

앙골라 주경기장 구조설계

Structural Design of Angola Stadium

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요약

본 논문은 앙골라 주경기장에 대한 구조설계에 대해 설명하고 있다. 앙골라 주경기장은 연면적 78,000m², 지상 4층 구조물로서 스탠드 부분은 Steel moment frame으로 구성되고, 지붕부분은 캔틸레버 트러스 시스템으로 설계되었다. 기초는 파일기초가 사용되었으며, 내진과 내풍설계, 스탠드 부분에 대한 다이아프램 액션, 스탠드와 지붕사이의 Interaction, 바닥진동 등 사용성 평가가 설계사항에 고려된 프로젝트이다.

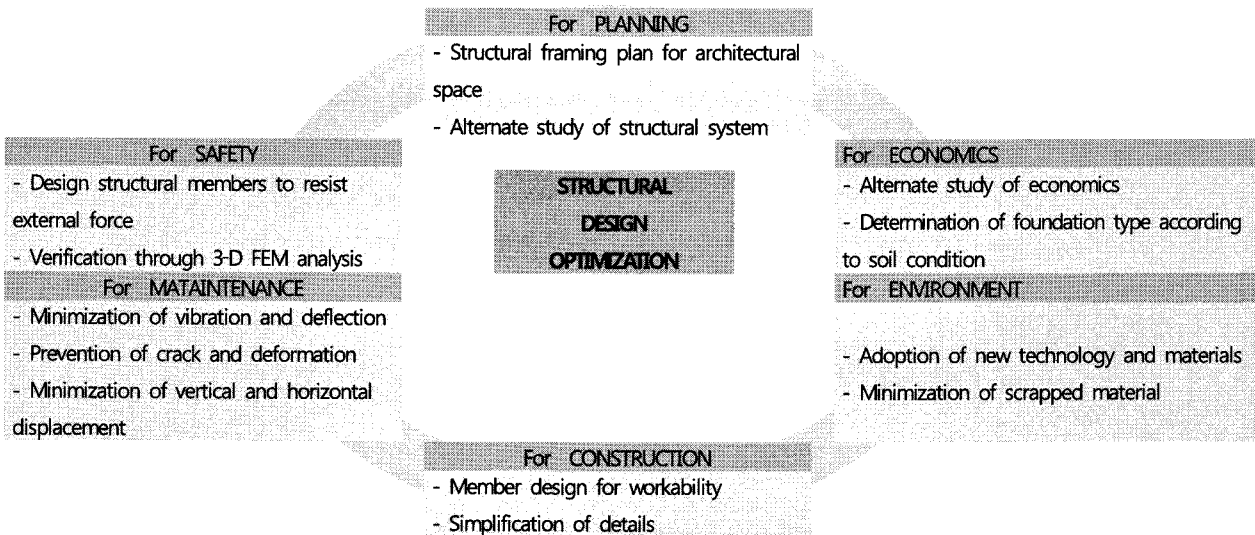
Abstract

This paper is concerned with the structural design of Angola Stadium. The Angola stadium is composed of a Steel moment frame system and a Cantilever steel truss roof. Whole structural analysis is necessary to ensure the stability. Considered FEM analysis, Design of Wind load & Seismic, Stand diaphragm, interaction between stand and Roof, Serviceability.

키워드 : 앙골라 주경기장, 철골구조, 캔틸레버 지붕, 대공간 구조

Keywords : Angola stadium, Steel moment frame, Cantilever roof truss, Spatial structure

