

Ultra-Modern Stadium Design

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1st Author: Kamanga Jacob Yakobe

Kamanga.jacob@yahoo.co.uk

Department of Engineering

Bachelor's Degree in Architecture

Information and Communications University

Lusaka, Zambia

2nd Author: Sapato Kamiji Pethias

kimsaps@gmail.com

Department of Engineering

Information and Communications University

Lusaka, Zambia

ABSTRACT

The aim of this article is to improve on the existing stadium designs in Zambia with a new ultra-modern stadium/ sports arena. The new stadium design is to be the first of its kind in Zambia and shall house the following;

- ✚ All indoor sporting activities including football, tennis, volleyball, basketball, cricket, running track, swimming pool, gymnasium etc.
- ✚ Accommodation,
- ✚ Food courts,
- ✚ Lounges,
- ✚ Police post,
- ✚ Clinic
- ✚ Well-defined road network
- ✚ Parking slots
- ✚ Shops and snack bars
- ✚ Conveniences
- ✚ Supporting offices space
- ✚ State of the art changing rooms

To the climax the design will hold a minimum capacity of about 50,000 spectators. The design is not only meant to be aesthetically pleasant but will include all necessary auxiliary facilities.

In the late 20th and the 21st century, the design of stadiums begun to transform from just the Design

to function but it started to look and incorporate aesthetic issues in design.

This stadium design is to have an exterior Surface made from ETFE (**ETHYLENE TETRAFLUOROETHYLENE**) plastic panels which will be supported on a steel Frame and concert, and an inflation Unit is also supplied which monitors the system. These foil panels will appear white from far away but when examined closely, there will have little dots on the panels. When viewed from afar the eye will Combine the dots and see white. The foil panels will all have a thickness of about 0.5 mm. Most importantly each panel will be independently lit with white, red, blue, Orange etc. The panels will be lit for each game with the colour of the respective home team. The roofing material is also to be of ETFE-foil air panels.

The author will also look at how best to incorporate the missing auxiliary facilities in the existing stadiums in Zambia and also demonstrate how best to adopt the use of water harvesting for water supply in the stadium and a commercial solar power plant for electricity generation. The thesis is also attempting to resolve lack of proper stadium infrastructure and supporting facilities in Zambia.

Key words: Design of an ultra-modern stadium; athletically pleasing; LEED standards; ETFE plastic

1.0 INTRODUCTION

This research focuses on the stadium design. This stadium is to be the first of the kind in Zambia and shall house nearly all indoor sport activities. The main aim is/and will be to design a modern, aesthetically pleasant, efficient and ultra-modern stadium with good flexibility and expansion capabilities. The minimum capacity for the stadium in question is about 50,000 and the stadium will have three level of bowl seating for spectators.

The stadium proposal for Solwezi is presented as a solution to the anticipated shortage of a proper state of the art multi-purpose stadium in Zambia. The proposal for the design of this stadium will include food courts, accommodation, police post, clinic, VIP lounges, public restrooms, media center, changing rooms, indoor sport halls etc.

This research will also use innovative development to address issues of water supply and preservation and electricity supply. The stadium will pass the threshold for the international LEED standards in attaining sustainable architecture.

2.0 BACKGROUND INTRODUCTION

Zambia, officially the Republic of Zambia, is a landlocked country in southern Africa. The neighbouring countries are the Democratic Republic of the Congo to the north, Tanzania to the northeast, Malawi to the east, Mozambique, Zimbabwe, Botswana and Namibia to the south and Angola to the west. For purposes of this research, focus will be made on the solwezi Town which is in North-western province of Zambia.

Solwezi town has approximately 260,000 inhabitants at an elevation of 125m above sea

level. Kaonda is the largest tribe represented in solwezi, in addition to large number of lunda and luvale speaking people.

The main industry of solwezi district is copper mining at kansanshi mine (located about 10km north) run by the first quantum minerals. Kansanshi mine exploits copper – gold ore. The mining site has intermittently been running since the early 20th century for copper and gold. The adjacent kalumbila district hosts lumwana mine (located about 65km west) and kalumbila mine (located about 140km west), run by Barrck Gold and first Quantum minerals, respectively.

Solwezi is among the few cities in Zambia that have access to both road transportation and air transportation.

2.1 HISTROY OF STADUIMS

The oldest known stadium is the stadium at Olympia in Greece, where the Olympic games of antiquity were held from 776 BC. Initially the games consisted of a single event, a sprint along the length of the stadium. Greek and Roman stadiums have been found in numerous ancient cities, perhaps the most famous being the stadium of Domitian, in Rome. The excavated and refurbished ancient panathenaic stadium hosted an early version of the Olympic Games in 1870, 1975, 1896 and 1906. The excavation and refurbishment of the stadium was part of the legacy of the Greek National benefactor evangelos zappas, and it was the first ancient stadium to be used in the Morden times.

The first stadium to be built in the modern era were basic facilities, designed for the single purpose of fitting as many spectators in as possible. With tremendous growth in the popularity of organised sport in the late Victorian era, especially association football in the kingdom

and baseball in the United States, the first such structure were ever built.



Olympia in Greece



Plate 1.2 Roman Amphitheatre

Source: (Ancient History Encyclopaedia by Mark Cartwright published on 21 December 2016)

2.2 MODERN INNOVATIONS IN STADIUM DESIGN

Architecture innovations have quickly pushed the boundaries of stadium design. The Olympics, the world cup, FIFA and major sports leagues on every continent, sports are major commercial events that attract millions of viewers. Such

widespread popularity means that major investment in innovative, state of the state of the art stadium design is on the table.

Spectacular new stadium designs that enhance the spectator experience and push design boundaries are popping up around the world. Many modern stadium feature rounded curved exterior designs.

The birds nest national stadium in Beijing kicked off this trend when it debuted for the 2008 summer Olympics. Other modern marvels using this design include Borisov arena in Belarus, al Wakrah stadium in Qatar and the upcoming national Olympic stadium in Tokyo.

2.3 ZAMBIAN STADIUM OVER VIEW

Zambia has about 7 stadiums but among these only two (2) are of great standard and can be used for officially matches. Since Zambia is growing, the demand to accommodate more fans/ people during games has become one of the biggest requirement. It's for this reason that more stadiums should be built.

Table 1.1 Stadiums in Zambia

#	Stadium	Location	Capacity	Home Teams
1	National hero's stadium	Lusaka	60,000	National team
2	Mwanawasa stadium	Ndola	50,000	Zesco United
3	Independence stadium	Lusaka	30,000	National Team
4	Nchange stadium	Chingola	20,000	Nchanga Rangers
5	Hammarskjold stadium	Ndola	18,000	Ndola united Fc
6	Woodlands stadium	Lusaka	15,000	City of Lusaka F.C
7	Garden park	Kitwe	10,000	Kitwe United football Club
8	Railway stadium	Kabwe	10,000	Kabwe warriors
9	Nkana stadium		10,000	Nkana FC

Source: (Author)

2.4 DUTIES OF RESEARCH

The main focus of this research will be to design a stadium and auxiliary (supporting) facilities within the landside premises. The design will incorporate the following supporting facilities;

- ✚ Indoor sports courts
- ✚ Dressing rooms
- ✚ Accommodation
- ✚ restaurants
- ✚ Well-defined road network
- ✚ Parking slots
- ✚ Signs
- ✚ Entrance hall
- ✚ Shops and snack bars
- ✚ Conveniences
- ✚ Supporting offices space

The main purpose of research is to inform action, to prove a theory, and contribute to developing knowledge in a field or study. This article will highlight the significance of research with the following points:

- ✚ A Tool for Building Knowledge and for Facilitating Learning
- ✚ Means to Understand Various Issues and Increase Public Awareness
- ✚ An Aid to Business Success
- ✚ A Way to Prove Lies and to Support Truths.
- ✚ Means to Find, Gauge, and Seize Opportunities
- ✚ A Seed to Love Reading, Writing, Analyzing, and Sharing Valuable Information
- ✚ Nourishment and Exercise for the Mind

3.0 DESIGN, MATERIALS AND METHODOLOGY

3.1 PROJECT JUSTIFICATION

This research proposal looks at the benefits that the newly proposed stadium design for Solwezi will bring and also how it will affect the entire north-western province and Zambia as a country at large.

