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RESEARCH ARTICLE OPEN ACCESS

DYNAMIC STRUCTURE FOR AIRPORT- study on structural features of Kempegowda International airport (KIA), Bangalore

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ABSTRACT
Dynamic architecture is an important step ahead of the architecture of the future development of increasingly widespread works. The idea of dynamic architecture was derived with the desire to have buildings that adjust themselves to life, which are part of nature our building in which roof changes their shape continuously and never looks the same.
I call them buildings designed by time shaped by life to imagine a roof of the building that can deformation in shape according to needs and whims, allowing them to decide their light exposition and view to the sky. Architecture seems today as an expression of artistic imagination as most architects are competing in designing buildings that can become iconic to their particular shapes. This particular building is visually dynamic it has movement in 3 dimensional way due to adjusting the height of the roof we can get a lot of deformation in a roof-like curved, straight, symmetric, asymmetric oblique and unlimited shapes to achieve this by using a hydraulic pump, elastic roof sheet, rolling sheet connection, etc many more all the above thin are connected to non-load-bearing members. Without disturbing load-bearing members in the roof structure. Thus the roof structure is adopting for Kempgowda international airport (KIA) Bangalore without changing the column position of the present structure.
KEYWORDS: Truss system, cable system, Hydraulic jack, dynamic flow.

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I. INTRODUCTION

Kempegowda International Airport is an international airport serving Bangalore, the capital of the Indian state of Karnataka. Spread over 4,000 acres (1,600 ha), it is located about 40 kilometres (25 mi) north of the city near the village of Devanahalli. It is owned and operated by Bangalore International Airport Limited (BIAL), a public-private consortium. The airport opened in May 2008 as an alternative to increased congestion at HAL Airport, the original primary commercial airport serving the city. It is named after Kempe Gowda I, the founder of Bangalore.

Kempegowda International Airport designed by HOK. The expansion of Terminal 1 repositions South India's busiest airport as an important hub for international travellers and cargo. The structure creates a grand, dramatic presence that blends with the existing terminal.

Present it is mixed with both pinned support columns and plated roof structure. The roof undulating shape forms a canopy that protects passengers and visitors from the elements. Its structural system includes a monolithic plinth with elegant steel branches that pass through a suspended ceiling to meet the structure above. It is static in structure but dramatic in presence in view. Through this, we can't feel as a dynamic structure visually that's why we are innovating a new design roof structure that can change their shape continuously and never look the same.

The passengers who are coming to the airport should not feel bore by looking at the same roof structure. We have to give intension to them to know how it works and how it keeps on changing the roof and make them feel like a galaxy before flying the flight to this we made visually dynamic or animated roof structure at the airport.

BACKGROUND

The background of the study is to learn the roof adapted to airport Kempegowda international airport with relevance to dynamic architecture this

study is direct towards an understanding of dynamic architecture only some parts of the building with reference to planning, architectural characters, and material usage and construction techniques. The roof was made to keep on changing their shape continuously and never looks the same. The roof is changing its shape, size but well protected from the weather conditions and creating skylights at a different position at any time. The structure is changing in the position but there is no structural drawback.
This document is trying to tell how we can create a roof structure to get a visually dynamic flow in the building.

NEED FOR STUDY

The documentation of KIA Bangalore was to obtain real life experience of the still existing dynamic architecture exclusive to the India provisions. The motive of the study was to understand how dynamic architecture works in the form of roof structure and to get multi zones construction and whims of the passengers and use them in our project our design flexible, sustainable, imaginary structure and also ensure the dynamic style specifics to that area.

AIM

To study dynamic flow in airport roof structure by using truss structural system.

