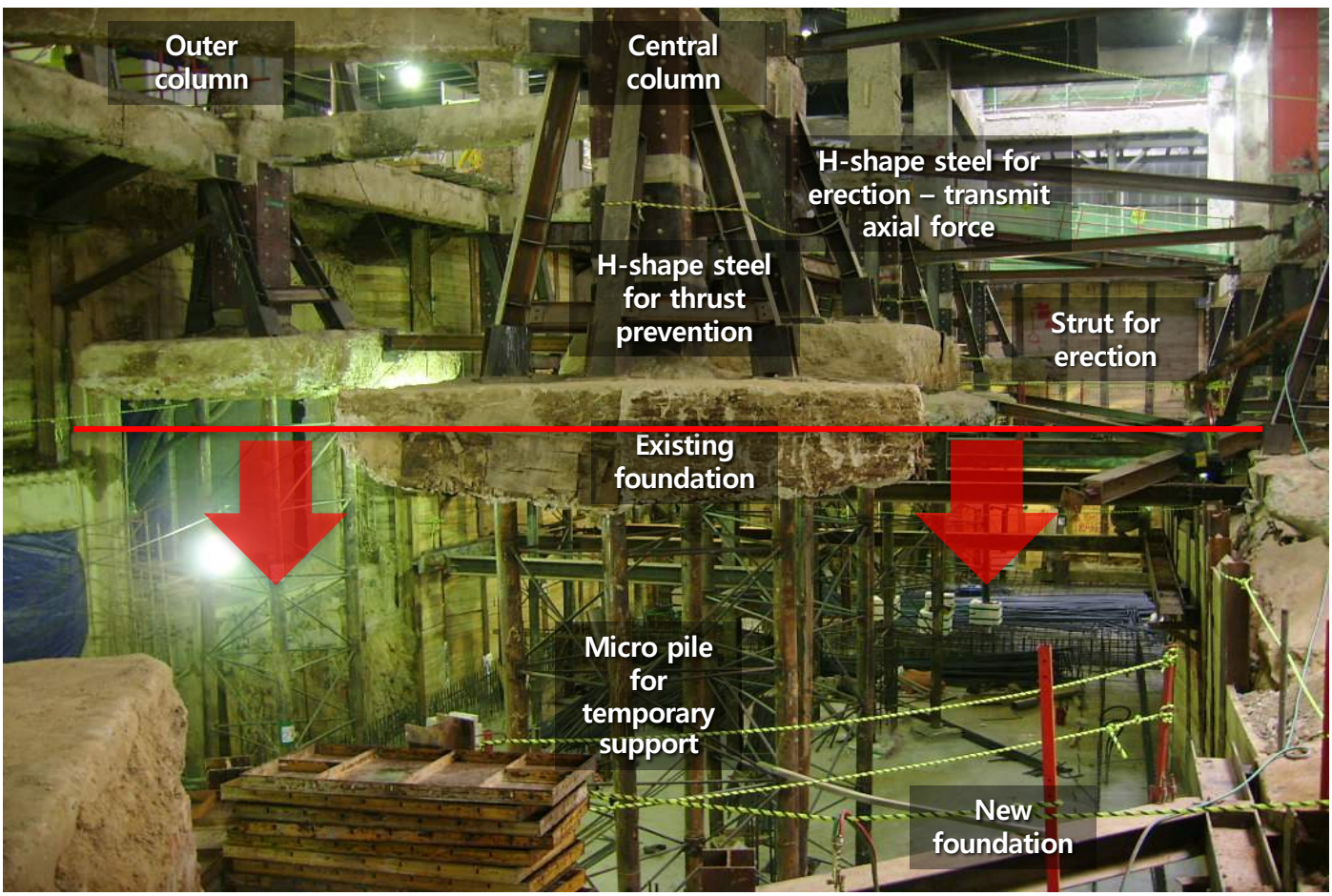
9. Renovation and Remodeling

Remodeling for the new era of construction market

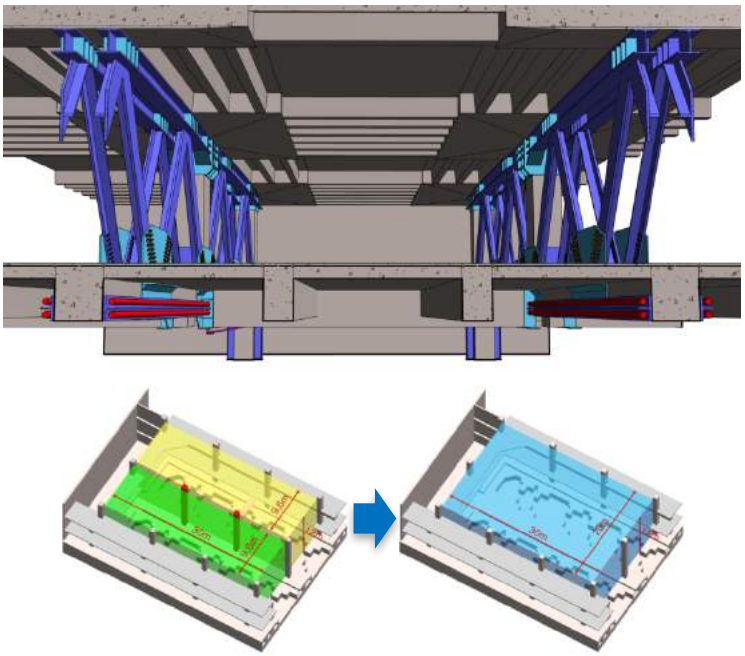
- 60+ out of our 100+ patents are related to remodeling and retrofitting.
- Our patented "Floating Structure Method" enables adding basement floors while keeping the existing structure over the ground untouched, and in many cases, the existing building may be even fully serviceable during the construction period.
- Our Floating Structure Method portfolio includes Korea's major landmarks, such as historic Seoul City Hall and Head Store of Shinsegae Department Store, both of which are national cultural properties built in the Japanese colonial period back in 1930s.
- We also have the best record in Korea in wire tensioning method utilizing high-tensile steel wire and the patented special fixing blocks.

