CSSE NEWS

• NEWS

Contract with Jeju Combined Cycle Power Plant GE(GENERAL ELECTRIC COMPANY)

<KOMIPO -GE, Jeju LNG Combined Cycle Power Plant main equipment supply contract>
The first liquefied natural gas(LNG) plant in the Jeju area will be built.
Jeju LNG combined cycle power plant is planed to be built at Samyang-dong in Jeju, on the idle land owned by Jeju Thermal Power Plant, and the project will cost a total of 260.9 billion won. The development scale is to be 240MW, expected to contribute significantly to meet the soaring demand for electricity in Jeju. Korea Midland Power(KOMIPO) is to complete a test run until the end of June 2018, and plans to enter full-scale commercial operation afterwards.
CSSE is appointed to do the structural design of Jeju Combined Cycle Power Plant.

Win for re-establishment development project, "The house of soldiers" (Turn-Key)

Location : Yongsan, Seoul (total gross area; 40,755.02m²)
Usage : Accommodation, Business and Cultural Facilities
(B7F / 30F)
The house of soldiers, a 30-storey and 142.6m-height building, will be re-created as a new landmark in Yongsan.
The lower floors include retails, convention and wedding hall, and on the upper floors, hotel and business facilities are planning. CSSE carries out the building structure design for this project.

• Oversea Market Development Activity

CSSE Qatar Receive an order for Small Project and Bid 2022 World Cup Stadium Project

2016 GE(General Electric Company) cooperative firm registration completed

2016 Chosen Oversea Market Devlopment Activity "Ministry of Land, Infrastructure and Transport"

2016 Chosen Export Support Program "Small and Medium Business Administration"

• Technical Papers

- **Structural health monitoring during construction in Philippine Arena**
  2015 Proceedings of the International Association for Shell and Spatial Structures (IASS)
  Jongsoo Kim, Duckwon Cho, Eungyu Choi, Hyunwook Cho
- **Structural performance evaluation and monitoring during construction in Philippine arena**
  2016 KASS(Korean Association for Spatial Structures) Sysposium-Autumn
  Jongsoo Kim, Duckwon Cho, Hyunwook Cho

• New Employees

Welcome!!

Hyunik Jo

Phung Quang Truong

• Promotion

Structural Design Unit 1 :
Manager Daeha Park,
Assistant Manager Areum Han

Structural Design Unit 2 :
Assistant Manager Haejung Kim

Registered Company of ISO 9001/ISO 14001

Concrete/Customers C
Steel/Satisfaction S
Structural S
Engineers E

News-Record
2016. 09

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String Over 27 Years of Excellence

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WATERFRONT TWIN TOWER IN Lusail (Qatar)
Heesu Lee, Keumjung Song, SungYong Park, Marta Gil Perez

THE GATE PROJECT IN CAIRO (EGYPT)
Heesu Lee, Keumjung Song, Jeongwha Park, Marta Gil Perez

PARADISE CITY PROJECT IN YEONGJONGDO
Hyunhee Ryu, Minsu Kim, Hyeyoung Park, Hyunwook Cho
Daehoon Kim, Jooyeon Lee, Daeha Park, Arum Han

WATERFRONT TWIN TOWER

Heesu Lee, Keumjung Song, Sungyong Park, Marta Gil Perez

■ Work Scope

Figure 1. Waterfront Tower 3D images

The Waterfront Twin Towers, located in Lusail, Qatar, presents an architectural design that follows a high-end luxury demand residence with an iconic shape characterized by a curved façade structure that covers both towers and a central steel sphere which cuts the podium of the building creating a unique space. CSSE has been appointed for the scheme design of the tower steel works which includes the Sphere & Podium and the Façade & Roof structure. This work is currently under develop.

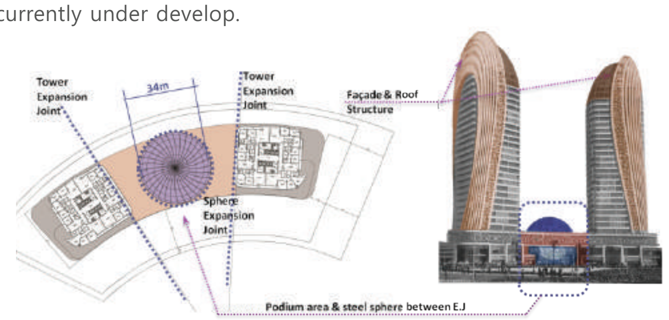


Figure 2. CSSE Work Scope

■ Podium and Sphere Structural Concept

The Podium is composed by 3 floor levels which are intersected by the steel Sphere. The Sphere incorporates ring beams at the 2 and 3 floor levels to connect the floor frame beams and receive the gravity loads of the tributary area around the Sphere. Then, the Sphere node levels are adjusted to match the necessary tension and compression structural rings with the 3F and GF respectively. Since the columns below the Sphere are extended to the B1F, the displacement behavior is driven by the Sphere becoming very flexible. To control this behavior and strengthening the structure, braces are designed at the B1F columns.