A stadium is said to be the central building of its system. Its architecture reflects the glamour, scale and technological prowess of this fast growing industry. As sporting activities become more popular and accessible, the stadium has assumed greater importance as a fundamentally new and challenging building. It is a miniature city reflecting the values and aspiration of the society. National image is reflected more directly in the design of the stadium than in any other building type,

The design of the proposed new and improved stadium has been chosen and located to be constructed in Solwezi North-western province,

3.2 RESEARCH OBJECTIVE

3.2.1 OBJECTIVES

The principle objective of this project is to provide Solwezi with an ultra – modern, befitting and function stadium /arena which has been badly absent in all Zambian provinces at large and also to upgrade the landscape around it and prescribe other salient facilities' which have been omitted in other already existing stadiums around the country.

In appreciation of the particular demands of the design, I opt:

- ✚ To situate the structure in an ideal location that easily catch's eye sight from around the environment and can be easily accessible to staff as well as visitors
- ✚ To ensure good road network that create easy flow of vehicular and human traffic;
- ✚ To consider the environmental consequences as far as they are not a detriment to the proposed development
- ✚ To minimise costs by putting construction techniques, and employing materials within the level of technology that is commensurate with national aspiration
- ✚ To ensure flexibility and adoptability for future changes in use of facilities or space;
- ✚ To ensure efficient security within and around the facility premises;
- ✚ To ensure the stadium, the parking lots and other auxiliary facilities are strategically placed for easy accessibility from one to the others.

3.3 RESEARCH METHODOLOGY

This project will make use of the following software's that will facilitate its good presentation in terms of providing both visual and audio output. And also secondary data collection method

- ✓ AUTOCAD
- ✓ REVIT
- ✓ LUMION
- ✓ EXCEL
- ✓ MICROSOFT WORD
- ✓ PHOTOSHOP

3.4 DATA SOURCE USED

3.4.1 PRIMARY SOURCES

Observations

Direct observation enabled the researcher to put the elements of study in context and therefore understanding them better . It also enabled first hand documentation of the situation as it was the study area. The researcher used structured and unstructured observation method. The structured observation would assist the author to answer research questions while the unstructured one was to make sure any other relevant information found in the field is not left out purely because it was not covered in the predefined observation list. Sketches photographs and measured drawings were used to capture the observations made.

Photographs

All the subjects of the study were captured in photographs and analysed in sketches. Photographs were the major tool in capturing the existing situation in the area of study. Images of both the exterior and interior of the terminal were taken to give a clear understanding of the same. The photographs are used to support text in the analysis of the information obtained from the field.

3.4.2. SECONDARY SOURCES

Documents, plans, drawings and any other literature on the field of study. Documents will be source from the following sources; the JKIA data were sourced from the architects who include the Gensler international firm. Other drawings were sourced from initial archives.

3.5 SCOPE OF RESEARCH

The scope of this research will focus mainly on the 5 important building components and characteristics, required by the LEED rating system as follows;

1. Site Design and planning

- ✚ Site a building within close proximity of commuter rail or bus lines, to reduce pollution and any land-development impacts with increased automobile.
- ✚ Establish building specifications that maintain the current level of storm-water run-off, or decrease the amount of imperviousness already existing onsite.
- ✚ Develop as site with a minimum density of 60,000 square feet per acre. Channelling development to urban areas with existing infrastructure protects green spaces and preserves natural habitats and resources.

2. Materials and Product Selection

- ✚ Use building materials and products that contain post-consumer recycled content.
- ✚ Support the regional economy by using materials and products manufactured locally

3. Construction and Demolition Waste Management

- ✚ Develop and implement a waste management plan that diverts a substantial amount of construction, demolition and land-clearing debris from landfills to recycle or salvage facilities

4. Water Management

- ✚ Use water-efficient irrigation, captured rain, or site-recycled water for onsite landscaping.
- ✚ Utilize innovation waste water technologies, such as treating waste water

on site or significantly decreasing the amount of portable water used for sewage conveyance

5. Indoor Environment

- ✚ Design the HVAC system and building envelop to provide for most optional delivery and mixing of fresh air. Effective air exchange supports the safety, comfort, and well-being of building occupants.
- ✚ Reduce the number of indoor air contaminants by selecting paints and coatings, adhesives,

I. Photographs

One of the strongest tools of communication employed is the study of photographs. Each element studied was recorded in terms of clear photographs of different times and at different angles. The photographs were used mainly to show other forms and types of airport terminal buildings already designed.

II. Architectural drawings

Measured drawings of the subject of study include plans, elevations and sections are used to present the findings of the study to ensure easy interpretation of the findings. Of interest were the plans, sections and mainly elevations, which were used to show the design of the new airport terminal building.

4.0 DEISGN PROCESS

CASE STUDY

Case studies play a cardinal role in design as the designer learns from the existing designs and constructions and is able to cooperate the relevant details and have limitations to his current work. Four case studies have been studied, two of which

are international case studies and two is local. The local studies considered are Hero's stadium in Lusaka and Levy Mwanawasa stadiums in Ndola, Copperbelt province. The international case studies are the Green field stadium and FNB stadium in South Africa

4.1 LOCAL CASE STUDY

4.1.1.0 NATIONAL HERO'S STADIUM

NAME : NATIONAL HEROS STADIUM
LOCATION : LUSAKA, LUSAKA PROVINCE, ZAMBIA
TYPE : MUTI PUPOSE STADIUM
CAPACITY : 60,000
SUFACE : GRASS
ACCESSIBIL : WHEELCHAIR ACCESSIBLE
CAR PARK AND-WHEEL CHAIR ACCESSIBLE
ENTRANCE

4.1.1.1 BACKGROUND

Construction works were completed in 2013, it was originally named the Gabon Disaster Hero's National Stadium but was later renamed to national hero's stadiums



Bird view; Interior of Hero's
Plate 2.3 Photos of National Heroes Stadium

Source: (Zambian four new stadium-skyscraper. [https www. Skyscraper.com](https://www.skyscraper.com) city and Author)

4.1.1.2 THE STRUCTURE

The structure incorporates a modern style of architecture with lots openings.it has a combination of brown and white colour, the stadiums roof if made from plastic.

PROS:

- ✓ Its multi- purpose and host most home matches
- ✓ Biggest stadium in Zambia at the moment in terms of capacity
- ✓ Wheelchair accessible elevators
- ✓ Wheelchair accessible parking lots
- ✓ Wheelchair accessible seating

CONS

- ✓ Its located along the great north road and hence causes a lot of traffic during a match
- ✓ It near a residential areas and causes noise pollution
- ✓ location of the stadium is not idea enhance the dirty seen on the stadium roof during dry seasons

4.1.2.0 LEVY MWANAWASA STADIUM

NAME : LEVY MWANAWASA STADIUM
LOCATION : NDOLA, COPPERBELT PROVINCE, ZAMBIA
TYPE : MUTI PUPOSE STADIUM
CAPACITY : 59,800
SUFACE : GRASS
ACCESSIBILITY : WHEELCHAIR ACCESSIBLE
CAR PARK AND- WHEEL CHAIR ACCESSIBLE
ENTRANCE

4.1.2.1 BACKGROUND

Construction works were completed in 2012, the stadium is named after levy Mwanawasa, third president of Zambia, who served from 2002 to his death in 2008



Isometric view

Plate 2.4 Photos of Levy Mwanawasa Stadium

Source: (Zambian four new stadium-skyscraper. <https://www.skyscraper.com/city> and Author)

4.1.2.2 THE STRUCTURE

The structure was recently renovated and upgraded and is mostly constructed from concrete block and curtain wall. The airport is used for both military and public

PROS:

- ✓ Its multi-purpose and hosts most home matches
- ✓ Second biggest stadium in Zambia at the moment in terms of capacity
- ✓ Located away from residential houses, causing less pollution.
- ✓ Wheelchair accessible elevators
- ✓ Wheelchair accessible parking lots
- ✓ Wheelchair accessible seating

CONS

- ✓ Its located along the t3 highway, causing traffic and convinces to Other road users

4.2 INTERNATIONAL CASE STUDY

4.2.1.0 GREEN FIELD INTERNATIONAL STADIUM

NAME: GREEN FIELD INTERNATIONAL STADIUM

LOCATION: THIRUVANANTHAPURAM, KERALA, INDIA

TYPE: MUTI PUPOSE STADIUM

CAPACITY: 50,000

ARCHITECT: COLLAGE DESIGN MUMBAI

SUFACE GRASS (OVAL)

ACCESSIBILITY : WHEELCHAIR ACCESSIBLE CAR PARK AND- WHEEL CHAIR ACCESSIBLE ENTRANCE



Bird View



Lounge: Plate 2.5 Photos of Green Field Stadium

Source: (<https://thesportshub.in>)

4.2.1.1 FACILITY

- ✚ The ground is designed such that it can be used for international cricket and football
- ✚ The stadium is demarcated into four zones, where the north zone is dedicated for cricket and the east zone for football and the west zone has a players lounge, gymnasium, media centre and Stock room.
- ✚ Shopping malls and a food court are placed in the south zone.
- ✚ The adjoining pavilion accommodates the latest facilities for squash, volleyball, Basketball, table tennis and Olympic size swimming pool

CONSTRUCTION DETAILS

It was the first stadium in India built on the DEOT (design, build, operate and transfer) basis. It is also the first stadium in the country to be developed on annuity mode. The green field stadium will be operated for 15 Years by the company that built it. It will then be handed over to the University of Kerala, which has leased 36 acres for it.