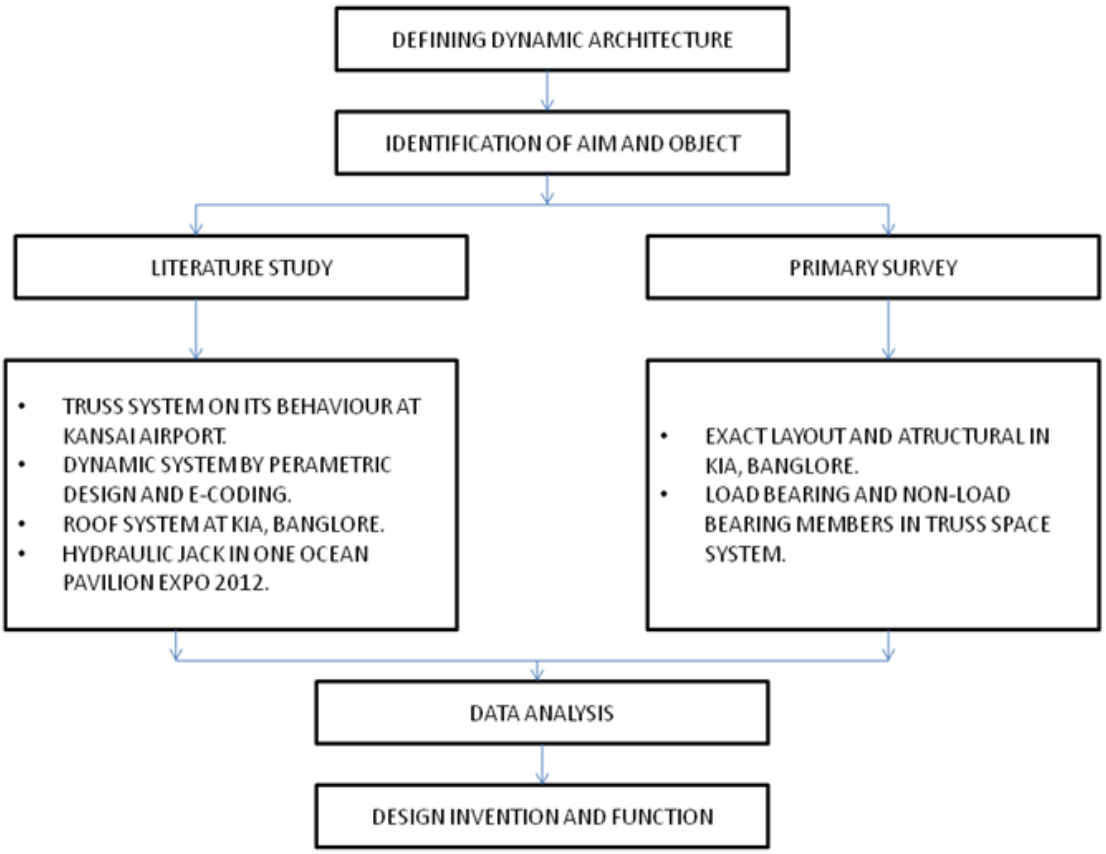
OBJECTIVE

- To study the different structural system presently employed for the airport design.
- To study of the existing structural system building layout in Bangalore airport.
- To propose design guidelines, integrating dynamism structural system into Bangalore airport.

SCOPE

- Detail study on structural, dynamic system.
- Dynamic structural system which can be constructed in any type of zones, soil and it is independent upon structure.
- Dynamic structure came from expansion-compression and hydraulic pressure system.
- Dynamic flow will be by changing of roof structure shape and function.

METHODOLGY



II. LITERATURE STUDY

a. TRUSS SPACE STRUCTURE SYSTEM, KANSAI AIRPORT, OSAKA, JAPAN.

This research paper is written by Fermanto Lianto, who is a senior lecturer at the department of architecture, Tarunanagara University, Jakarta, Indonesia.

This paper is published on 11th November 2018 which was written in September 2017 (IJCIET JOURNAL VOLUME 9).

This paper mainly focuses on development on architectural works by using the truss structural system their methods and material usage. Mainly focused on the truss frame structure, truss space structure, space frame structures.

This article is written based on the principals of truss frame structures and truss structural system. The motive of this study is to absorb the stability of the system, truss forces, truss design, and height of the trusses with comparing to the type of trusses.

Principals of the truss system

1. Stability of the truss system

Each truss system is a stable arrangement of triangular shape (Figure A) so that it can't change it shape or collapse. A collapse will occurs if truss system is unstable not forming a triangular patterns under burden (Figure B).