1. Design Concept



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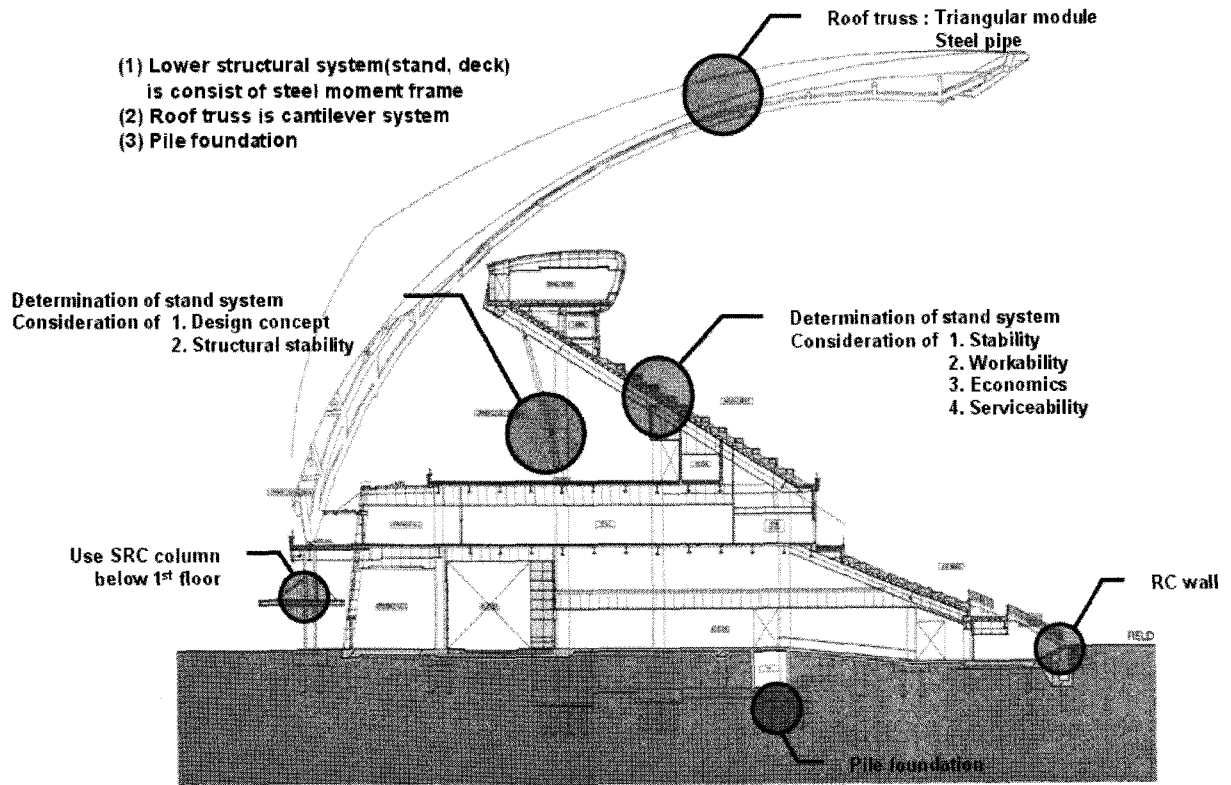
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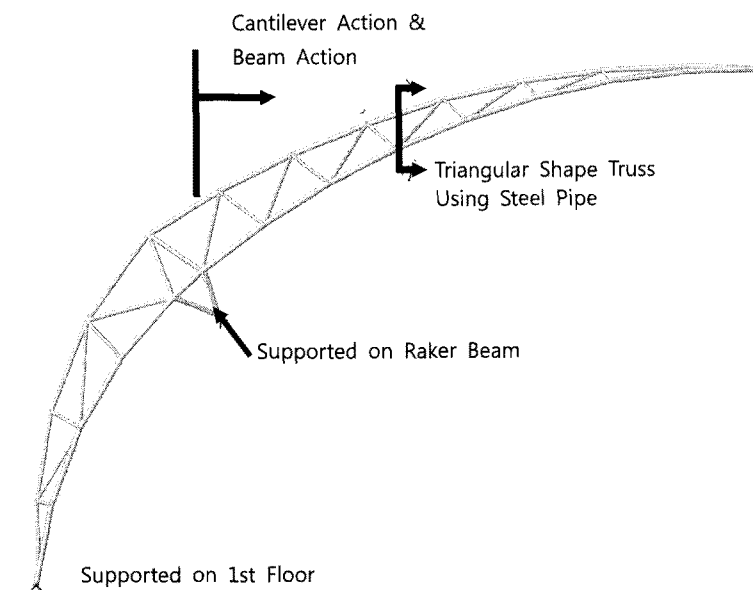
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2. Study of Structural System