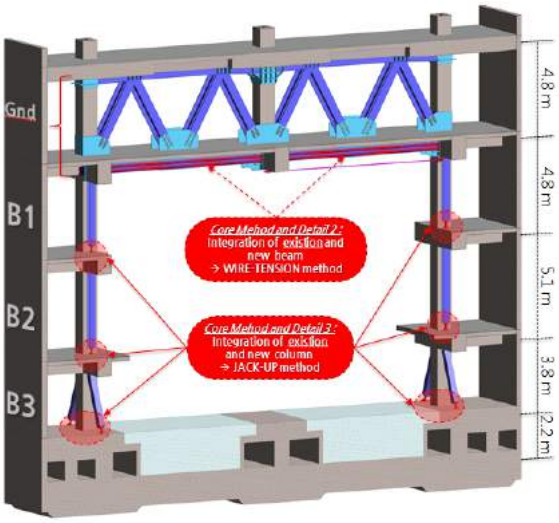
Shinsegae Department Store – added 5th floor and basement floor (2007)



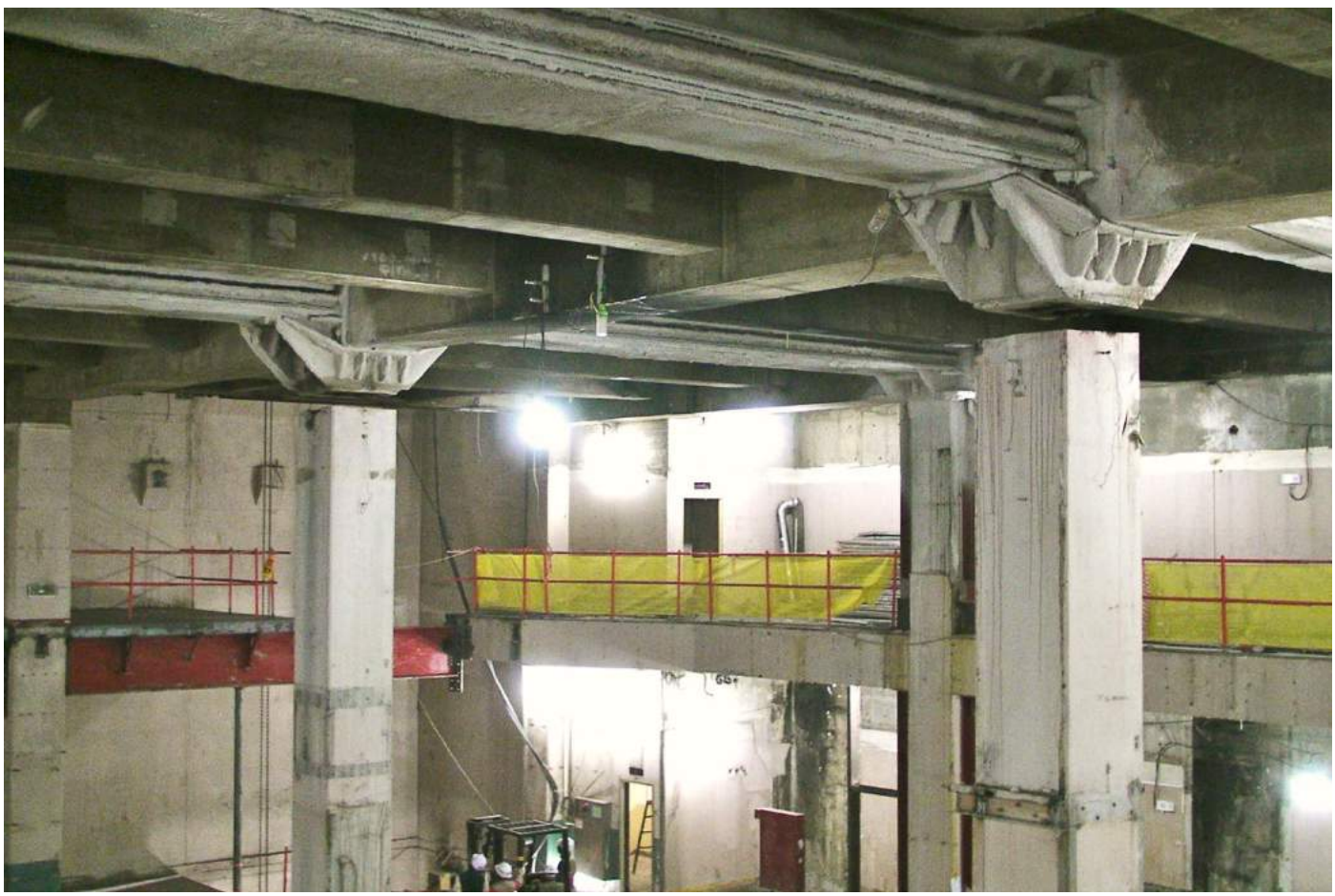


Joongang Daily :Created large underground space for broadcasting studio (2011)