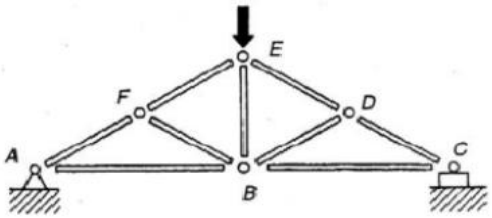


Figure A

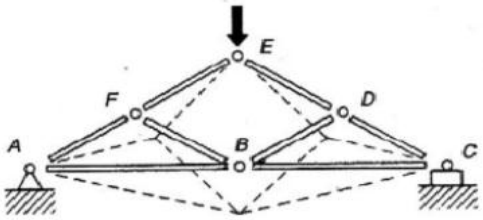


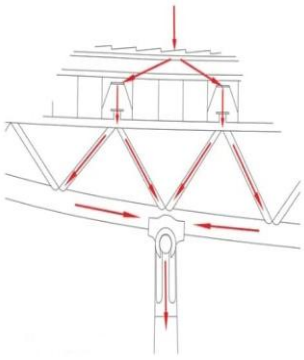
Figure B

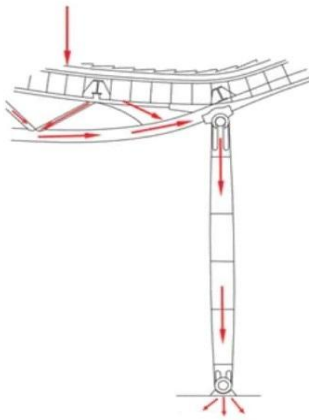
2. Truss-Assumptions

There are 4 main assumptions made in the analysis of truss

1. Truss members are connected together at their ends only.
2. Trusses are connected together by frictionless pins.
3. The truss structure is loaded only at the joints.
4. The weights of the members may be neglected.

The major component that makes this airport have a triangular truss system with long horizontal supports in one way direction through the pin support columns and there is no secondary truss in the structure which is perpendicular to main truss. The total roof structure load is bearing on this horizontal truss system.





Transformation of load from roof structure to columns

Source
https://www.barthe.net/jgallery/airport.htm (Retrieved on September 26, 2018 [9])
http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=9&IType=11

b. Dynamic architecture systems(parametric design and digital fabrication towards conversational customization)

This research book is written by Mateus Van Stralen. He is an assistant professor at UFMG, a researcher at LAGEAR and director of KUBUS4D. He is a member of the Scientific Committee of the Iberoamerican Society Of Digital Graphics (SIGRADI) and a reviewer of the journal Kybernetes (England).

This paper is published on 28th December 2018.

This book is mainly focused on several chapters like virtual reality devices for architecture design learning, parametric design, and digital fabrication, the machines for living in the conventional age, Metadesign against control by the restriction in architecture.

The chapter of parametric design and digital fabrication mainly focused on the ability of parametric designs to generate variations and bespoke products, combined with the capability of digital fabrication to render this variety physical enables the mass production of non-standard products. These parametric designs mainly used for dynamic structures by given a coding system. The total dynamic structures are controlled through computers according to the design module.

This paper addresses the idea of parametric design or democratization of designs with a critical viewpoint and advocates for a different perspective of design democratization based on conversation cycles and the copying, transforming, and sharing code. The kinetic structures are controlled by this method to function according to the design module.

Source
https://www.researchgate.net/publication/331261234_Dynamic_Architectural_Systems_Parametric_Design_and_Digital_Fabrication_towards_Conversational_Customization

c. One Ocean Thematic Pavilion EXPO 2012, designed by Soma

Architect: Soma Architecture with local partner DMP architects
Location: Yeosu, South Korea
Status: Complete
Materials: Glass- fiber reinforced plastic
Process: Bio mimetic design exploration
Fabricator: Local fabrication with Soma Architecture, DMP Architects and Knippers Helbig

This building is an example of kinetic architecture by changing the facade elevation by twisting fins. Soma drew its inspiration for the facade by studying the natural's sway of various types of vegetation. Because of its high tensile strength and low bending stiffness, glass fibered reinforcement plastic was an idea for the construction of 108 twisting fins that would give movement to the facade. These movement functions through the hydraulic jack below part of fins by the following figure.




Process to get dynamic facade

He is first architect who use the hydraulic machines to get a kinetic facades in a building.

Source
https://archpaper.com/2012/06/south-koreas-expo-2012-pavilion-active-facade/

d. Canopy roof form of KempeGowda International Airport

It was designed by HOK architects in 2008 May it is a great example of dynamic architecture in the presence of a dramatic field. The dynamic architecture is in the roof structure.

