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Using Approximate Method for the Construction of Mosque Domes

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Abstract:- Domes remain a unique structure in building construction as a result of stylistic forms and composition in the field of architecture. They are important elements that adequately define the Islamic architecture. The construction of domes which is a doubly curved surface and formed by rectilinear structures always resulted in difficulties to get the curvilinear shape correctly. The study therefore made the use of an approximate method to develop the dome using materials that are provided in the locality. The knowledge of descriptive geometry in surface development was adopted to obtain approximation cone components that produce the hemispherical dome. The components were properly installed and supported by centering which composed eight equally spaced timber frameworks that were supported by planks. Lack of appropriate modern technological advancement should not be factor militating against production of perfect forms, thus appropriate technical drawing basic skills should be acquired by the builders to take the construction of dome from a poor to a good system of accurate centering with good quality control.

I. INTRODUCTION

Dome is an important element in the field of architecture and an identity in Islamic composition of roofs. According to Gohnert (2022), domes are shell structures in nature and have meaning in many world's civilizations and many iconic structures of the world make use of domes as architectural centre-piece. Majority of these structures are mainly places for religious gathering such as shrines, temples, cathedrals, mansoleums, mosques and also in sports assemblies, theaters and sports arenas. Dome is a vaulted roof having a circular, polygonal or elliptical base which are doubly curved shells (Elkhateeb, 2012) and can take several shapes or forms which live at the mercy of the architect or designer. Dome is an architectural symbol of Islam (Youssef, 2014) and the king of all roofs (Elkhateeb, 2012) that plays an important role in Islamic architecture (Ashkan and Ahmad, 2010). They have no angles and no corners and an enormous amount of space is covered with the minimum materials and require no interior support for the structure to function effectively.

Being an important element of architecture which resembles the hollow upper half of a sphere, the construction still remains very difficult to form by the builder on the site. As a perfect example of geometry which provides diverse stylistic developments for construction and designs (Korsavi and Ahabadi, 2015) and a tool for understanding any form (Leopold and Matievits, 2001), the dome brings about distinguished symbolism in the architecture of mosques in particular and Islamic architecture in general. The geometrical concepts are commonly used to bring out the form in the construction of the formwork. Formwork assists in geometry realization and development of form using materials such as steel, wood, aluminum etc. According to Johnston (2008), three major types of formwork are identified for various types of form. These are traditional formwork, flexible formwork systems and recyclable formwork. Traditional formwork are mostly fabricated on site using timber/wooden members which remains time-consuming and mostly for regular shapes. Nowadays, free form shell designs are very common which can be achieved using pneumatic systems which are flexible formwork systems (Kromoser and Huber, 2016 and Kromoser and Kolleger, 2017) in technologically advanced countries.

In countries like Nigeria, geometry plays a fundamental role to achieve surfaces of the forms. Geometrical objects in building and civil engineering projects are obtained by methods of development in basic technical drawing. The development of these forms are categorized as developable and non-developable surfaces (Vekariya and Mekwana, 2021 and Kanta, 2015) which are used for curved surfaces. Developable surfaces are referred to as surfaces that can be developed in plane form without cutting or stretching their middle surfaces which are mainly used for singly curved surfaces like arches while non-developable surfaces are surfaces that need to be cut and stretched in order to be developed in a planar form which are mainly for surfaces with double curvature like dome. The development of domes meant for production of the form that are doubly curved surfaces such as spheres, paraboloid, ellipsoid, hyperboloid and helicoid in construction practice. These surfaces are folded and configured on a plane before mounted on the desired form created. This study therefore sought the use of an approximate method in detailing the doubly curved dome to construct the formwork that would produce exact form with striking and beautiful appearance. The study intends to fill the void of lack

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of adequate development skill of appropriate formwork for domes.

➢ *Statement of the problem*

The construction of formwork domes remains a serious problem to the constructor in any mosque project in Oyo town. There are lots of imperfections noticed in the form which results in the loss of shape desired by the designer or the architect that conceptualized the designs. The constructor either looks for natural shapes that resemble the dome and use it as the formwork or use flexible materials to just cast the shape. In most cases the shape formed by rectilinear structures always result in difficulties to get accurate curvilinear doubly curved surfaces. The construction of formwork of these non-developable surfaces does not attract any geometry processing, thus creating architecturally pleasing form in the built environment.

II. METHODOLOGY

The site of the dome construction is Emmanuel Alayande College of Education, Oyo which is under construction. The dome is centrally placed on the building spanning 6m x 6m grid. The dome is the tallest part of the structure as designed by the architect and is a perfect circular form. It is situated on the third floor (above roof) of the building.