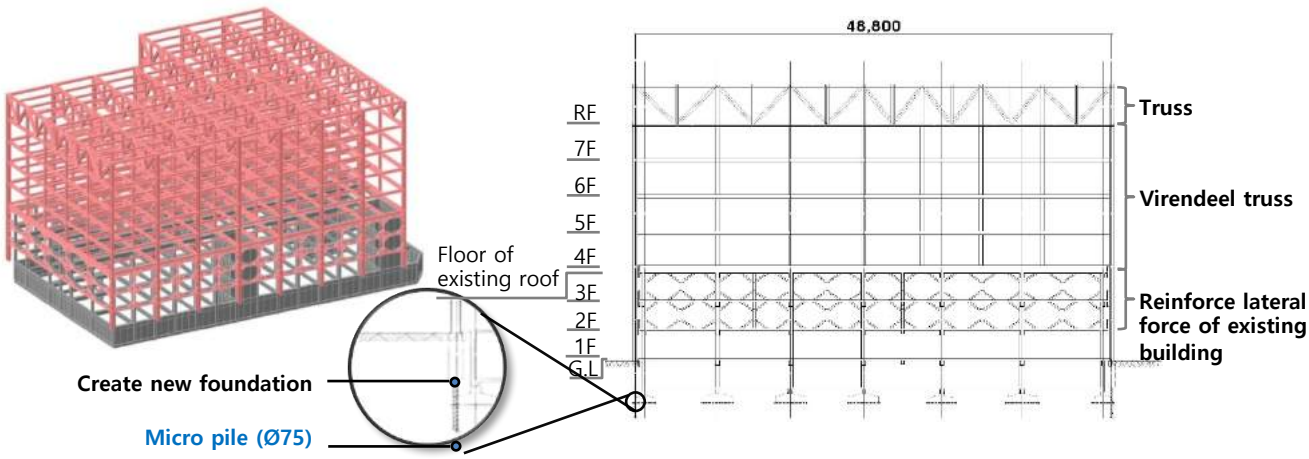
- Secured a non-columned large space of 180 square meters (20m(w) x 30m(l) x 12m(h)) by eliminating 2 columns (900t of axial force each) which had been bearing the weight of 9 floors(B1 ~ 8F).



9. Renovation and Remodeling

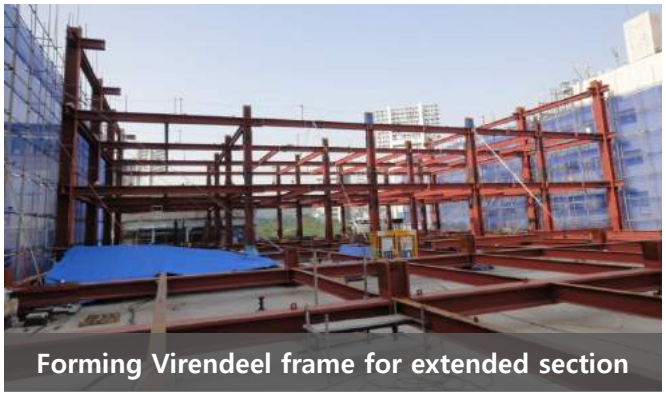
Jeil Pyeonghwa Market – vertical extension of extra 4 floors using truss (2014)

- **Location**: Sindang-dong, Jung-gu, Seoul
- **Use**: sales and business facility
- **Size**: B1F/ 3F (4 floors of vertical extension)



Waffle-shaped lateral force system

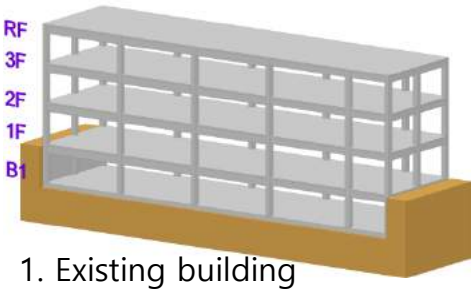
Lifting main girder (47.25m)



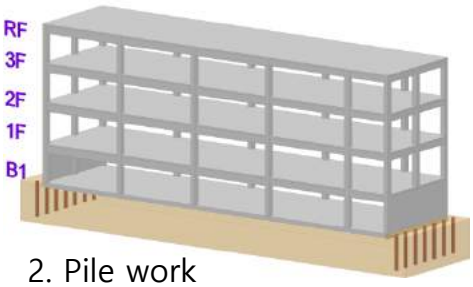
Forming Virendeel frame for extended section

Roof truss for top floor

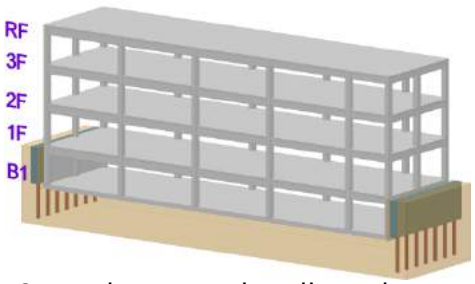
Jeil Pyeonghwa Market - Construction order