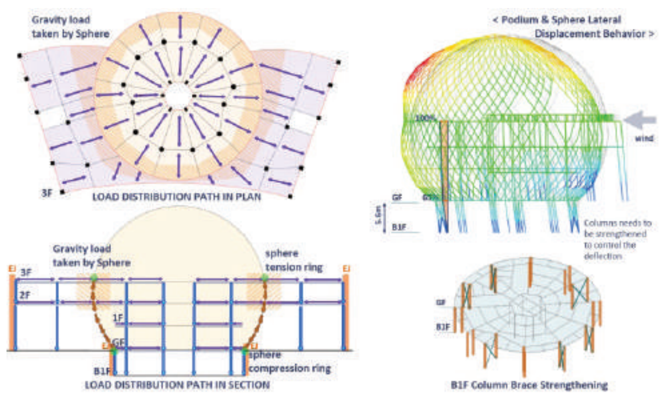


Figure 3. Podium & Sphere Structural Concept and Behaviour

■ Podium Structural System Design

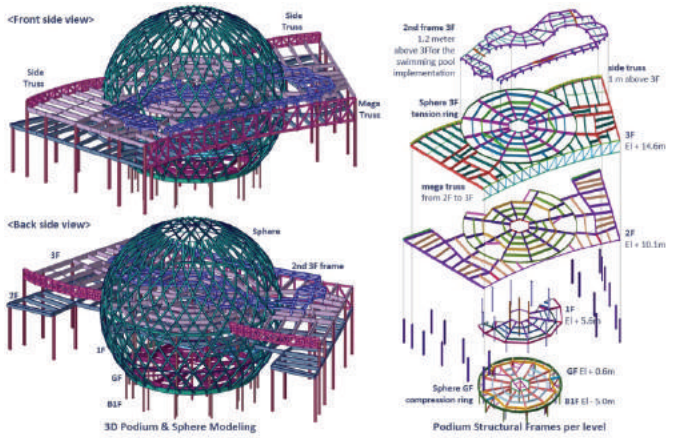


Figure 4. Podium Structural Model and Floor Frames

The Podium frame presents an irregular geometry driven by architectural features as a limited number of columns located in radial axes inside the Sphere and following the RC frame outside the Sphere. The structural concept is developed to achieve the most efficient solution which can satisfy all the architectural requirements. Expansion joints are designed at both sides of the tower and around the Sphere at the at the GF.

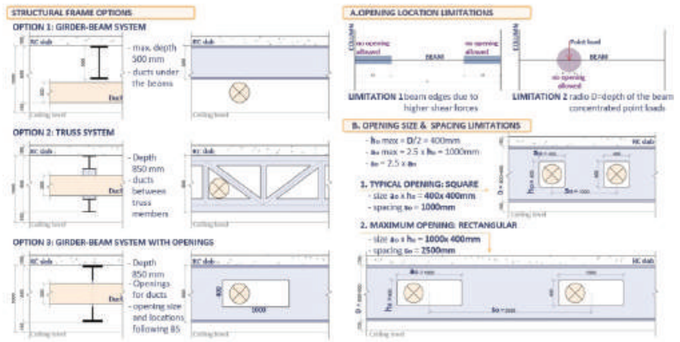


Figure 5. Floor Frame System Study

Different frame options are studied to allow the implementation of MEP elements within the structure, resulting in the use of a girder-beam system with web openings for the MEP ducts. The openings location and size limitations are also deeply studied to optimize the design of the Podium and ensure the safety of the structure.

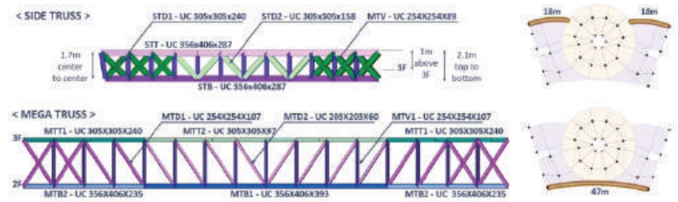


Figure 6. Truss Design and Optimization

For the longest span areas, trusses are designed. At the back side 2 side trusses which stands 1meter over the 3F, and at the front side a Mega Truss which connects the 2nd and 3rd floors. To control the deflection of these areas the section size of the top, bottom and diagonal members of the truss are grouped and optimized.

■ Sphere Structural System

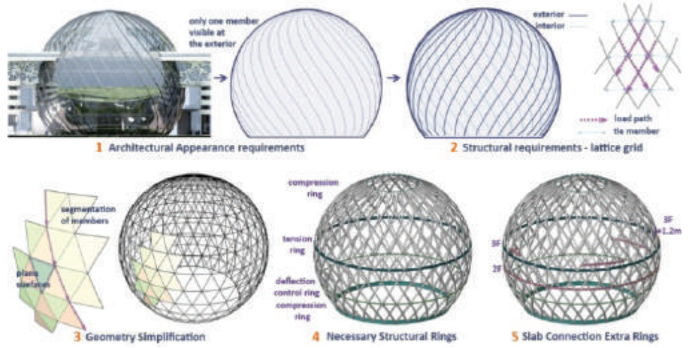


Figure 7. Sphere Structural System Concept

The architectural appearance of the sphere required only one spiral member visible from the outside. However, for structural reasons, two direction spirals needs to be designed creating a lattice diagrid. The minimum necessary structural rings are designed and slab connection rings are placed in the resting locations where Podium slab and sphere intersects. Finally, the implementation of openings is coordinated with the Podium and structural load path of the Sphere.