1) Concept Sketch of Overall Structural System



2) Roof System



2. Structural System for Stadium

- Comparison between PC, RC and Steel system

Alteration	PC Structure	RC Structure	Steel Structure
Structure Method	<ul style="list-style-type: none"> · Dry construction, · Heavy-weight · Constructability uniformity · Temporary Structure NOT needs 	<ul style="list-style-type: none"> · Wet construction, · Heavy-weight · Constructability ununiformity · Temporary structure necessity · Disadvantage of high-place work 	<ul style="list-style-type: none"> · Dry construction, · Light-weight · Constructability uniformity · Temporary structure unnecessary · Advantage of high-place work
Structure	<ul style="list-style-type: none"> · Long-span Prestressing · Advantage of vibrations 	<ul style="list-style-type: none"> · Disadvantage of long-span · Advantage of vibrations 	<ul style="list-style-type: none"> · Advantage of long-span · Disadvantage of vibrations
Environment Friendly	<ul style="list-style-type: none"> · No construction waste 	<ul style="list-style-type: none"> · Construction waste 	<ul style="list-style-type: none"> · No construction waste
Maintenance	<ul style="list-style-type: none"> · Minimize maintenance · Good durability 	<ul style="list-style-type: none"> · Maintenance costs · Normal durability 	<ul style="list-style-type: none"> · Steel member maintenance costs · Normal durability
Height plan	<ul style="list-style-type: none"> · Free of main air duct 	<ul style="list-style-type: none"> · Interference main air duct · Height problem 	<ul style="list-style-type: none"> · Interference main air duct · Height problem
Direct Construction Cost	102%	100%	117%
Construction Duration	85%	100%	80%
Method of Construction	<ul style="list-style-type: none"> · Steel Raker Beam · Using Deck Slab as Stand System 		

SELECTION STRUCTURAL SYSTEM for ANGOLA STADIUM

1) Consideration for environment of a construction field

- A Transportation method for structural members
- A material supply and demand program
- Employee fee and a cost of materials
- Construction conditions

2) Disadvantage of PC and RC system due to pre-study

2-1) PC system

- Difficult to carry structural members
- It need to establish PC production factory in situ
- it spends much time (about 2~3year)

2-2) RC system

- Need much time to curing
- Difficult to make forms for Raker Beam and Stand

- Much construction period (not satisfying given construction period)

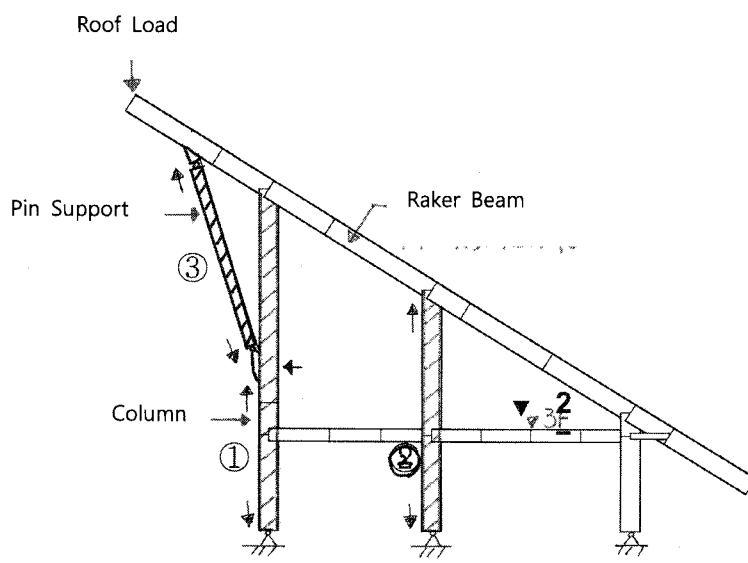
3) Important factor for Angola Stadium construction