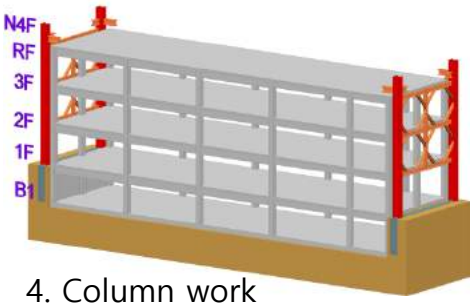
1. Existing building



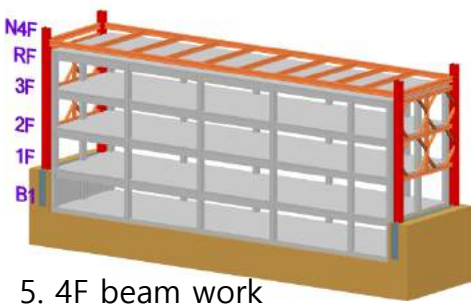
2. Pile work



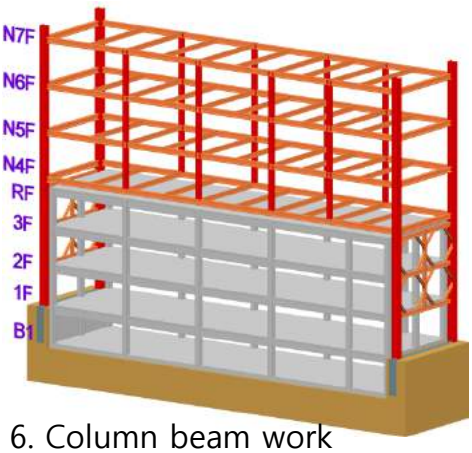
3. Underground wall work



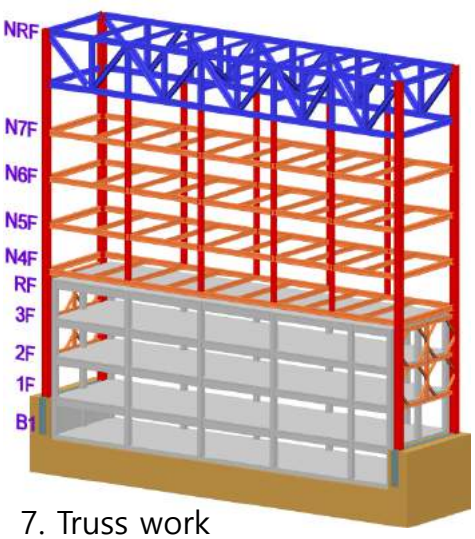
4. Column work



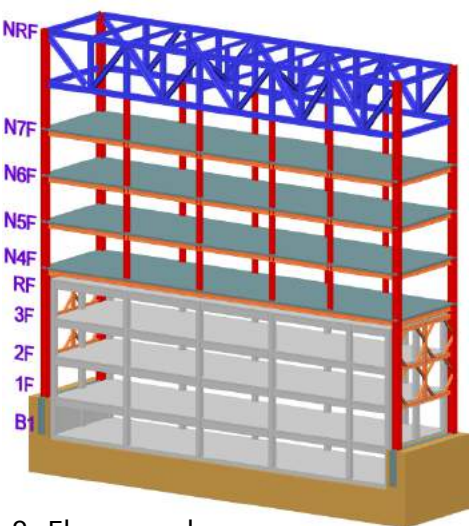
5. 4F beam work



6. Column beam work



7. Truss work



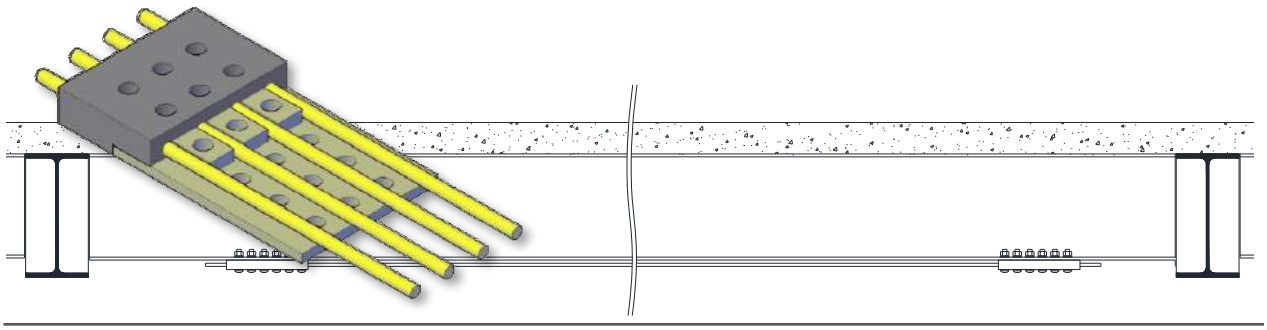
8. Floor work

Wire tensioning solution

- SEN Engineering Group has leading record in Korea in providing patented products and engineering service related with wire tensioning method.
- We have developed and sold various patented materials related with wire tensioning.