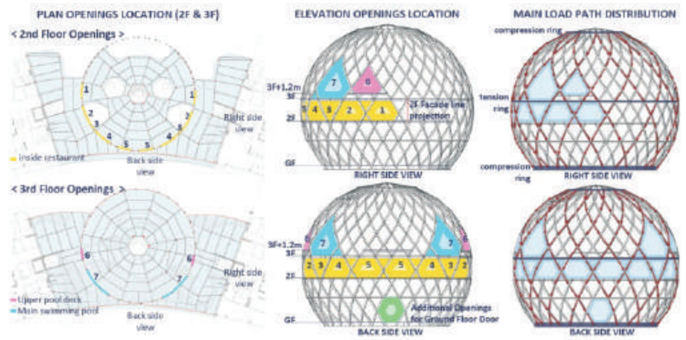


Figure 8. Sphere Openings implementation

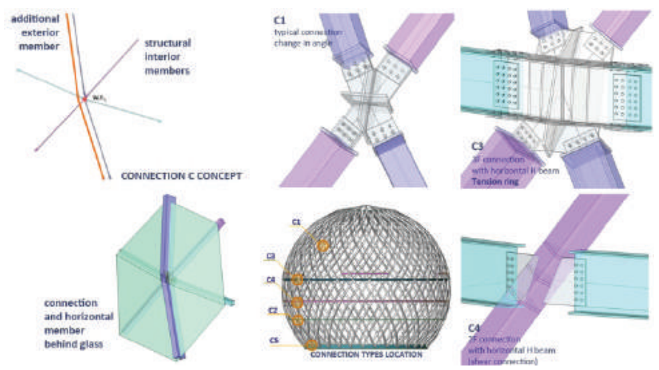


Figure 9. Sphere Connection Detail

With the Sphere connection design, the architectural requirements are achieved by adding an external member at one of the 2 directions spiral members. Figure 9 shows mayor connection concepts for the Sphere with and without horizontal ring. Besides, the GF compression ring connection corresponding with the sphere expansion joint is shown in Figure 10.

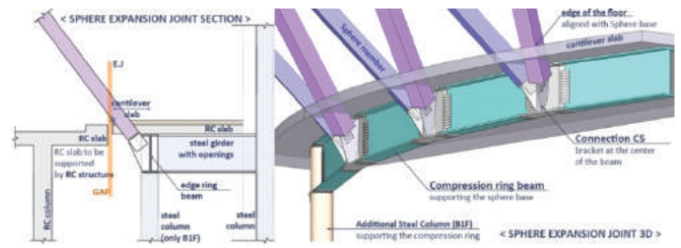


Figure 10. Sphere Expansion Joint Concept

■ Façade & Roof Structure Design

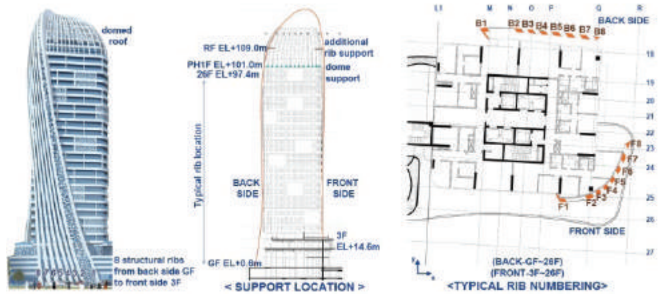


Figure 11. Façade Structure and Support Location

The twin RC towers are covered by an exterior envelope that surrounds the buildings from bottom to top, rotating and giving a more organic appearance. This architectural feature looks like a continuous band composed by 8 ribs connected between them by cladding that wraps the towers in the vertical direction. The structure is connected to the RC slabs at every typical floor level transferring gravity and horizontal loads, while the deformation caused by temperature change will be absorbed by long slot holes and a 10㎜ expansion joint filler also located at every typical floor.

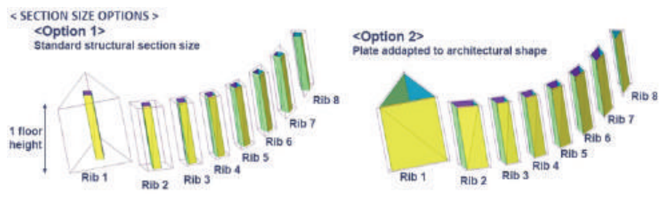


Figure 12. Facade Section Size Optimization

Each of the ribs presents a very irregular geometry with different section sizes that rotates and bends along the height. Two section size options are studied. The first one uses standard sections to which the organic cladding needs to be connected. The second option follows the architectural envelope using offset plates adapted to the irregular geometry. The comparison between constructability and material quantity needs to be considered in parallel for all the structural members, connections and the cladding to achieve a more efficient structure and cost efficient façade.