These sources describe the following questions how airport had constructed

1. How they achieved canopy form?
2. Types of materials used for different structural members?
3. The connection between the structural members?
4. How the roof structure is protected from the weather conditions?
5. The low transformation from the roof to the column?
6. How the process is taken to complete the structural system of the airport?
7. How the steel braces are suspended roof to above the ceiling?

Source

https://www.arch2o.com/kempegowda-international-airport-hok/

PRIMARY CASE STUDY

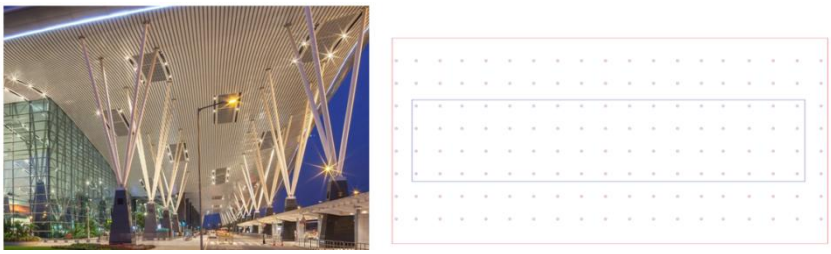
Structural Members In Kempegowda International Airport

a. Columns

1. There are two directional columns placed in a rectangle shape.
2. There are 144 columns arranged in 18X8.
3. It is a pin supported column.
4. Each column has four-pin supported members which elaborated like a tree.
5. The column is made up of two materials.

a. 1.RCC
b. 2.STEEL MEMBER

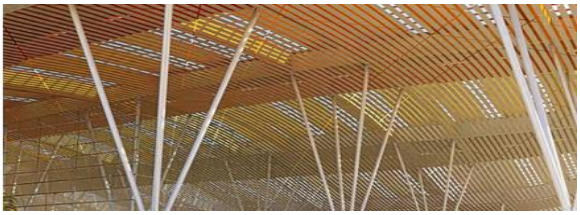
6. RCC material is used from ground level to 6 meters and Steel member is used from 6 meters to roof structure.
7. The distance between the two columns is 16 meters.
8. Distance between the pins supports at each column.
9. At ground level 0 meters.
10. At ceil level 6 meters.
11. All columns are in different heights and different positions to achieve a cured roof structure.



COLUMNS AND PLAN LAYOUT

b. BEAM

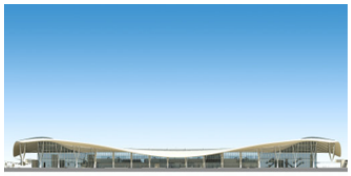
1. It is a PEB structure.
2. It has inverted U shape.
3. If the column height is varies the size of the beam also varies.
4. The beam is connected in two directional ways.
5. The beams are designed in curve shape according to the heights of the column and the roof design.
6. It made up of steel.



BEAM

c. ROOF

1. There is a grid connection between the beams to get stiffness to the roof structure. Large over hang roof, the use of low e-glazing reduce unwanted heat gain to create an energy efficiency high performance structure.
2. Skylights enable natural light to penetrate from above thinking the atmosphere and spacious feeling of original building with expression.
3. The material of a roof structure is silver metallic and bright white finish recall the hi-tech nature of the city.



FRONT VIEW

SIDE VIEW

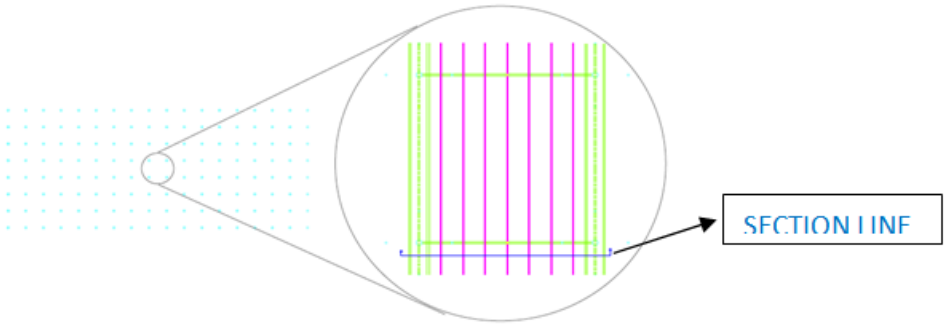
d. CONNECTION BETWEEN THE STRUCTURAL MEMBERS

1. Columns and beams are connected by pin and hinge connection.
2. Bracings and beam is connected by bolting system.
3. Roof and braces are connected by ribbed bolt system.