PROS:

- ✚ Its multi-purpose and hosts most home matches including sports like football and cricket
- ✚ It is Among the biggest stadium in India in terms of capacity
- ✚ Located away from residential houses, causing less pollution.
- ✚ Its located 13.3km from Trivandrum international airport, 14.4km from Trivandrum central railway station and central bus station Thiruvananthapuram
- ✚ Wheelchair accessible elevators
- ✚ Wheelchair accessible parking lots

- ✚ Wheelchair accessible seating

CONS

- ✚ Environmental issues.
- ✚ External cost, noise and air pollution

4.2.1.2 STRUCTURE

The structure is built from concert blocks and bricks and steel

4.2.2 FIRST NATIONAL BANK STADIUM

NAME	:	FIRST NATIONAL BANK STADIUM
LOCATION	:	JOHANNESBURG, SOUTH AFRICA
TYPE	:	MUTI PUPOSE STADIUM
CAPACITY	:	94, 736
ARCHITECT PARTNERS,	:	BOOGRTMAN AND HOK SPORT (NOW POPULOUS)
OPENED	:	1989
SUFACE	:	GRASS
ACCESSIBILITY: CAR PARK AND- ENTRANCE	:	WHEELCHAIR ACCESSIBLE WHEEL CHAIR ACCESSIBLE

4.2.2.1 BACKGROUND

The first national bank stadium – known as soccer city – was renovated in 2009 Ahead of the 2010 world cup in South African. Although it is home to South African club side Kaiser chiefs, the stadium is fondly Remembered for hosting the showpiece event of the 2010 final, but also for hosting the opening game and goal of the tournament- siphwe tshabalala finding the back of the Mexican net with a thumping effort.



Bird view

Night view

Plate: 2.6 Photos of FNB Stadium

Source: ([https:// en.wikipedia.org>FNB_ stadium](https://en.wikipedia.org>FNB_stadium))

CONSTRUCTION AND STADIUM DESIGN

The outside of the stadium is designed to have the appearance of an African pot; the cladding on the outside is a mosaic of fire and earthen colours with the ring of light running around the bottom of the structure, simulating fire underneath the pot. No spectator is seated more than 100 meters (330ft) from the field, and there are no restricted views in the stadium

PROS:

- ✚ Its multi- purpose used for football matches, rugby, concerts, Christian gathering's, crickets etc.
- ✚ It was the site of Nelson Mandela's first speech after his release from prison in 1990
- ✚ It's the Biggest stadium in south African
- ✚ Wheelchair accessible parking lots
- ✚ Wheelchair accessible seating
- ✚ Wheelchair accessible entrances
- ✚ One of the biggest airport in the word

- ✚ Clear signpost to give clear directions
- ✚ Very modern construction and design

CONS

- ✚ its located along a highway, causing traffic or convinces to other road users
- ✚ causes noise pollution to residents living near by
- ✚ External cost, noise and air pollution

4.3.4 DESIGN REQUIREMENTS

To achieve this objective, the various components and departments of the modern stadium are planned in a technical manner so as to meet the different types of requirements that may arise. This design guide provides the basic criteria to evaluate, plan, program and design standardized Stadium facilities. The design scheme will fall into the following categories;

- ✚ Office space
- ✚ Indoor sports court
- ✚ Swimming pool
- ✚ restaurants
- ✚ Dressing rooms
- ✚ Shop / store space
- ✚ Run track
- ✚ Media lounge
- ✚ Presidential lounge
- ✚ Vip lounges
- ✚ Rest rooms
- ✚ Police post
- ✚ clinic

4.3.5 AIM OF DESIGN:

The primary aims/goals of the design are as follows:

- ✚ To provide / design a suitable ultra-modern multi-purpose stadium which would portray a good image.
- ✚ To provide an ultra-modern multi-purpose stadium as well as other auxiliary facilities
- ✚ To ensure these facilities will streamline the productivity in the stadium without interruption or interference from each other or any source



SCOPE AND LIMITATIONS:

The scope of this thesis is restricted to the stadium design and the mechanism to be adopted for supply of electricity and water to the stadium and surrounding areas. This is to say that the work involves only the landside of the stadium which includes all auxiliary (supporting) facilities within the landside premises. These are briefly listed below;

- ✚ Stadium
- ✚ Well defined road network
- ✚ Parking lots
- ✚ Signs
- ✚ Fire station
- ✚ Indoor sports activities
- ✚ Accommodation
- ✚ Food and recreation facilities etc.

4.5.3 CONCEPT ANALYSIS AND CONCEPT IDEALIZATION

Stadium buildings are normally surrounded by secondary elements such as landslides. In this design, such structures are integrated into the main building, taking into account the topography of the local area. The canyons – large courtyards full of daylight - establish a sequence that incorporates the landscape into the interior space. The design concept of the Solwezi sport arena

(stadium) was derived from a **Sports Wrist Watch**. It's important to note that for this particular design the main focus is on the belts of the watch and the head itself. Where the belts represent the dressing rooms/restaurant and the other belt will hold all indoor sports activities like swimming, basketball, tennis, volley ball Etc.

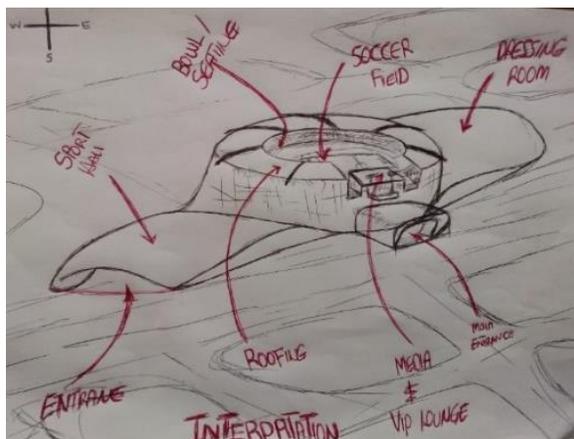
The adjustment knob on the watch is to be treated as the main entrance to the stadium. The building is to display a unique sense of place and is a true vision and a definite gateway to the nation.

The roof and out lay of the stadium is to be made entirely of ETFE FOIL PLASTIC PANELS which will be supported on aluminum and steel space frame or trusses. This will be explained in detail in the special study. The roof will curve, creating an arc like bubble façade shape which creates a dramatic central cathedral-like space, and tapering towards the edges of the building to provide areas that are more intimate.



Plate 2.8 The Concept

SOURCE: (Author)



SOURCE: (Author)

5.0 STRUCTURAL ANALYSIS

Dynamic analysis of grandstands and stadiums

- Eigenvalue and dynamic analysis
- Wind loading
- Crowd loading

When designing grandstands and stadiums the real challenge for a structural engineer is not the static strength or stiffness of the structure but the way in which the structure responds to the imposed dynamic loadings from both crowds and wind. With modern stadium design requiring large cantilevers to give clear views and protection from the weather there is a potential for these roofs to be quite lively structures. Accurate prediction of the natural frequencies and calculation of the effects of the imposed loadings is therefore very important. The UK guide to safety at sports ground specifies that where a seating deck has a vertical frequency of less than 6Hz or a sway frequency of 3Hz then a fully dynamic evaluation of the structure should be carried out. Modern elegant and economic designs are likely to have fundamental frequencies well below these values and so require a full dynamic analysis to demonstrate suitability. LUSAS civil and structural is used by

consultants to design stadium and grandstands all over the world and has been proved to be ideal for this type of staged construction and dynamic analysis work.