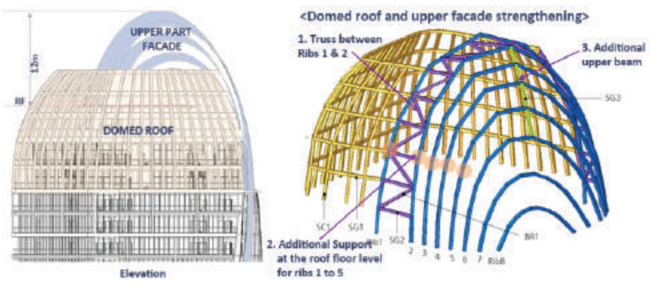


Figure 13. Roof Structure Design

By architectural requirements the roof structure of both twin towers is a cut domed roof which covers the penthouse and roof. However, the roof dome is not completed in the side where the façade structure gets to its top. Therefore, there is a necessity to strengthen both parts and make them stiffer structurally. As a solution Ribs 1 and 2 are connected in a truss form. Besides, an additional horizontal support will be added in the interior part of the ribs 1 to 5 to hold the façade to the roof floor level. Also an additional upper beam is necessary at the highest point of the ribs connecting ribs 2 to 6 to control the deflection of this part.

THE GATE PROJECT

Heesu Lee, Keumjung Song, Jeongwha Park, Marta Gil Perez

■ Work Scope

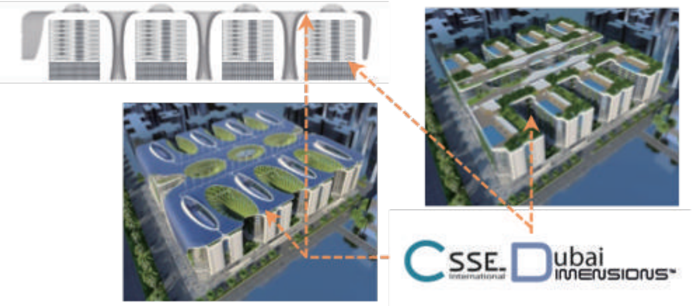


Figure 1. Work Scope

The Gate Project is the first of its kind in Egypt, being a sustainable multi-use complex which includes residential, office and retail facilities. The concept design was proposed by Vincent Callebaut Architectures, and the design has been developed by Dimensions Engineering Consultants. CS Structural Engineering has been appointed to provide services for the Structural Design and Engineering of the Roof Structure.

■ Roof Structure Geometry

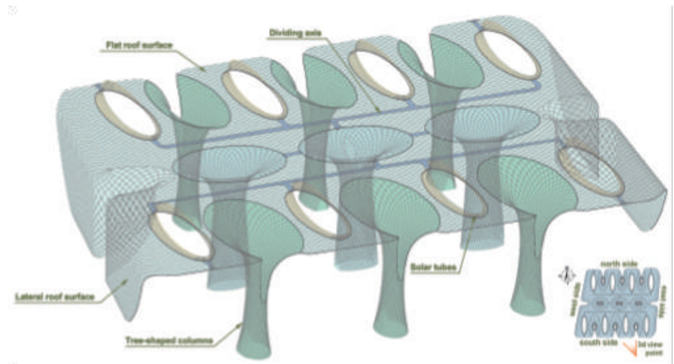


Figure 2. Roof Geometry Parts

The roof structure of The Gate Project is like a second skin of the building that creates a landscape garden in the top of the building. To achieve this purpose, a steel mesh grows between the buildings from tree-shaped columns. Because of that, we can differ the structure into 3 parts: 9 tree-shaped columns that support the structure, a flat roof surface that covers all the building roof area, and a lateral roof surface that folds on the east and west sides as a façade for the building.

Besides, the flat roof surface has 8 solar tubes just over the building cores that provide direct sun light to the swimming pool areas in the roof, and 2 horizontal axes that will divide the roof flat mesh area. All of this features produce discontinuities in the regular grid which structurally increases the stress at the intersection axis and produce difficulties for its connection design.

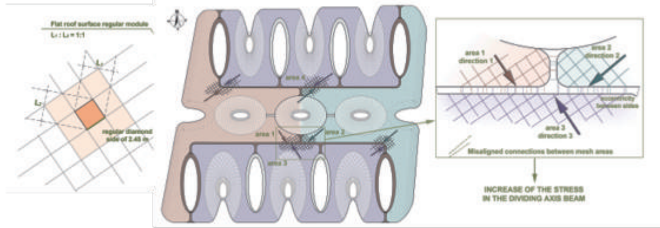


Figure 3. Regular Grid and Discontinuities

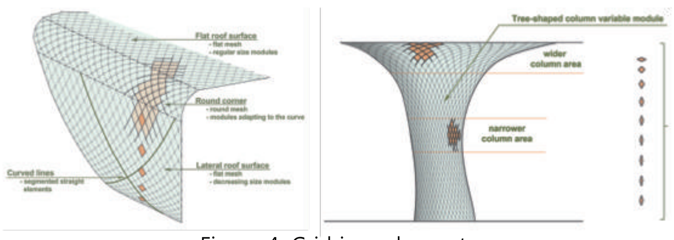


Figure 4. Grid irregular parts

Other irregularities are found in the lateral roof surface area where the diamond module gets smaller as the façade goes down. In the case of the tree-shaped columns, the mesh becomes more irregular as the diameter of the column decrease and increase along the height. This makes the diamonds to become narrower when the diameter is smaller and wider at the top of the column when the three shapes open to meet with the flat roof surface. Therefore, for the optimization of the structure alternatives for the grid and a more regular shape are studied.