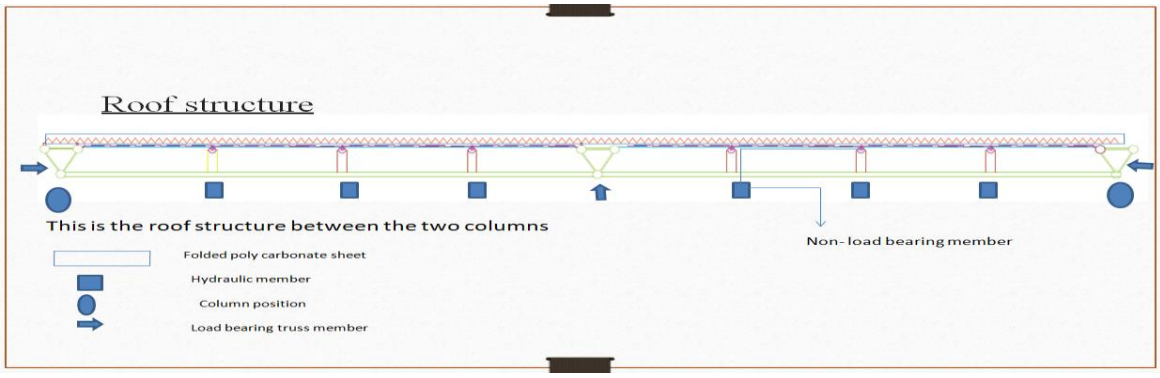
DATA ANALYSIS (ADAPTING ROOF STRUCTURE)

The main idea is to create movement in the roof structure. For that, we have chosen dynamic architecture as a concept according to the literature data and primary case study finally roof structure should work under the hydraulic machine and e-code system. By using these two the kinetic roof structure can achieve.

We are adapting this roof structure to KIA Bangalore without disturbing any design and structural members other than the roof system. The settlement roof structure in the airport as placed without changing the column position of the present design.



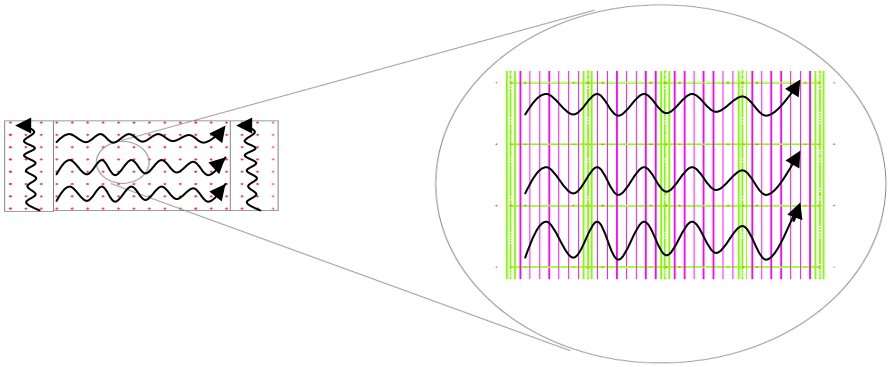
PLAN LAYOUT AND TRUSS PLAN BETWEEN THE TWO COLUMNS



The major components involved to get movement in roof structure are

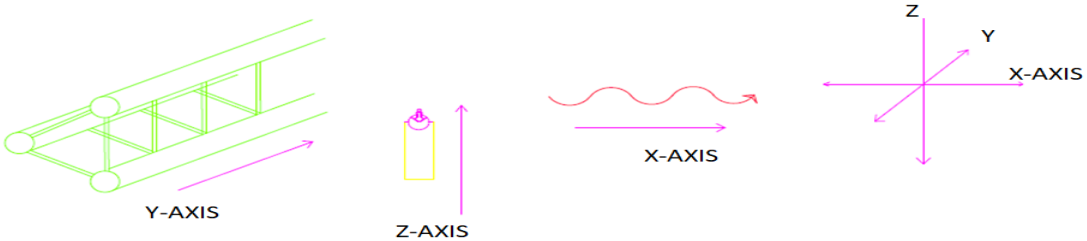
1. Triangular shape truss space system.
2. Non load bearing (like purlins).
3. Hydraulic jack.
4. Roof sheet.
5. Cables (e-coding).