Why LUSAS for grandstands and stadium design

Unlike other analysis system LUSAS offers;

- ✚ Full linear and nonlinear analysis
- ✚ Full model analysis on all or parts of the structure
- ✚ Time step linear and nonlinear dynamic
- ✚ Lumped mass modeling
- ✚ Proper cable analysis
- ✚ Staged construction analysis
- ✚ Differing degrees of connectivity of members
- ✚ Damping of all or parts of the structure any variation of wind and dynamic loading

LUSAS SOFTWARE

LUSAS software consist of a windows based modeler, used for model building and viewing of results, and a solver for carrying out an analysis. Four commercial application products cater for the following industries;

- Civil and structural – for civil, structural, nuclear, seismic, geotechnical and offshore engineering.
- Bridge – for bridge engineering analysis, design and assessment
- Analyst – for automotive, aerospace, defense, manufacturing and general engineering analysis
- Composite – for engineering designing composite products or components

5.1 FORM AND STYLE

The design of stadium will see an extensive use of reinforced concrete and glass in the construction stage. This improved technology will help the stadium achieve certain statements that they want to put across. Steel is particularly important in the huge roof spans that are common throughout the design of this project.

5.2 SERVICES

5.2.1 UNDERSTAND BUILDING SERVICES

Building Services are the electrical, plumbing, and mechanical systems in a building. For this reason they are also called MEP services, for mechanical, electrical, and plumbing.

- ✚ Understand HVAC Systems
- ✚ Understand Firefighting Systems
- ✚ Understand Fire Alarm Systems
- ✚ Understand Plumbing Systems.

5.2.2 SERVICES TO BE PROVIDED IN A BUILDING FOLLOWS:

MECHANICAL SERVICES

- ✚ Firefighting Systems
- ✚ Elevators
- ✚ HVAC Systems (heating, ventilation, and air-conditioning systems)
- ✚ Gas Supply Systems (such as for heating and cooking in residential buildings, or oxygen and nitrogen in hospitals)
- ✚ Compressed Air Systems used in industries

ELECTRICAL SERVICES

- ✚ Power Supply
- ✚ Backup Power (such as diesel generators)

- ✚ Emergency Power (such as battery-based uninterrupted power supply)

PLUMBING SYSTEMS

- ✚ Water Supply
- ✚ Drainage of Wastes
- ✚ Water Recycling Systems (these allow you to recover the water from your waste and re-use that water for low-grade applications such as flushing)
- ✚ Rainwater Harvesting
- ✚ Storm Water Drainage

DATA BASED SYSTEMS OR LOW-VOLTAGE SYSTEMS

- ✚ Security Systems
- ✚ Fire Alarm Systems
- ✚ Building Management Systems
- ✚ Public Address Systems
- ✚ Cable TV Systems

6.0 RESULTS

6.1 RESEARCH FINDING

SUMMARY AND WAY FORWARD

Review of different literature as shown that stadiums are an important developmental infrastructure to any country as they not only contributes to development and appearance of a nation/ city but it's also serves as a tourist attraction. Zambia has about seven stadium and most of these are in serious need of rehabilitation or a face lift.

The proposed design of Solwezi stadium is meant to not only improve the facility but also to raise the standards and operations of north-western province. The fact that Solwezi is the mining

capital of north-western province is important that it has a modern stadium.

The new stadium design is expected to introduce Solwezi / north-western province to the world at large as both domestic and international games will be handled

6.2 RESEARCH PURPOSE

The main purpose of this research is to provide north-western province with an ultra-modern stadium having all the necessary facilities in accordance with the standards and quality required. The information from this research will be used for proper planning and designing of the Solwezi stadium.

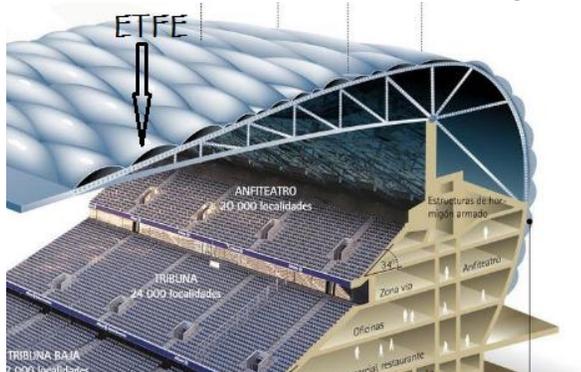
7.0 DISCUSSION

7.1 SPECIAL STUDIES

The design of the stadium will have three special studies, namely:

- I. The exterior inflated ETFE plastic panel for roofing and the out lining of the stadium
- II. Commercial solar power plant for electricity generation and supply to the stadium
- III. How water will be supplied to the stadium

EXTERIOR INFLATED ETFE PLASTIC PANELS / BUBBLE FAÇADE



ETFE: ETHYLENE TETRAFLUOROETHYLENE

- The stadium is to have an exterior Surface made from ETFE plastic panel Which will be supported on a steel Frame and concert, and an inflation Unit is also supplied which monitors the system
- the roof material is also to Be ETFE-foil air panels

7.1.1 LUMINOUS EXTERIOR

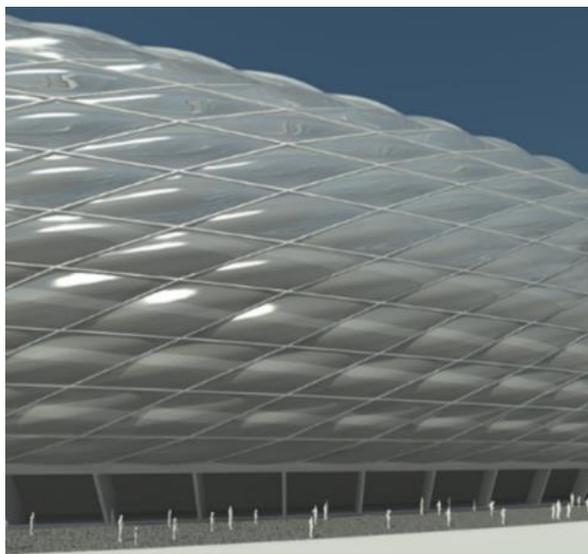
The Arena Façade Will Be Constructed from EtfE – Foil Panel That Will Be Kept Inflated with Dry Air to A Differential Pressure of About 3.5 Pa. The Panels Will Appear White from Far Away but When Examined Closely, There Will Have Little Dots on The Panels. When Viewed From Away The Eye Will Combine The Dots And See White. The Foil Panels Will All Have A thickness Of About 0.5 Mm Most Importantly Each Panel Will Be Independently Lit With White, Red, Blue ,Orange Etc .The Panels Will Be Lit For Each Game With The Colure Of The Respective Home Team

7.1.2 HISTORY OF ETFE MATERIAL

ETFE was originally developed in the 1970s, by DuPont as a lightweight, heat resistant Film to serve as a coating for the aerospace industry. Since that time, the film has been used sporadically in various agricultural and architectural projects, such as Coverings for greenhouses and protection for solar cells. Then, in 2001, the material saw its first large-scale application as the encapsulating membrane of the Eden –Project in Cornwall, UK, a natural evolution of Buckminster fuller's biosphere

Concept. The consultant engineering firm for the project, Arup, seated ETFE because of its Ability to reliably regulate environmental condition within the building through Uv transparency- the film can be printed with specific patterns and layered to Control solar conditions

7.1.3 PROPERTIES OF ETFE FOIL PANELS



SOURCE: (<https://www.etfe-film.com>)

Expectancy:

ETFE has an excellent life expectancy as it is un-affected by UV light atmospheric pollution and other forms of environmental weather

While no ETFE structures have been in place for long enough to gain a true understanding of the life cycle of the foil, the material has been extensively researched and tested in a laboratory environment and out in the field. These tests have concluded that no degradation

or loss of strength has occurred and there is no sign that material will become brittle or discolors over time.

Safety/

Explosion risk:

As a flexible material, ETFE foil can take very high loading for short periods of time which, makes it an ideal material for use in location where there is risk of explosion. If vandalism is a threat, ETFE foil is also an advantage as the cushions will not break or fall from the extrusion frames if damaged.

Repair and replacement:

one of the outstanding characteristics of ETFE foil is its exceptional tear resistance, lack of notch weakness and stress crack concentration. Any cuts and scratches initially propagate but the material rapidly stretches and rounds out into a tough low radius area that dissipates the loads and prevents further tearing.

Minor repairs to the foil, such as a puncture hole, can be carried out in situ and within a relatively short timescale by using an adhesive ETFE foil patch.