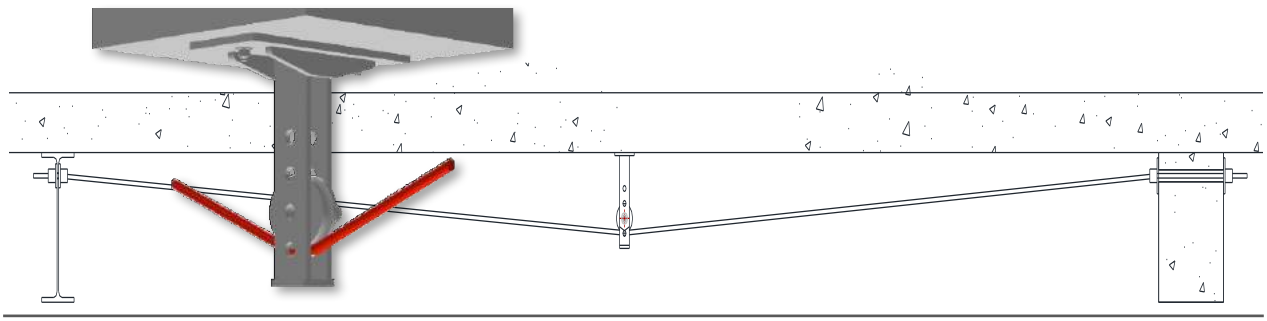
Multi-hole fixture combined with different steel materials

- Fixture for 1 through 4 steel wires, a patented bestseller successfully applied to numerous construction sites



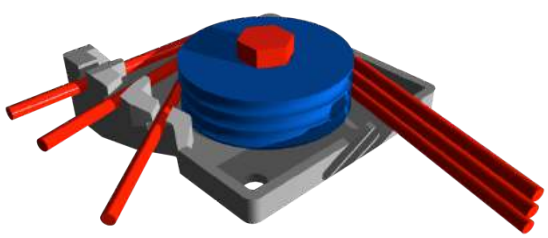
Pair slab reinforcement

- Precisely adjust the restoration volume where deflection occurs (patent pending)
- Cost-effective and easier to apply than other competing products



“The Snail” wire anchor block

- Patented wire anchor which changes the direction of steel wires
- Designed for placing at the narrow space of column-beam joint
- Suitable for exposed environment thanks to the unique design and optional painting / plating is available on request



Advantages of wire tensioning

- Enhance strength and restore deflection of the member of framework by giving up-lifting force using steel wire or jacking up
- Wire tensioning is one of few restoration methods that "restore" the already deformed member of framework to its original form without removing upper load.
- Superior result than attaching steel plate or carbon fiber

Restored steel beam of L department store (2011)

Restored RC beam
of L department store (2008)

Restored steel beam
of J broadcasting studio (2011)

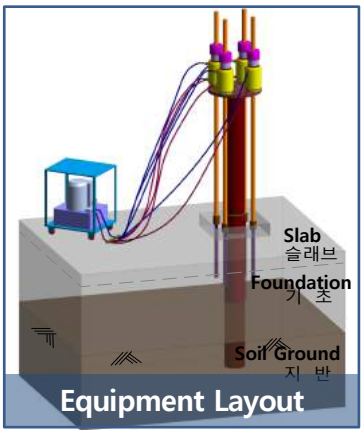
Restored RC beam of J broadcasting studio (2011)

Restored RC beam and slab of head office of K bank: wire tensioning + steel pipe bracket restoration method(2008)

10. PPP (Pressure Penetrating Pipe) Pile

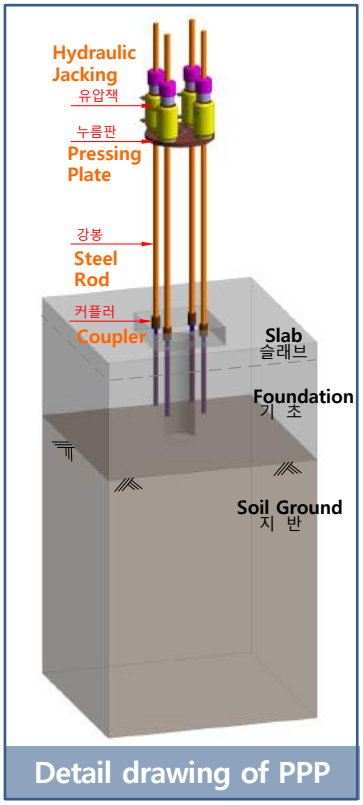
Pressure Penetrating Pipe Pile (PPP)

- PPP Pile method allows press fitting of steel pipe pile using our patented hydraulic jack.
- It generates no noise or vibration and can be applied in very cramped space as narrow as 0.6m(L)×0.6m(W)×2.0m(D).
- Ground bearing power is measured directly while pressing the pile.