■ Structural System & Support Conditions

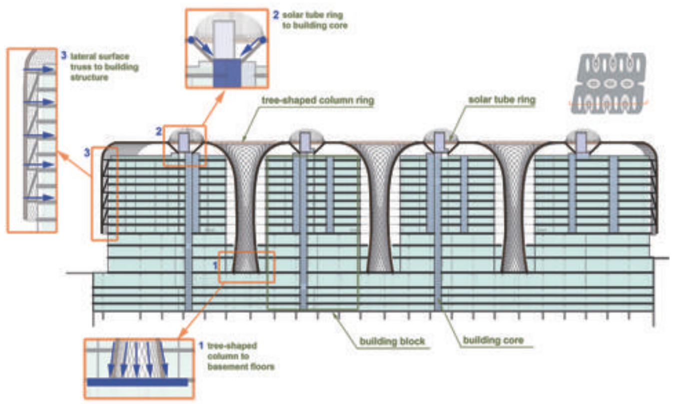


Figure 5. Structural System Supports

The most proper structural system for the architectural design and aesthetic requirements is a lattice single layer steel structure. Besides, the loads need to be transfer to the RC building through different supporting methods at different locations. 4 supporting systems are proposed: at the base of the tree-shaped columns, at the building core just below the solar tube rings, at the lateral surface through a truss connecting to the main structure, and some columns for the roof surface grid to control the deflection of the longer spans. These systems are studied and alternatives are proposed.

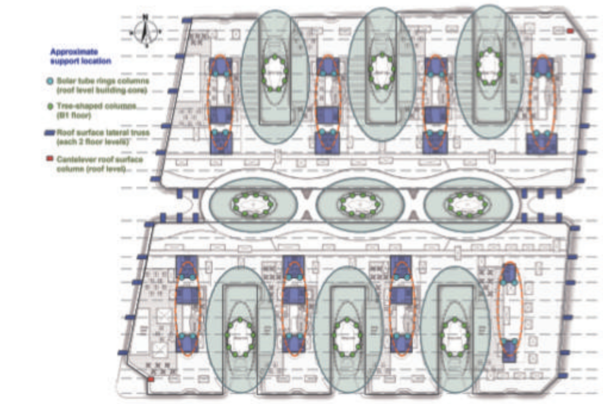


Figure 6. Supports Location

■ Structural Behavior

The flat lattice grid surface does not present frame action, leaving the lateral stiffness to be driven by the tree-shaped columns behavior, fact that makes the whole structure to present a very weak resistance against lateral buckling. This also makes the deformation against lateral loads very large. At the same time the deflection at the flat roof is also significant since the spans are quite long compared to the structural depth. At the Scheme Design Stage CSSE studied different alternatives to improve the structural behavior, constructability and cost efficiency of the whole structure. An automatic modeling process using a script in "Grasshoper" has been used to generate the 3D mesh geometry of the different alternatives.

■ Alternative Regular Shape

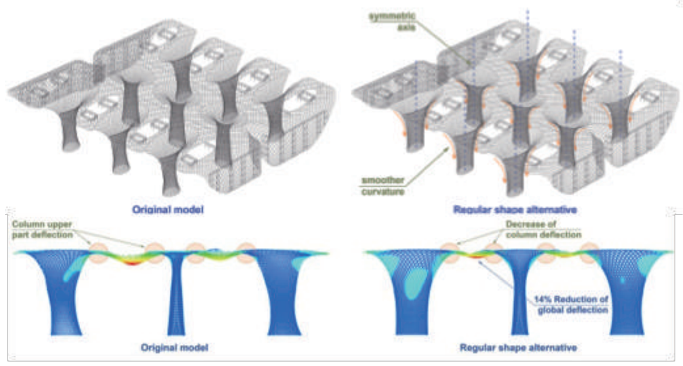


Figure 7. Regular Shape comparison

The most irregular geometry is found in the tree-shaped columns presenting asymmetries along its vertical axis and abrupt curvatures at the top which increase the roof deflection and make the grid very irregular. Therefore, CSSE proposes to regularize the geometry. Firstly, by making the tree-shaped columns symmetric, the structural members can be greatly optimized since the stress is equitably distributed. Secondly, the curvature is proposed to be smoother reducing the deflection at the upper ring and improve the buckling behavior or the column. The most beneficial influence when analyzing the regular shape model is found with the reduction of the global vertical deflection of the roof and the improvement of the constructability, as a side effect steel quantity can be reduced and connection details will be more regular.