We are going to create a movement in roof structure as shown in below plan.



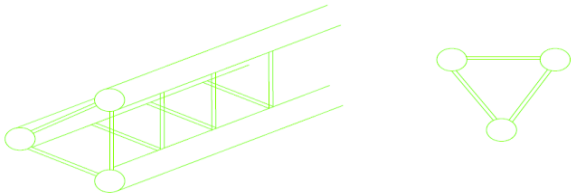
MOVEMENT OF ROOF STRUCTURE

If you see the plan in 3-D the roof structure moves or roof wave moves along the X-Direction then the triangular truss faces along Y-Direction and vice-versa. Hydraulic jack always functions towards the Z-Direction which is perpendicular to both truss system and roof movement.



TRIANGULAR TRUSS SPACE SYSTEM

If we have taken a section between the two columns as you have seen above movement in the roof structure if truss place along X-axis the roof movement in Y-axis. They are two main trusses and one sub truss in between two columns. The main trusses are placed above the columns and the sub truss is placed to support the hydraulic jack supported member. The edge trusses are load-bearing members which transfer the load from roof to column. These trusses are static position without involving in a dynamic process.



NON-LOAD BEARING MEMBERS

These members are placed along the parallel to the trusses and connected between two hydraulic jacks and roof sheets. These are movable members in the system along the direction of hydraulic jack. These are made up of steel and placed in between two columns for next two columns it having a separate pipe, it means for every two columns there will be two hydraulic jacks and one non-load-bearing member.

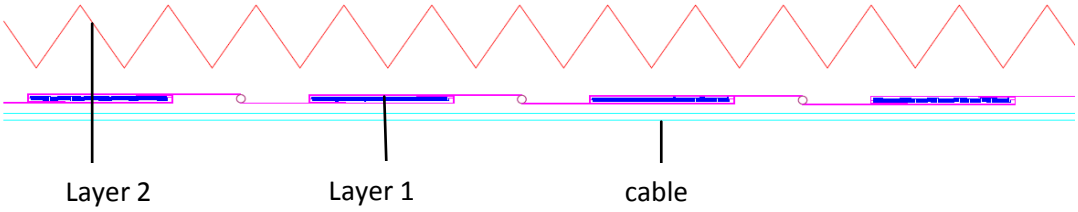
HYDRAULIC JACK

It is used to lift the non-load-bearing member to change the hydraulic roof continuously. These hydraulic jacks are placed on the load-bearing member, which is connected to columns and perpendicular direction to the truss system. These are operated by a coding system according to the design module.

ROOF SHEET

Dynamic movement majorly appears in the roof sheet for that the roof sheet should be expandable, flexible, rotatable, and also reset from the weather condition. We have created an innovative roof sheet to overcome the all above problems that are described into two layers.

1. To get movement.
2. Resist from weather conditions.

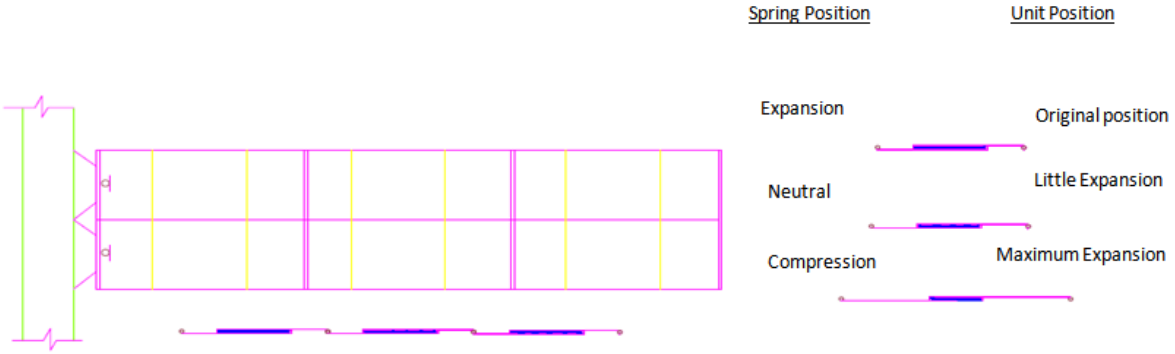


ROOF LAYER 1

To get movement it should be expandable, flexible, and rotatable.