Equipment Layout


Hydraulic jack and pump

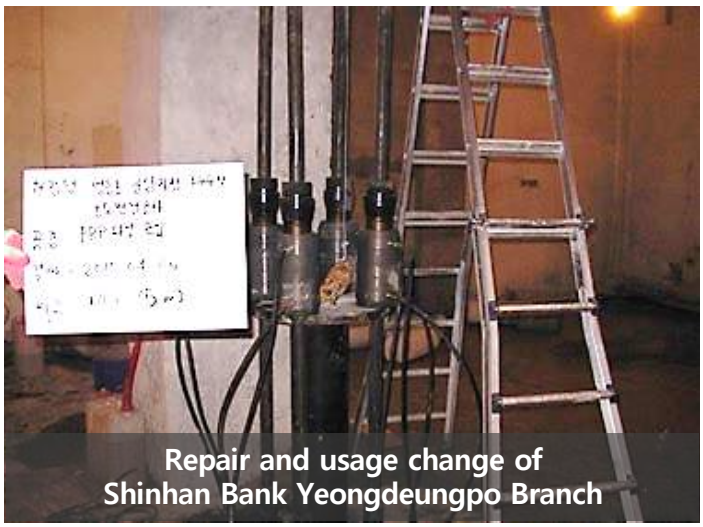


Detail drawing of PPP

Advantages of PPP Pile system

Product description	Advantages
Possibility of entry of equipment into a limited space	Assembly, disassembly and transportation of equipment can be made by manpower.
Confirmation of bearing power during construction	Press fitting load is directly measured from the pump pressure gauge
Assurance of profitability by adjustment of optimal length of pipe pile and prevention of hallow wall	Adjustment of length of pipe pile for upper load and separate casing of steel pipe are not needed.
Prevention of public complaints with non-noise and non-vibration	Press fitting construction generates no noise or vibration.
Maintenance of clean working environment	Non-displacement method generates no exhaust gas or slime.
Easy load test	Press fitting equipment works as load testing device.

Application examples of PPP Pile



Repair and usage change of
Shinhan Bank Yeongdeungpo Branch

Extension and remodeling of
Woorideul Church, Bundang

Extension of Busan Finance Center

Extension of Olympic Coliseum Fitness Center,
Nonhyeon-dong

Remodeling of Ssang Yong Town Office

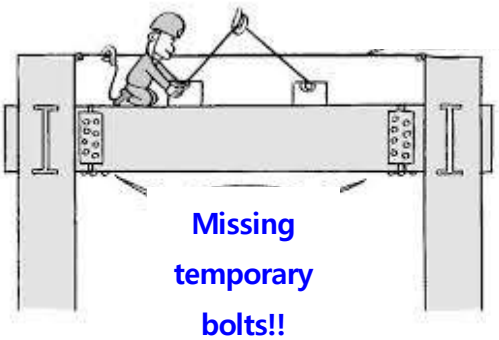
◆ Design and suggestion cases

1. Vibration reinforcement for Factory III of Dongseo Machine and Tools, Dangjin
2. Butress reinforcement for Myongji University
3. Extension for Jeil Pyeonghwa Market
4. 6 block extension for TFT-LDC of LG Electronics
5. Extension for joint market for Eumseong livestock products organized by National Agri-cultural Cooperative Federation
6. Extension for Samsung Heavy Industries, China

11. SS Splice

Purpose of Development

- Safe erection of structural steel



→ Collapse by defect in the bolt connection

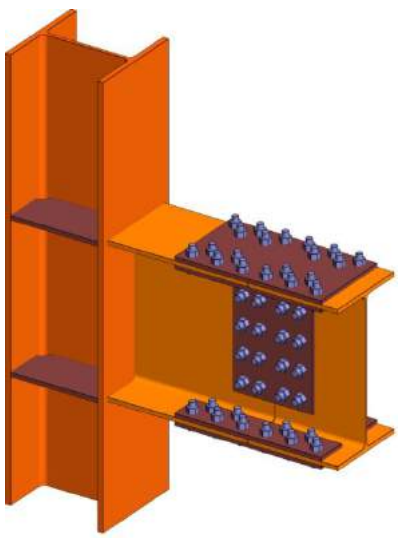
→ Collapse accident of concrete slab casting

Driving safety in installation of structural steel beam

Concept of SS Splice

As Is

Typical Steel Connection



Gusset Plate

+

High strength bolt

Friction type bolted joint

To reduce the construction time

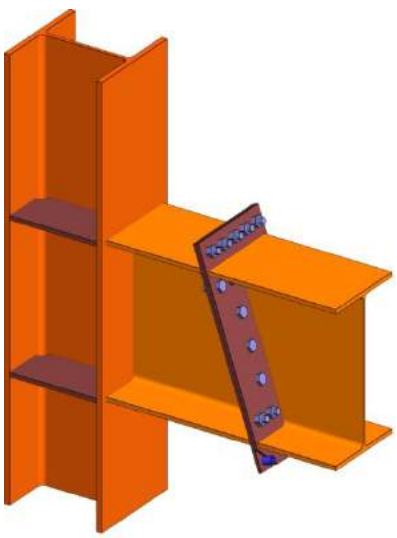
To improve workplace safety

To achieve competitiveness

To Be

Modularized

Steel Connection



Extended End Plate

+

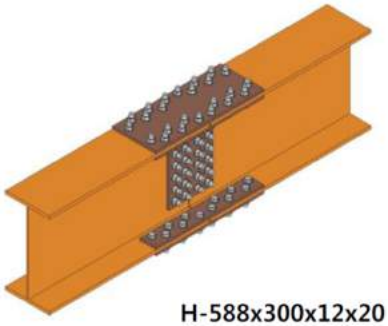
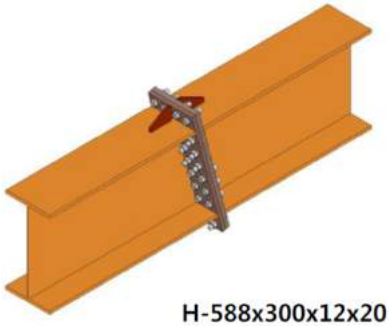
High strength bolt