■ Grid alternative Study

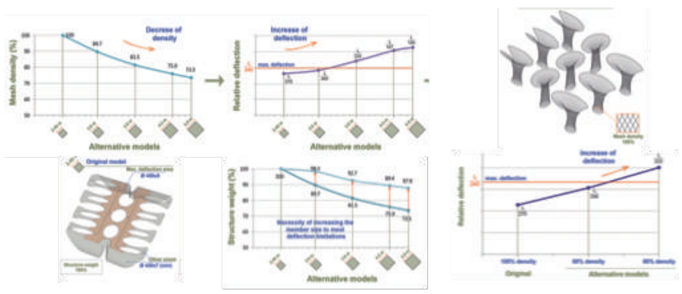


Figure 8. Grid alternatives study

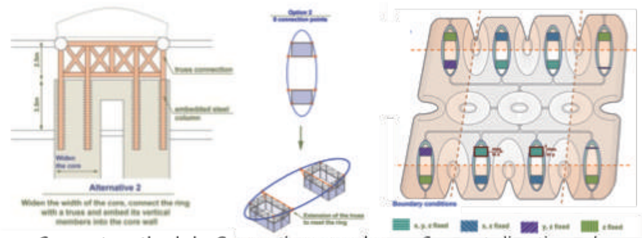
With the aim of reducing the steel quantity and thus the cost of the structure, as well as improving the constructability and manufacture of the members, several grid options have been studied for the flat surface and the tree-shaped column separately. The global deflection is the most determining issue for the assignment of the member sizes. When decreasing the density of the grid, the deflection increase and therefore, the member size needs to be increased to meet deflection limitations. However, the total structural weight can still be reduced. The combination of the different flat roof grid sizes and tree-column densities gives the four combined alternatives results expressed in the following table.

Table 1. Grid combine alternatives results

Issue		Alt. 2_ 3.6m flat grid		Alt. 4_ 4.5m flat grid	
		Alt.5_ 80% column	Alt.6_60% column	Alt.5_80% column	Alt.6_60% column
Flat roof size	Max. deflection	Ø 520 x 12	Ø 520 x 15	Ø 520 x 15	Ø 570 x 14
	Other areas	Ø 520 x 8	Ø 520 x 8	Ø 520 x 8	Ø 570 x 9
Final deflection	L (m)	33.4	33.3	33.9	34.0
	δ (mm)	121	121	125	124.5
	Ratio	L/276	L/276	L/272	L/274
Modal Period	Mode 1 (s)	9.21	9.79	9.28	9.83
	global period (s)	5.69	5.57	5.96	5.66
Connections amount	Compared with original model	66.4%	45.6%	61.9%	41.5%
Structural weight	Compared with original model	91.2%	83.2%	88.5%	80.4%
	Weight/area (kg/m^2)	117	107	113	103

The most cost efficient solution is alt. 4+6. However, if the grid is considered too wide, alt.2+5 could be used, which represents a more moderate solution that will also reduce the cost and improve the constructability.

■ Support Alternatives Optimization



a. Support method b. Connections number c. Support direction release

Figure 9. Core Support Optimization

Three issues were studied for the connection between solar tube ring beam and building core. It was found that, a truss system results more appropriate and efficient than a direct beam connection to the core. Then the number of points connecting the ring and the truss was also investigated to assure the connection area strengthening and distribute the stress. Finally, to reduce the horizontal reactions at the RC core and at the same time transfer the loads properly, the degree of freedom releases shown in the figure is also proposed. Based on these concepts the connection details for the truss as well as its member size optimization needs to be further study.

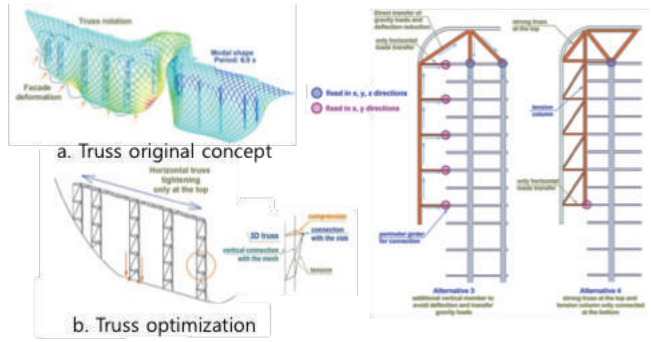


Figure 10. Lateral façade truss optimization

When checking the first truss concept of single layer vertical trusses to support the façade it was found that the truss was instable and rotated producing the façade deformation. For its optimization a more rigid 3D truss connected to the slab was proposed, along with a horizontal truss at the top tightening all vertical trusses together. For its development different support locations and boundary alternatives were studied. The most efficient solution is alt. 3 that will have distributed small horizontal reactions every two levels and will not affect the loads transferred at the core. If it is required to release the lateral connections at the floor levels, alt. 4 could be used, but it should be noted that with this alternative the maximum reaction in the core will increase 30% compared with alt. 3. Therefore, all alternative studies need to be considered at the same time to choose the most efficient combined solution.

COMPLEX ENTERTAINMENT STATION DESIGN

PARADISE CITY PROJECT

Hyunhee Ryu, Minsu Kim, Hyeyoung Park, Hyunwook Cho, Daehoon Kim, Jooyeon Lee, Daeha Park, Arum Han

■ Overview

The Paradise City Project is culture & art complex resort built in yeongjongdo international business center(IBC) by Paradise Segasami. The culture & art complex resort is huge project - it costs 1.3 billion dollars and gross area is 302,500 m² - which includes hotel, entertainment, culture and retails.

Figure 1. Paradise City Bird Eye View

The project has limitation in building height(44m) since it locates close to the Incheon international airport. And it has very large area and various structural system from general RC, steel system to spatial structure(Plaza). The architectural design is changed often at last stage of the design so fast track method is applied which was not planned.

The design is separated in two phase(1-1, 1-2) based on schedule of the architectural design, and CM manager(Parsons Brinckehoff) participated from DD stage.