Fire: ETFE foil as a material has a low flammability (270c) and is considered self-Extinguishing. In the event of fire, hot smoke will cause the foil to soften fail and then shrink away from the fire source to create natural Ventilation. The quantity of material used in the roof is

not important in this situation the foil will not create molten drips or any fumes

Cleaning:

unlike traditional fabric structures, ETFE foil is an extruded material and therefore has a smooth surface. This smoothness reduces the amount of dirty retained on the ETFE foil surface and allows the rain to wash away the majority of bird droppings and dust. Its advice to clean ETFE foil at list every 2-3 years

The cushion themselves also need to be cleaned internally, although far less often. Depending on the amount of dirt collected in the internal atmosphere, it's recommended they are cleaned every 5 – 10 years on the interior surface of the cushion

The inflation units are to be serviced every year; however, an active monitoring system is incorporated in all units which supplied continual information on performance

Weight: ETFE foils cushion ae extremely light weight weighing only 2- 3.5kh/m.

system to help support the cushion should this arise

7.2 COMMERCIAL SOLAR POWER PLANT

The stadium will be solar powered, generating 100% of its electricity from photovoltaic technology. The watch shaped 50, 000 plus seat

Inflation units:

ETFE cushion system are continually inflated by air handling units from which air pipes run to each individual cushion. As the cushions only need to maintain pressure and not generate air flow the energy consumption used by these units is minimal. An entire roof is generally powered by a single air handling unit which contains 2 fans powered by electric motors. For large installation there is sometimes a need for additional air handling units to be installed

The fans usually alternately to maintain pressure within the cushions, with only one fan running at any given time. In the event of a cushion failure, adverse weather conditions or a drop cushion pressure, both fans will run simultaneously to maintain a steady pressure

Power failure: In the unlikely case of a power failure, the ETFE cushion system will maintain pressure for between 3 and 6 hours before deflating (dependent on weather conditions). It's therefore recommended that they be a standby by generator or alternatively a cable bracing

arena is to be lit by about 8,840 panels which will cover an arena of about 14,160 sq. meters. The energy will be enough to power the stadium lights and two jumbo vision screens. Also the energy will still be enough to light up all the accommodation proved in the stadium.

All kitchens appliances like shovel will mostly be gas operated to help reduce on the cost of the energy been generated by solar panels. The

stadium design also integrates additional green features such as permeable paving and the extensive use of reasonable, domestically made materials

which is converted into DC electric Power by photovoltaic (PV) effect produced by the PV cell in the panels. This DC electric power is feed to a battery which stores energy. This DC power is converted to AC power of the inverter and the AC output of the inverter feeds the mains from where various application draw electric power.

7.2.1 BASIC ELECTRICAL DIAGRAM

The working of a solar power plant comprises of a bank of solar panels receiving sun' s energy

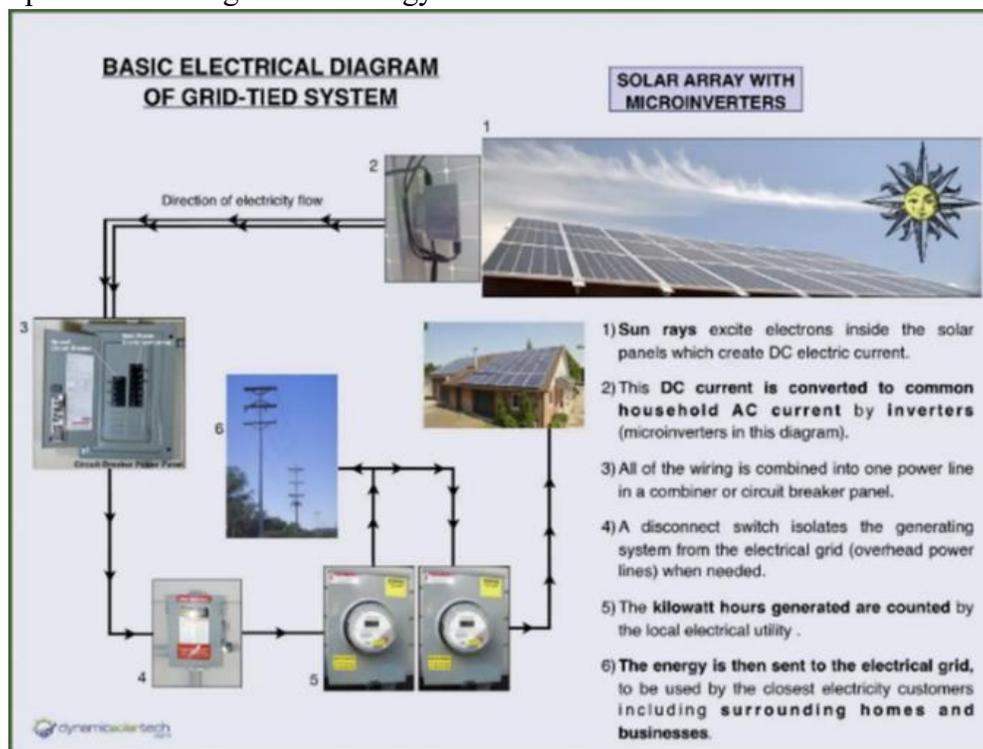


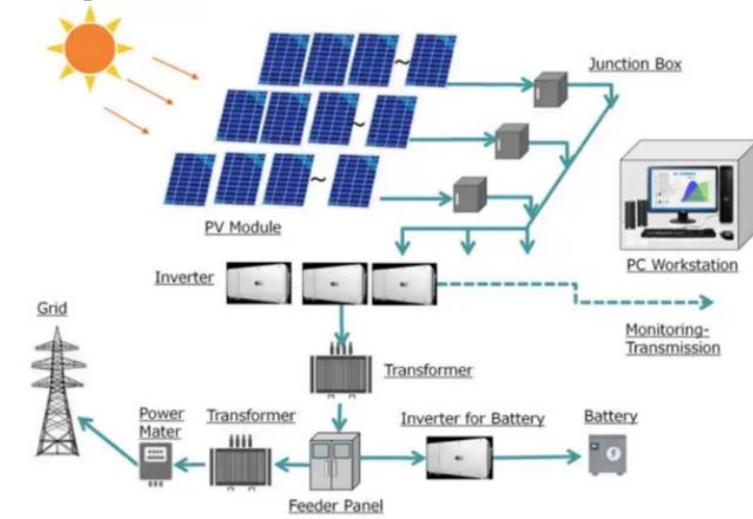
Plate 3.1 Basic Electrical Diagram

Source: <https://kenbrooksolar.com>>solar power plant

7.2.2 INSTALLATION OF A SOLAR POWER PLANT

Power plant can mainly be installed in three way

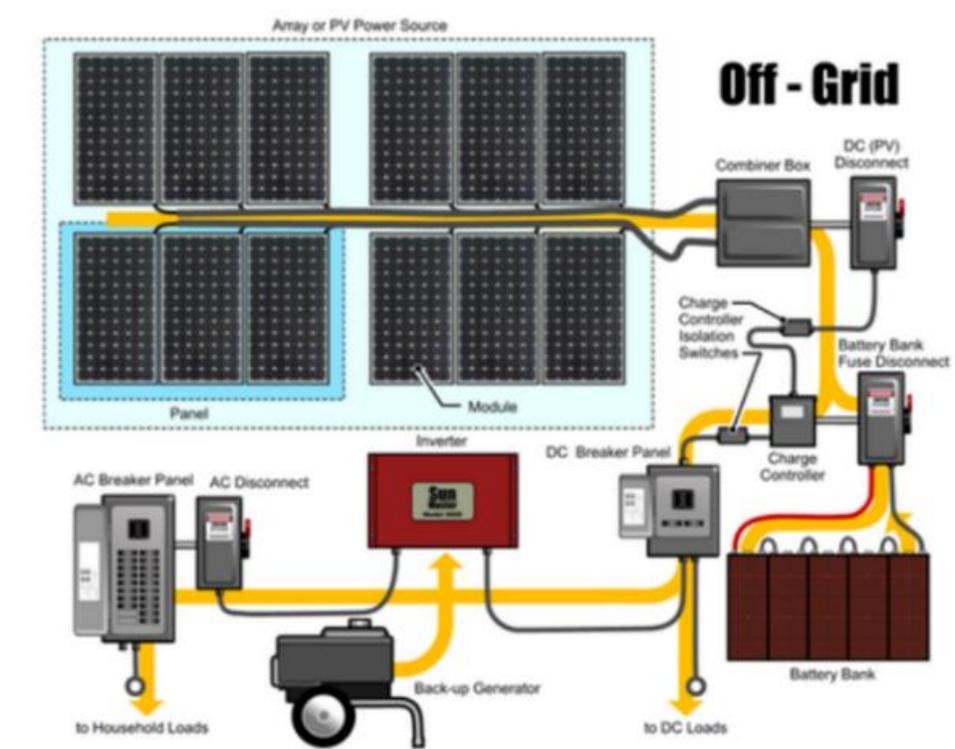
I. on grid solar power plant



Source: <https://kenbrooksolar.com>>solar power plant

Figure 3.2

Off grid solar power plant



Source: <https://kenbrooksolar.com>>solar power plant

Figure 3.3

- II. **Hybrid grid solar power plant:** this usually is a combination of the on grid and off grid solar power plant.