Tension type bolted joint

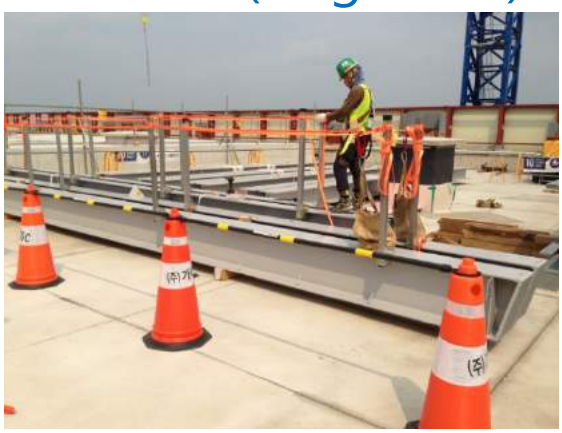
Advantages

1) Integrated welding system → Prevent plate drop accident

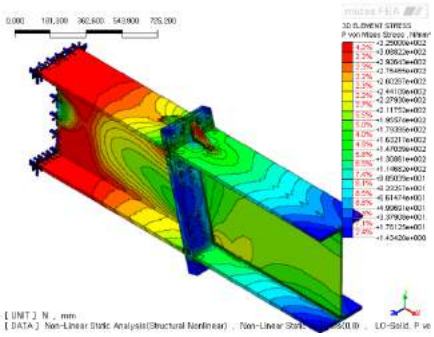
2) No. of bolts 60% ↓ → Prevent bolt drop accident

	As Is – Typical steel joint	To Be – Modularized steel joint
Joint type	 H-588x300x12x20	 H-588x300x12x20
No. of Plates	8 EA	2 EA (Field Installation 0 EA)
No. of Bolts	72 EA (100%)	28 EA (39%)
Install. Time	23 minutes	6 minutes

Application : SAMSUNG ELECTRONICS (Aug 2016)

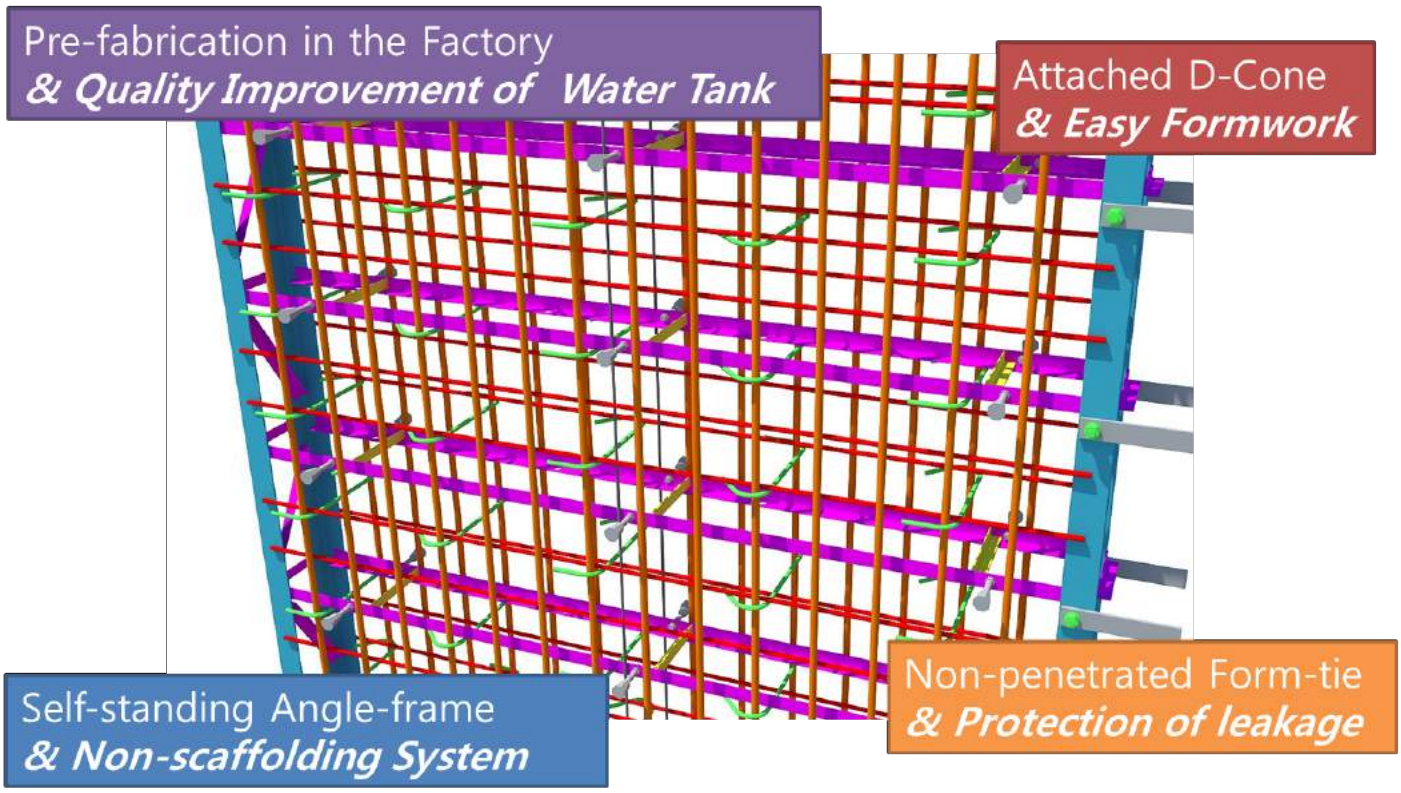


Certificate from KSEA (2015)