- Time : Construction period (about 2.6 years)
- Transportation : Structural members
- Construction : Need to easy work


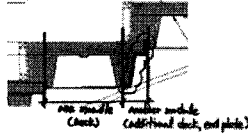
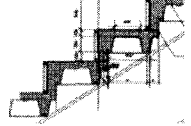
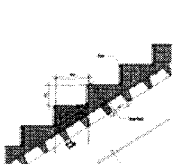
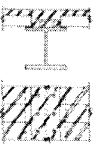
→ Selected System

- Easy to work
- Need to verify for a material supply and demand program
- Useful for short construction period

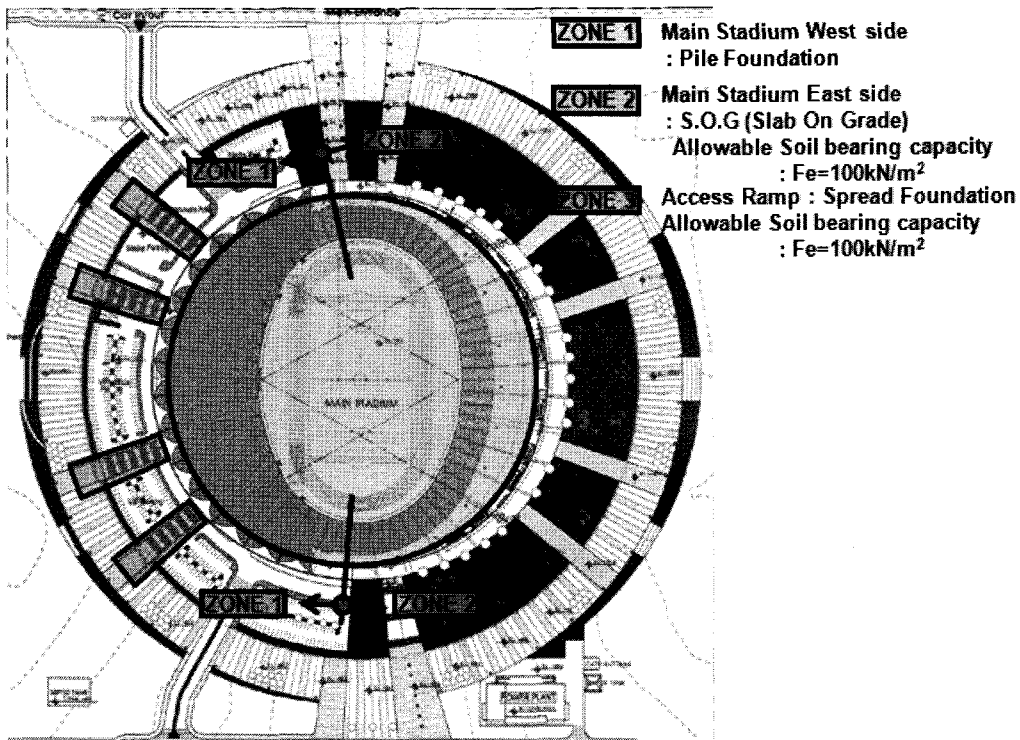
- UPPER STAND SUPPORT SYSTEM

Item	Description	Remark
Select System	 <ul style="list-style-type: none"> - This system is adopted for architectural design concept. - This system is consisted of 3-vertical column and 1-branched pin support. - ③ member mainly supports stand. - Concentrated force occurs at ① member due to pin-support column. And ① member should be considered for horizontal force. - The horizontal force is less and 2nd slab makes a rigid diaphragm, so there is no excessive moment at ① member. - It is Easy to work which pin connection detail - This is more efficient system than others. 	