1. To expand the sheet we used a spring.
2. To rotate we used a hinge between the two-unit roof sheets.
3. To get flexible we have used steel as a material.

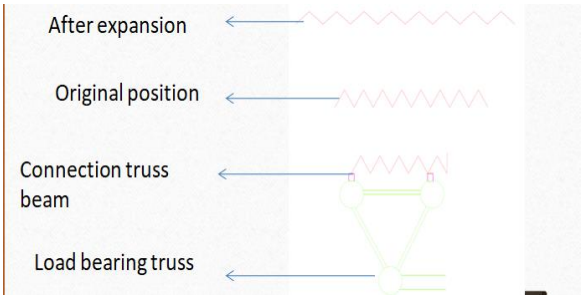
Sheet design and how its function with dimensions



ROOF LAYER 2

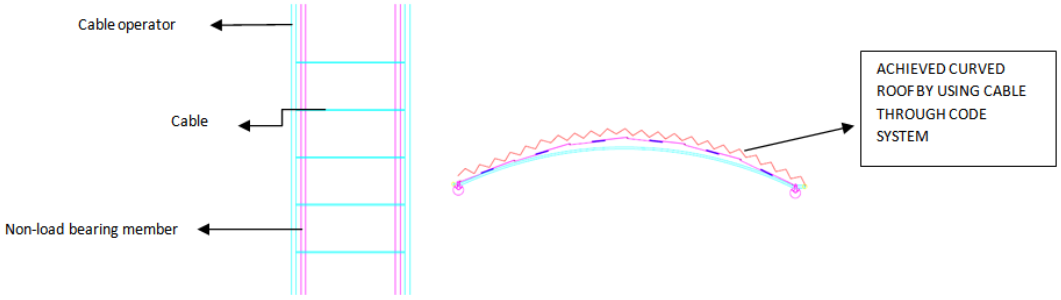
The second layer which protects from weather condition we have created a folded sheet as shown in the figure. It is made up of two layers.

1. The first layer made up of a polycarbonate sheet. It is used to protect from weather conditions.
2. The second layer made up of the ETFE (Ethylene Tetrafluoroethylene) sheet. It is used as a solar panel.



CABLE

Cables are used in between to non-load-bearing members along with the members which help to make a curve roof form by using the code system as shown in the figure.



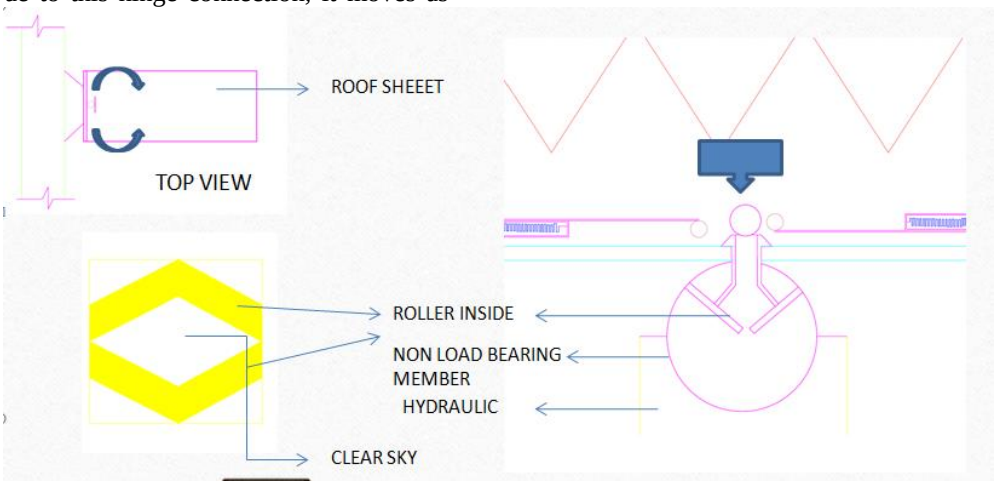
PLAN AND SECTION FOR CABLE IN TRUSS SYSTEM