Category			Phase 1-1 (Hotel + Casino)	Phase 1-2 (Plaza + Spa)
Design	Architecture	SD, DD stage (Foreign)	WATG	HAWKINS/BROWN, MVRDV
		CD stage (Domestic)	Gansam Architects and Partners	
	Structure	DD, CD stage	CS Structural Engineering	
	CM		Parsons Brinckehoff	
Construction	Construction		Posco E&C	SK E&C
	Site manage		HanmiGlobal	

Table 1. Design and construction group of each phase

Architectural design is carried out by foreign architectural group until DD stage. From CD stage, domestic architecture group, Gansam developed the design taking the domestic condition into. Since CSSE is in charge of the structural design from DD stage, so co-worked with foreign and domestic architecture group.
The project is going to be completed before 2018 Pyeongchang winter Olympic and phase 1-1 is planned to open this year.

■ Phase 1-1 (Hotel + Casino)

Phase 1-1 consists of hotel, casino, convention, public and parking section. Since the project locates near coast, C35 concrete is applied for underground and 27MPa for upper structure. SHN490 and SM490TMC are adopted for steel structure.

· Structural overview of Phase 1-1

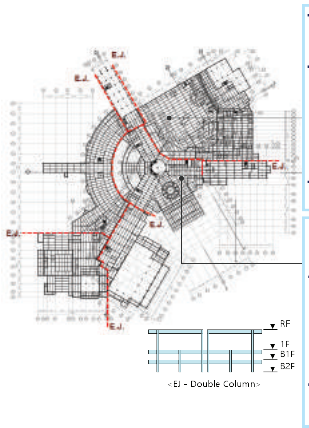
Category	Contents		
Building Size	B2F / 10F (Height : 44m)	Gross Area	198,962m²
Gravity resist system	Beam & Girder System (w/1-way slab) / Except Hotel typical floor (Flat slab)		
Lateral resist system	Building Frame system – Reinforced Concrete Shear Wall		
Foundation system	Pile foundation (Φ600 – PHC Pile, Ra=1300kN/EA)		
Ground water level	EL+4.5m (=1F FL-3.5m) / to apply permanent drainage system		

Table 2. Structural overview of Phase 1-1

· Structural Plan

Typical module of the Hotel section is 9.6(6.5)m x 6.9m. Since it has lots slab openings in hotel room and to reduce self-weight Steel Beam & Girder system was proposed, but Flat slab system is adopted because of story height.

Typical module of the Casino section is 13.0m x 15.0m. Gravity load is resisted by Steel Beam & Girder and lateral load is resisted by building frame system using RC Shear wall.



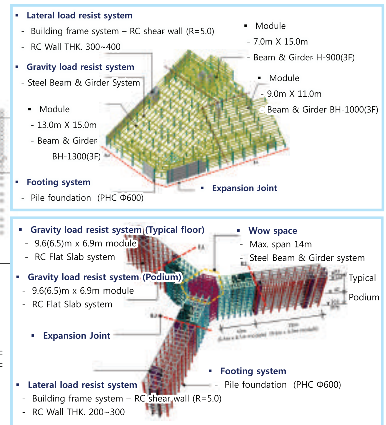


Figure 2. Location of Expansion Joint   Figure 3. Casino(T)/Hotel(B) 3D Model

· Joint Design

Overall length of the building is 300m and an irregular plan, it is predicted to behave differently under lateral load and temperature change. Expansion Joint is planned to correspond with that action. EJ is applied as double column type and space of the EJ is designed taking maximum displacement of roof by lateral load into consideration.

· Foundation Design

Pile foundation is applied considering soft ground of the site. Alternative study is performed to decide pile types and as a result of the study PHC pile is selected because of economic feasibility. However, after construction site is opened, the design is changed to large size PHC pile(Φ800~1000) to reduce construction time and it is applied in phase 1-2 also.

■ Phase 1-2 (Plaza + Spa + Entertainment Square)

· Structural overview of Phase 1-1

The Plaza of the phase 1-2 is the square that is surrounded by the four different buildings of Boutique Hotel, Art gallery, K-Stage and F&B Building. Also, The roof covers this plaza space, between four of the resort buildings.

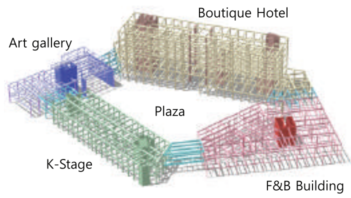


Figure 4. Plaza 3D Model View   Figure 5. Interior bird eye view of plaza

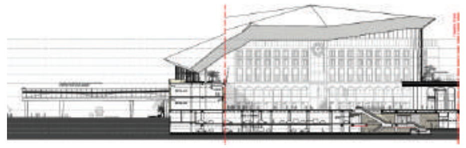


Figure 6. Plaza main section

· Plaza roof

The roof structure reflected the shape the traditional Korean style tile-roof structure and its dimension is 75m x 120m. To apply the most optimized structural system of the roof, many options were carefully explored. The main truss spanning between K-building and the hotel is corresponding to the shortest roof span with two knuckles (Figure 7. Point A,B). The secondary trusses follow the folding line from knuckles to each corner of the roof and are being supported by the buildings or columns. Edge trusses will be installed along the outline of the roof structure to support the cladding.