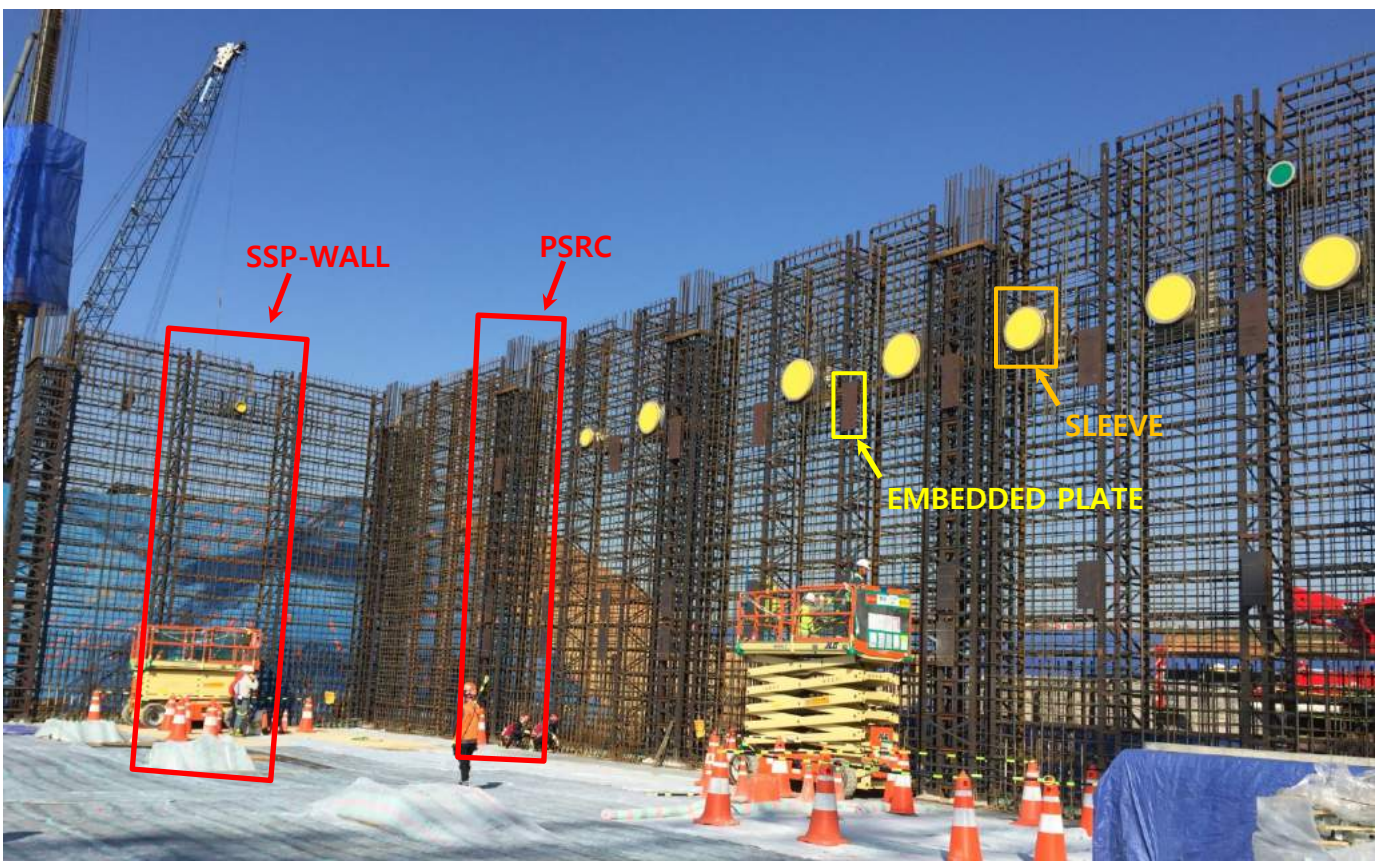


12. SSP Wall

CONCEPT of Development



Application : SAMSUNG ELECTRONICS (Aug 2016)



No need of Temporary scaffolding

As Is
Conventional RC Wall

To Be
SSP Wall

Minimize Field Formwork : Factory Prefabrication

Modularized unit : 3m x 13m (variable)

SEN ENGINEERING GROUP
SEN STRUCTURAL ENGINEERS CO., LTD.
SENCORETECH INC.
SENVEX CO., LTD.

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FACTORY1 T 82 43 532 0631
F 82 43 532 0633
A 391-10, JANGGWAN-RI, JINCHEON-EUP, JINCHEON-GUN
CHUNGCHEONGBUK-DO, 365-802, KOREA