For this stadium design we will adopt the off grid solar power plant since there are no existing power grid on the proposed site. But future consideration can allow the use of an on-grid solar power plant if the some power grids are sited on the site or near the site.

Advantages of solar energy

- ✚ No harmful emissions are produced
 - Reduces health risks
 - Reduces dramatic changes in the environment
- ✚ Reduces health costs
- ✚ Reduces costs to stabilize the environment

7.3 STADIUM WATER SUPPLY AND PRESERVATION

BRIEF HISTORY

Stadiums consume enormous amounts of water primarily for toilets and irrigation. It is estimated that the Gillette stadium, home of the New England Patriots, consumes between 600, 000 and 1 million gallons of water at every NFL game. Older stadiums generally did not deal with water issues on-site. At the ancient Olympic stadium they carried water from half a mile away – in Europe many of the older stadiums were merely bleachers, with no facilities on site.

Recently stadium have begun to seek long term solutions. At the new meadowlands stadium water consumption has been reduced by 25% approximately 11,000,000 gallons per year. Stadium Austria reduced their water consumption by 56 percent through the use of on-site water

harvesting. In order to make significant reduction innovative solutions are important, but often the first step is an assessment of where water actually needs to be used.

7.3.1 STADIUM WATER PRESERVATION

The average football stadium urinal is used 160 times during the course of one game and can consume up to 40,000gals of water per year. It's important that every male toilet in a stadium be fitted with falcon water free urinals which help to conserve water as well as limit maintenance on leakages that result from heavy abuse from fans. Installation is straightforward; the device can connect to any typical 2'' drainage system, allowing low cost retrofits.

All remaining toilets, sinks, aerator and showers in this stadium will be of low flow design as this has shown to help in the reduction of water usage.

All the innovations disused in this chapter are to be adopted and used in the design of the solwezi ultra-modern stadium to help reduce on the usage of water in the stadium. Rain harvested water will be one of the mechanisms of supplying water to the stadium and also a large water tank will also be sited on the site to help in the storage and supply of water to the stadium in an event that the rain harvested water finishes.

7.3.2 STADIUM WATER SUPPLY MECHANISM

RAINWATER HARVESTING

Rainwater harvesting means the technique used for collecting the rainwater and storing it by using

various means of different resources for the future use. The purpose of cultivation, irrigation etc. The rainwater can be collected into the natural reservoirs or artificial tanks

Another method for collection is infiltration of surface water into the subsurface aquifers before getting lost by surface overflow. The harvesting of the rooftop is also a method of collecting rainwater. There can be a continuous seasonal crop harvesting using the collected rainwater even in the lack of regular water supply. When it rains, rain water gets collected into the man-made ponds or tanks

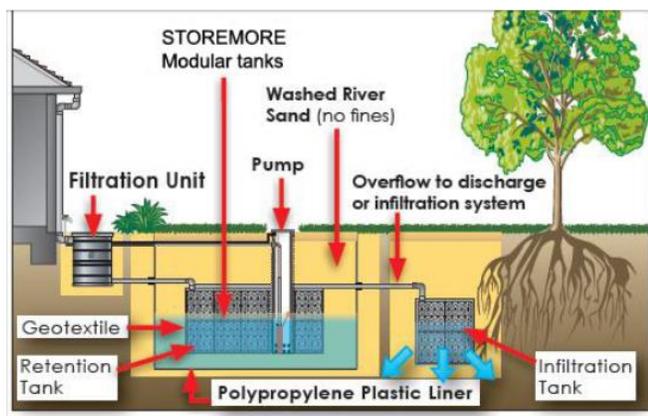


Plate 3.4 Water Harvesting Process

Source: (www.rainwaterharvesting.org)

Integrating rainwater harvesting device in the stadium design is very important. Sports facilities consume large quantities of water- Whether it is used to irrigate a pitch, as a dust binding agent on clay tennis courts or maintain shock-absorption surface in equestrian arena. It is therefore a logical step to collect the rainwater falling on the roof surface and glass surfaces such as football, rugby and cricket pitches.

The stadium building or roof collects rainwater through a siphonic drainage system that is connected to the primary arches of the stadium.

The water then flows to four water tanks located below ground with the capacity to hold 3,200m³ of water. The water is primarily used in irrigating the grass, toilet flushing, sinks, urinals and will led to a 56% reduction of water compared to other facilities of equal size.

For purposes of drinking water, this will be supplied directly from the water tanks through gravity. Water in these tanks will supplied via borehole, where water will be pumped into the large concrete or steel tank that is erected height twice to the building it will be supplying water. Supply is via gravity and no

Electricity will be required to supply the water to the stadium but will only be required during pumping for a just a short period of time.

8.0 CONCLUSIONS

In conclusion the new stadium design for solwezi is meant to improve the appearance and development of solwezi town and northwestern province at large. The design is to be athletically pleasant to the general public both from the sky view and ground view, the inside of the stadium and the outside of the side and will incorporate all modern architectural advancements available now.

The roof and outside layout of the stadium is be made entirely of ETFE FOIL PLASTIC PANELS which will be supported on aluminum and steel space frame or trusses. The roof will curve, creating an arc like bubble façade shape which creates a dramatic central cathedral -like space, and tapering towards the edges of the building to provide areas that are more intimate.

The interior of the swimming pool area and the all in sport hall building is protected from strong

sunlight by roof overhangs and tubular steel shading system, which, at the same time allows clear views of the outside. See figure below

The stadium design as already discussed will be a four story building and will also include all the necessary auxiliary facilities such as;

- ✚ Shops and snack bars
- ✚ Conveniences
- ✚ Supporting offices space
- ✚ VIP lounge
- ✚ Police post
- ✚ Clinic
- ✚ Accommodation
- ✚ Indoor sports halls
- ✚ State of the art changing rooms
- ✚ Well-defined road network
- ✚ Parking slots