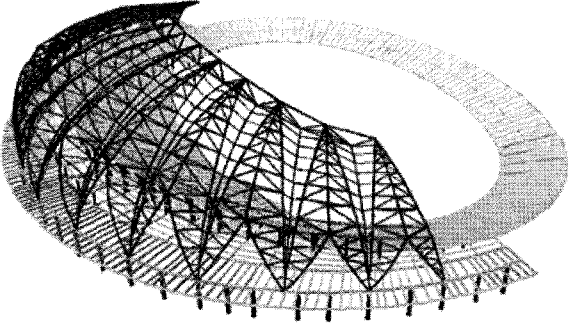
- CONSTITUTION of STAND

ITEM	DESCRIPTION	
ALT1		
ALT2		<ul style="list-style-type: none"> • This system require additional plates or materials → Need to fixing method • It is difficult to make stand diaphragm → Steel braces are needed
ALT3		 <ul style="list-style-type: none"> • It is difficult to pour a concrete in whole area at once. • Increase self-weight → alt2(67%) < alt1(100%) < alt3(126%) • Easy to work. • It is possible to make stand diaphragm. Thus steel brace can be reduced
SELECTION	<p>※ Alt 3 is selected</p> <ul style="list-style-type: none"> • Easy to work (construction, erection, fabrication...) • It is useful to make stand diaphragm for structural engineering, If stand has not diaphragm then brace is needed 	

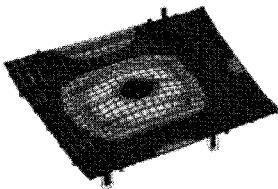
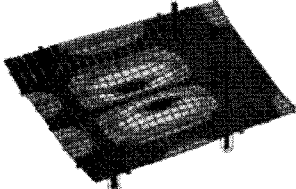
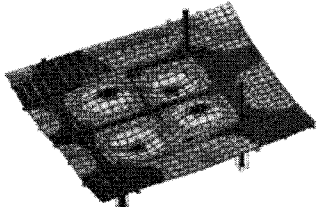
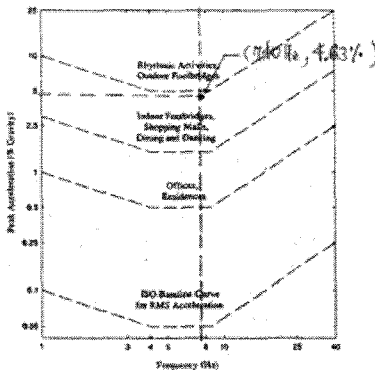
- FOUNDATION



3. Structural analysis concept

3D-FEM Analysis	Design for Wind Load	Design for Seismic
<ul style="list-style-type: none"> • A evaluation of structural behavior through FEM analysis 	<ul style="list-style-type: none"> • Adopt a provision of Eurocode • Static analysis performed 	<ul style="list-style-type: none"> • Low seismicity • Check for safety and stability
		
Stand Diaphragm	Interaction between stand and Roof	Serviceability
<ul style="list-style-type: none"> • Consideration of diaphragm actions of stand 	<ul style="list-style-type: none"> • Consideration of roof reaction to upper stand 	<ul style="list-style-type: none"> • A evaluation of floor vibration, lateral displacement, drift..

4. FLOOR VIBRATION

ITEM	VIBRATION ANALYSIS		
MODE SHAPE			
FREQUENCY	7.40 Hz	17.01 Hz	26.08 Hz
CONCLUSION	<div style="display: flex; align-items: flex-start;"> <div style="flex: 1;">  </div> <div style="flex: 2; padding-left: 10px;"> <ul style="list-style-type: none"> - The provision of ISO Standard(2631-2) about outdoor footbridges is applied to evaluate rhythmic activities performances for Angola Stadium's floor(deck). - Floor vibration satisfy with the provision of ISO Standard (2631-2) about outdoor footbridges - Floor vibration is checked 12.0m x 11.0m module which is the most long span in stadium. </div> </div>		