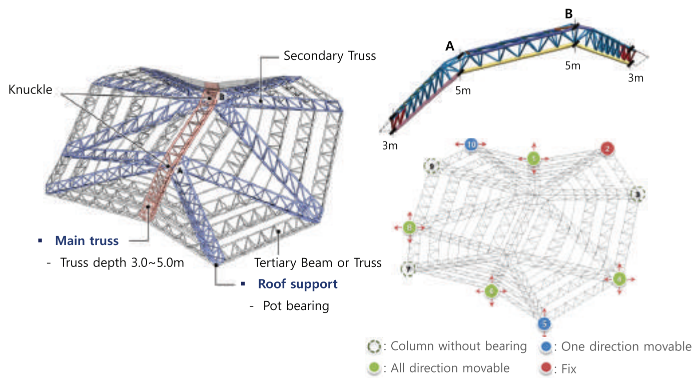


Figure 7. Plaza roof Structural system

The main and secondary trusses are considered with the one-way spanning 3D truss structure and all the members are pipe with maximum size of Φ1016.0x40t. The sliding bearings are placed at the bottom of the roof columns to separate roof and sub structures, which can reduce the roof lateral forces transferring to sub structures

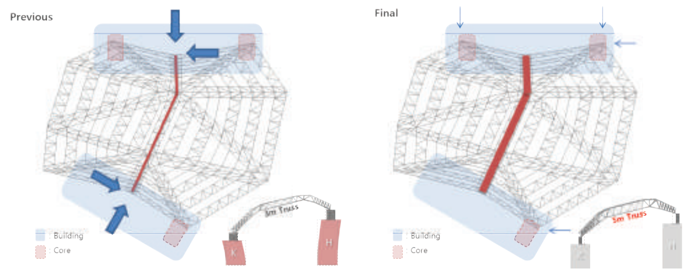


Figure 8. Roof support system comparison

· Plaza roof erection engineering

Due to its large scale of the elements used in roof design, the installation and erection are being seriously important part of the current project. Thus, the effective installation sequence for securing structural stability is being given by the CSSE.

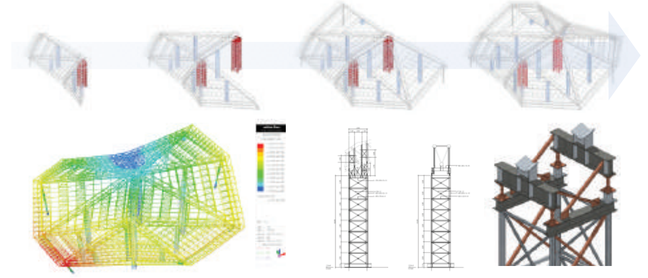


Figure 9. Construction stage analysis

· Maglev bridge

The full length of the link bridge for the maglev train is nearly 60 meter long and four different piers will support with max. 30m span.

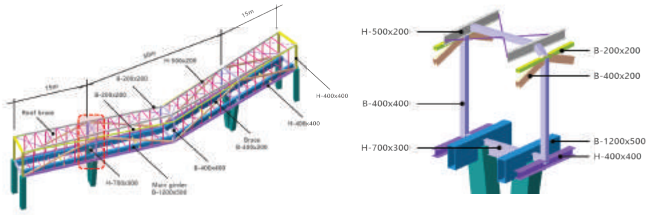


Figure 10. Maglev Bridge Structure system

· Spa & Entertainment square

Spa and Entertainment Square(E.S) that consists of Sandbox and Club are arranged at the north of the plaza. Both buildings have been designed as four stories with two basements floors made with a steel frame and concrete structure, separately. Furthermore, the mega brace will be installed in sandbox as its irregular shape needs long span cantilever structure.

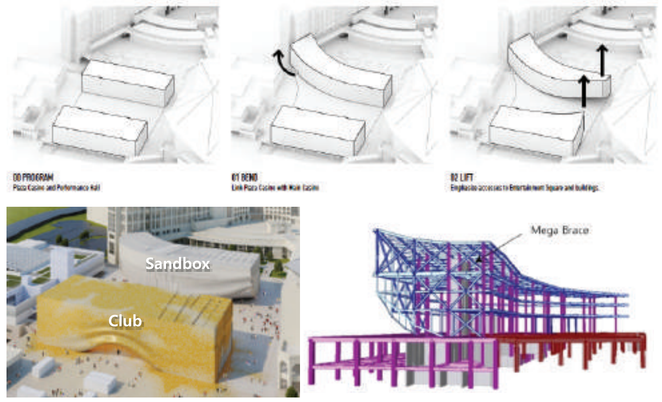
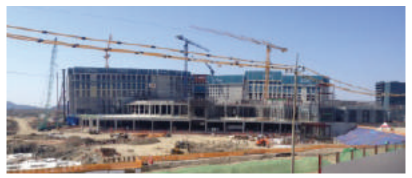


Figure 11. Sandbox Design

■ Structural engineering under construction

Paradise city is currently under construction. As the responsible engineering consultant of current project, CSSE is consulting structural issue of construction site including the check of complicated connection details through BIM tool such as TEKLA.



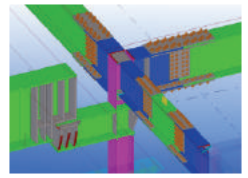


Figure 12. Construction site   Figure 13. TEKLA Model