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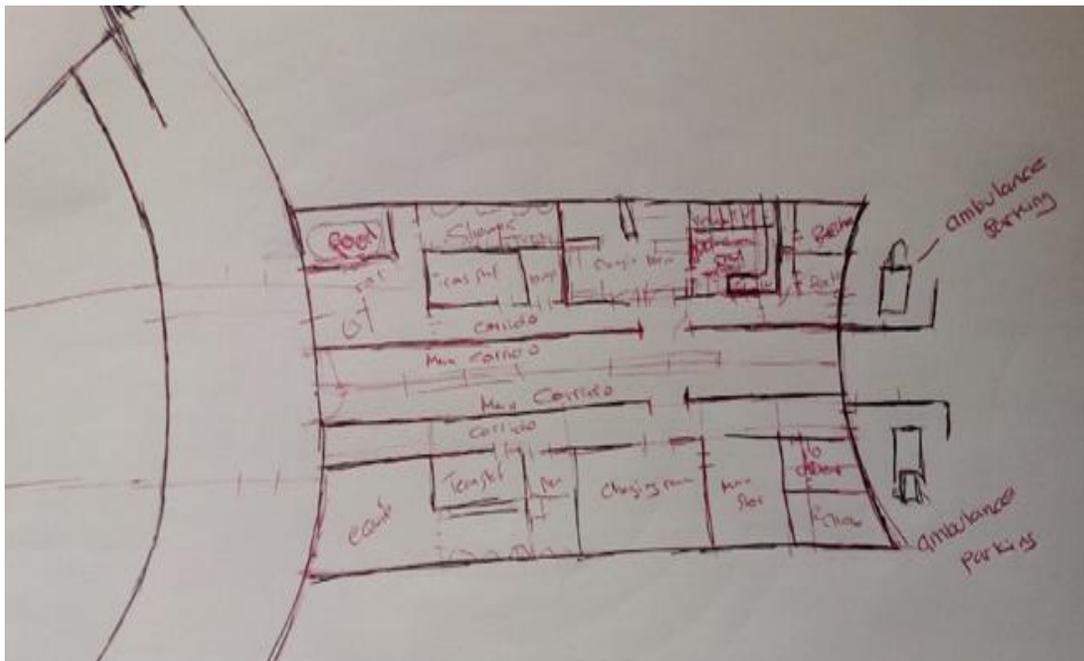
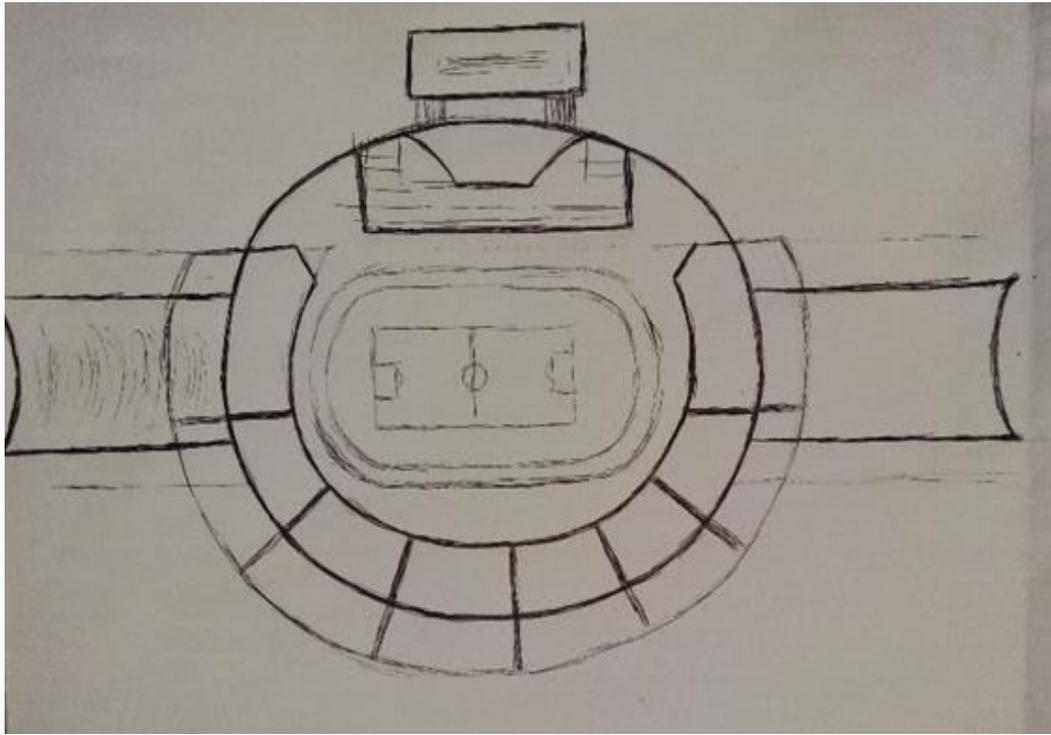
Mr. Martin kapongo, for his supervision and constant support. His valuable help of constructive comments and suggestions throughout my field in the thesis, and really his work has contributed to the success of this research. My appreciation is for his encouragement, motivation and support throughout my field in thesis.

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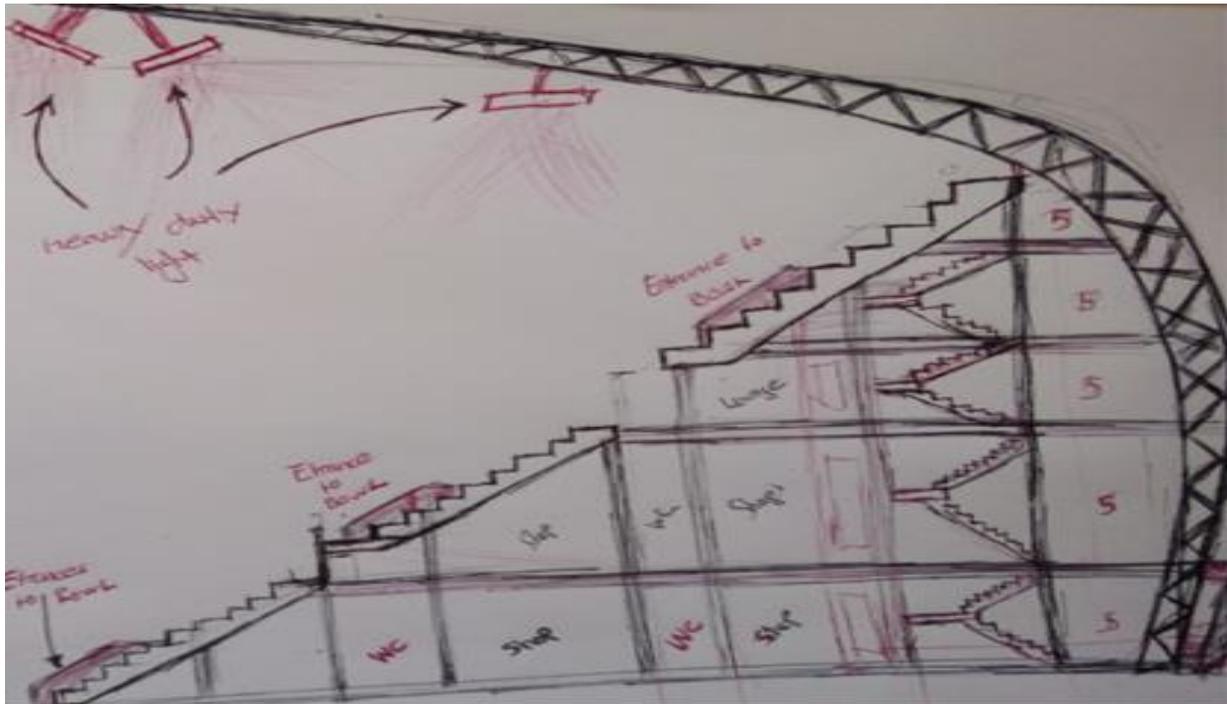
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FIGURES: Sketches