CONNECTION BETWEEN THE MEMBERS

1. Column and beam are in hinge and pin connection.
2. Roof sheet and members' connection.

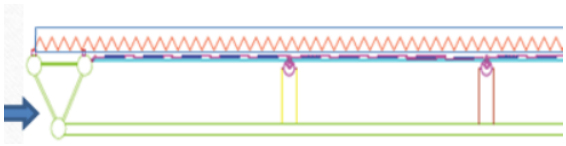
a. Connection to non- load-bearing member as shown in below figure there is a roller like structure inside of it. It helps to hold the roof sheet. There is a hinge connection between the roof sheet and roller these rollers are controlled by the code system. Due to this hinge connection, it moves as shown below. When hydraulic jack lift non-load bearing member at one side there is increasing in length to the non-load bearing member. Due to this, there will be a gap between the roof sheets unit to adjust these roof units the rollers are used. By getting a gap between these units skylight will create a different position and shape.

b. It is a fixed connection to the truss member as shown below figure.

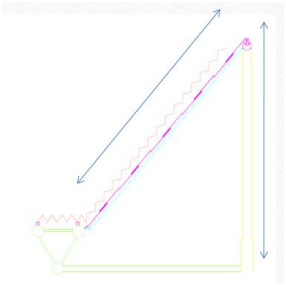


FUNCTION OF ROOF SYSTEM

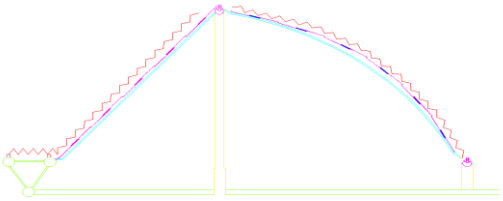
To get movement in the roof structure, the function of the roof system is as shown below.
Whenever the hydraulic jack starts working the non-load-bearing member starts moving upwards, the elastic roof sheet starts changing its shape from plane to triangular form, from here by using cables which are attached to roof sheets. We can transform into different shapes like curve, oblique, and many more.



AT ORIGINAL POSITION

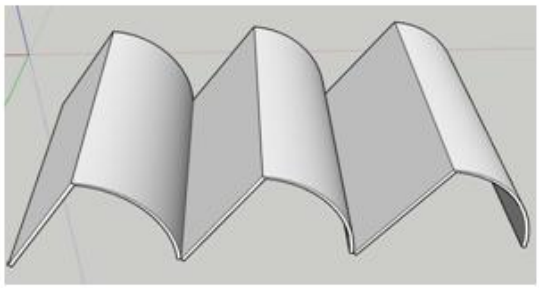


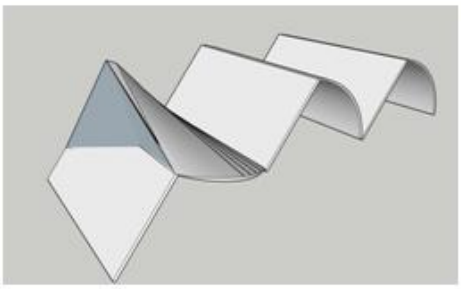
HYDRAULIC JACK LIFT

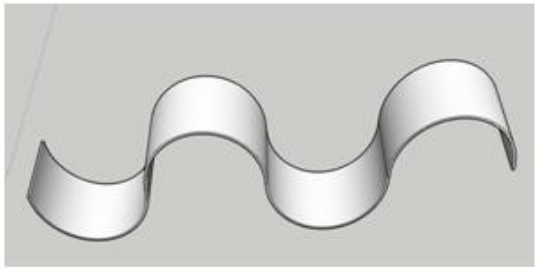


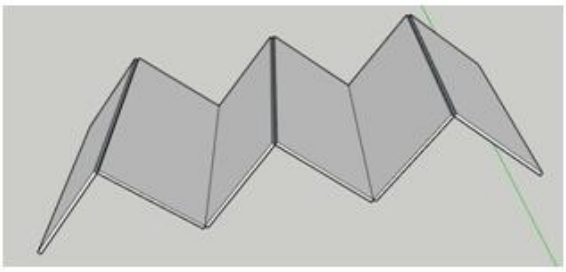
CURVE ROOF ACHIEVED BY CABLES

DIFFERENT TYPE OF SHAPES BETWEEN TWO COLUMNS









We can achieve many more shapes by this design and instant change in roof foam

III. CONCLUSION

The upcoming architecture based on dynamic function. it gives more pleasant and graphical manner. It means human brain thing as graphical view in them minds. We have to innovative techniques for the future years.

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