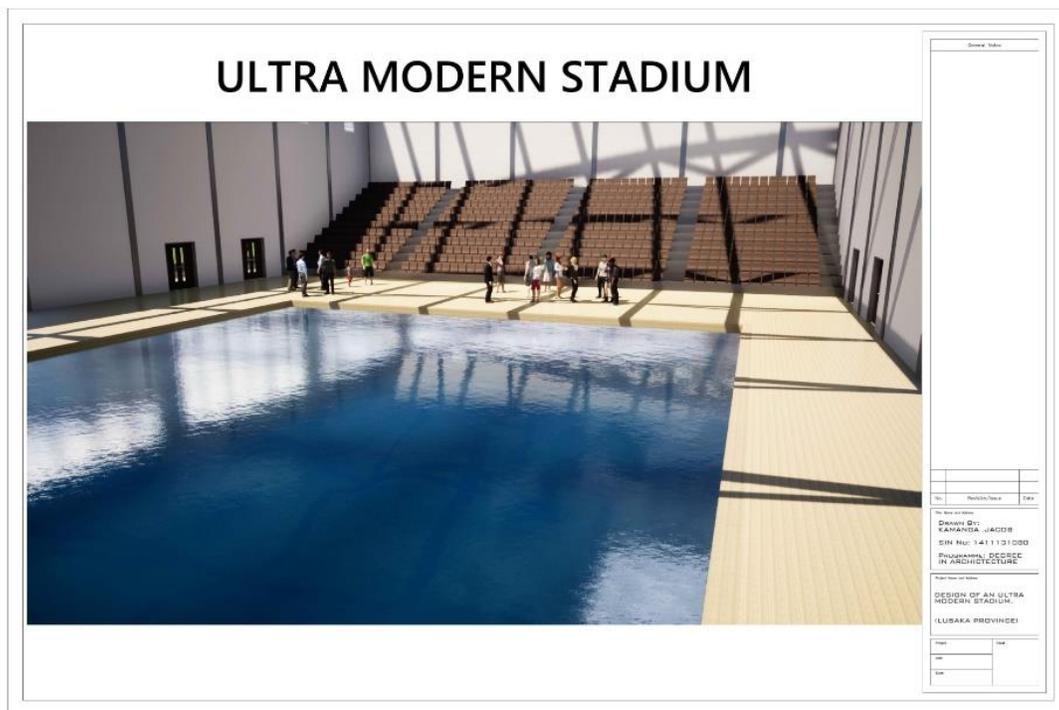


Source: Author for all Designs

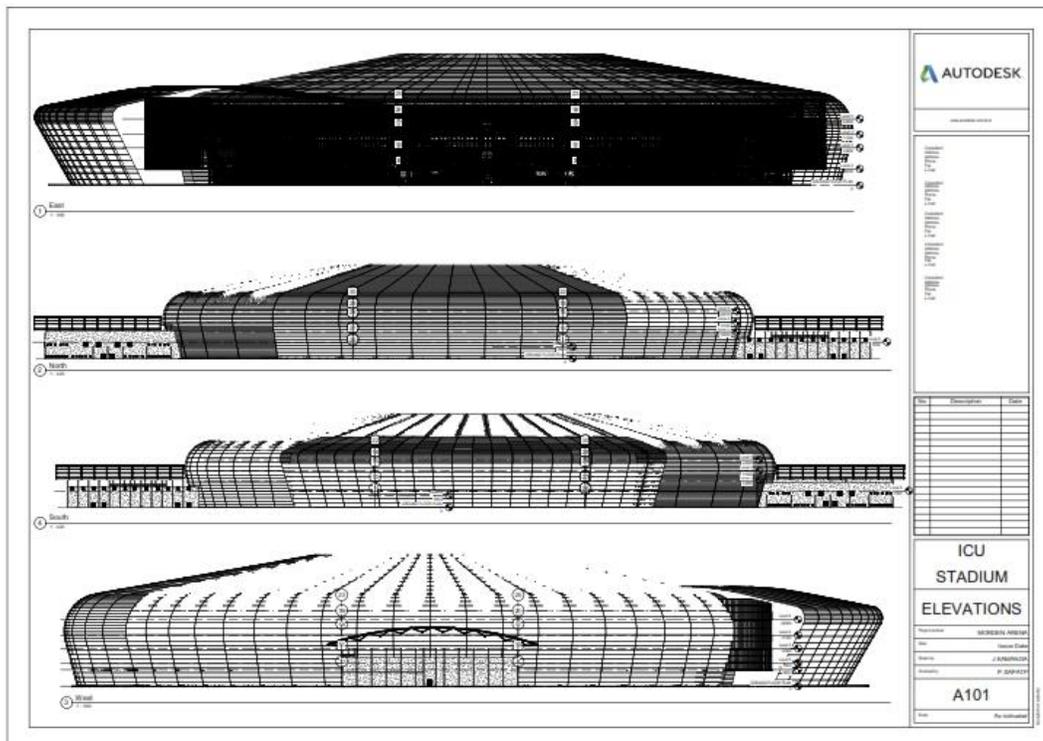
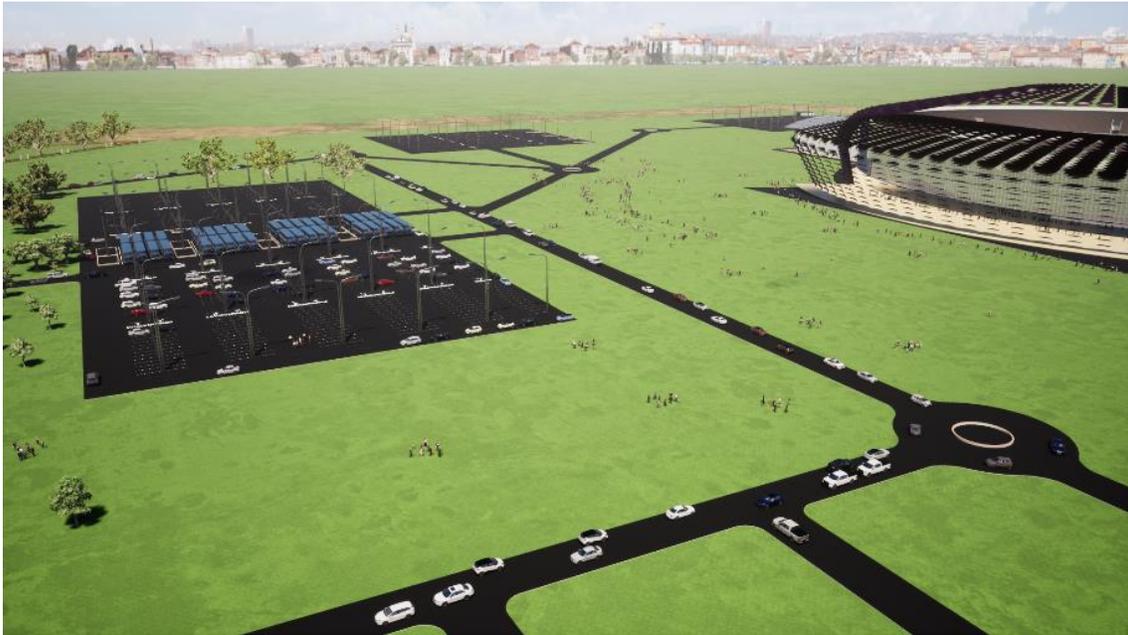


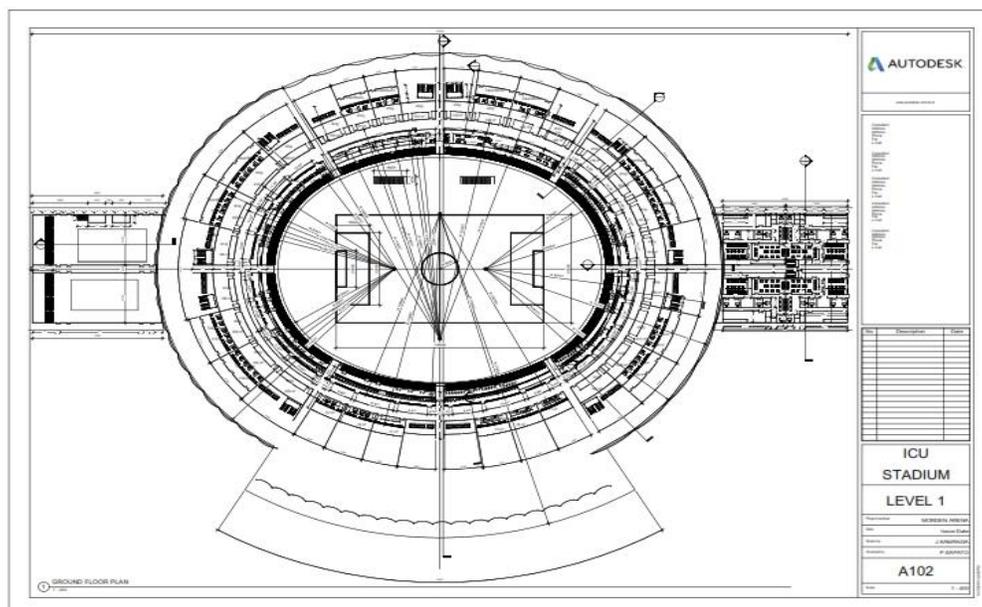
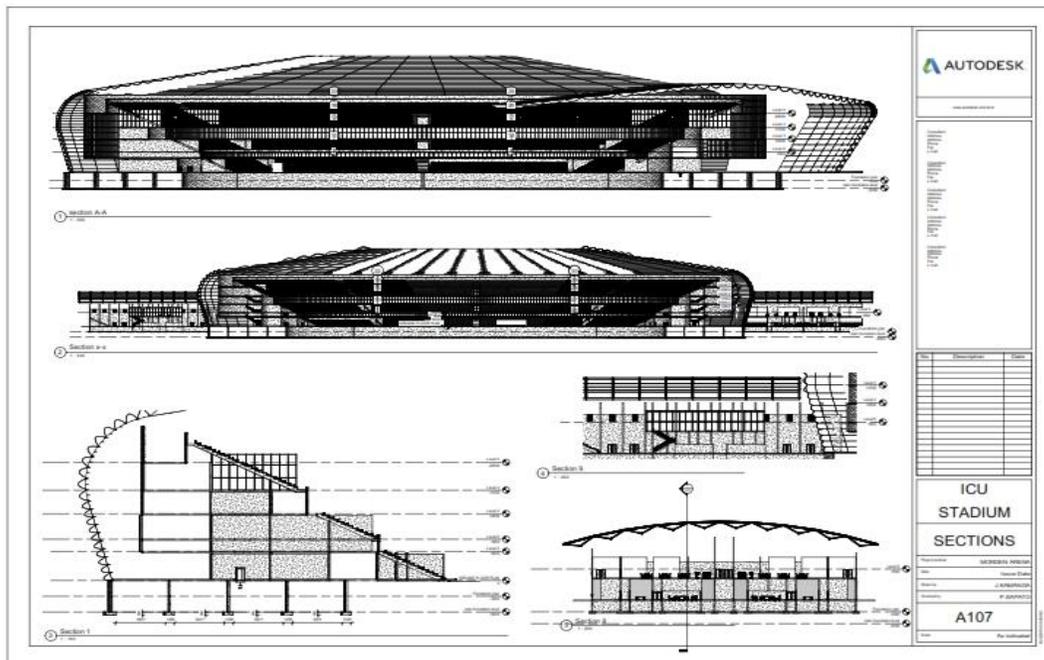
FIGURES

Source: Author for all Designs



Source: (Author for all Designs)





Source: (Author for all Designs)