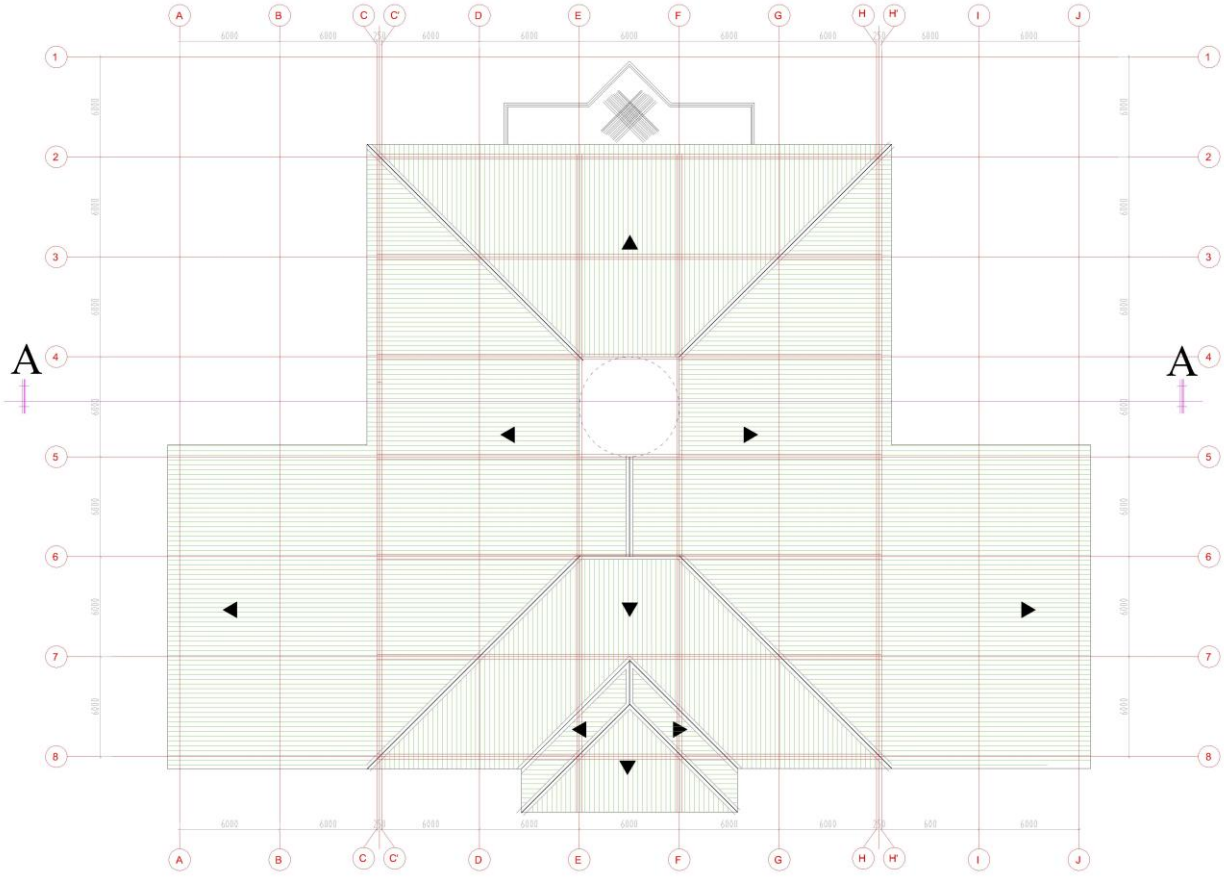

Fig 1: Roof Plan of the Plan showing the position of the dome

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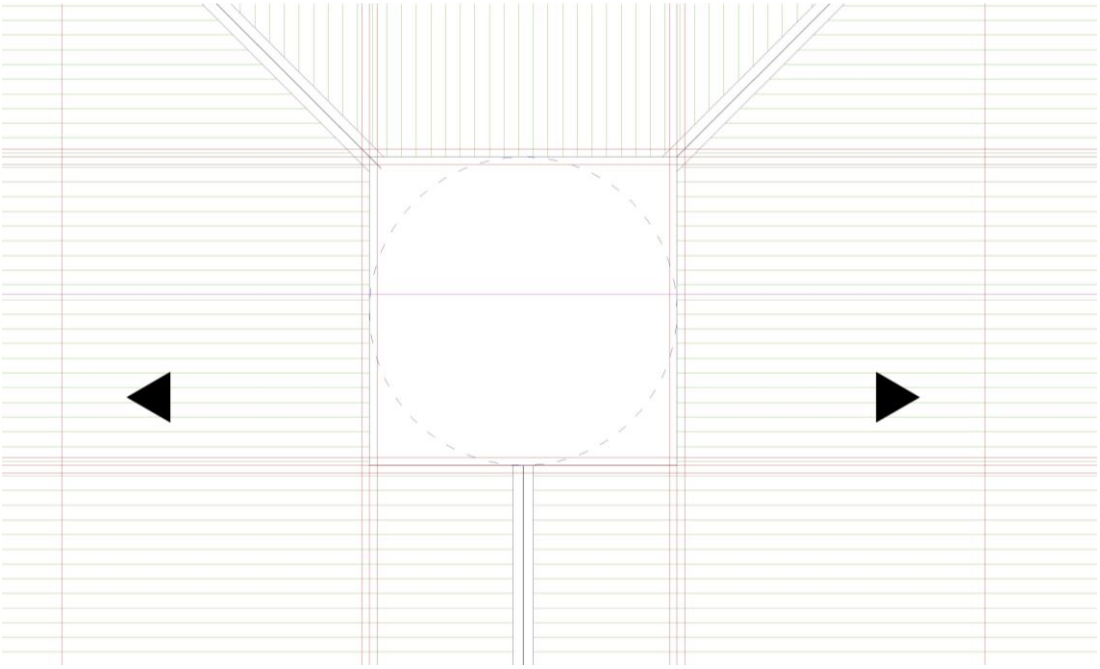

Fig 2: Part of the roof showing the dome

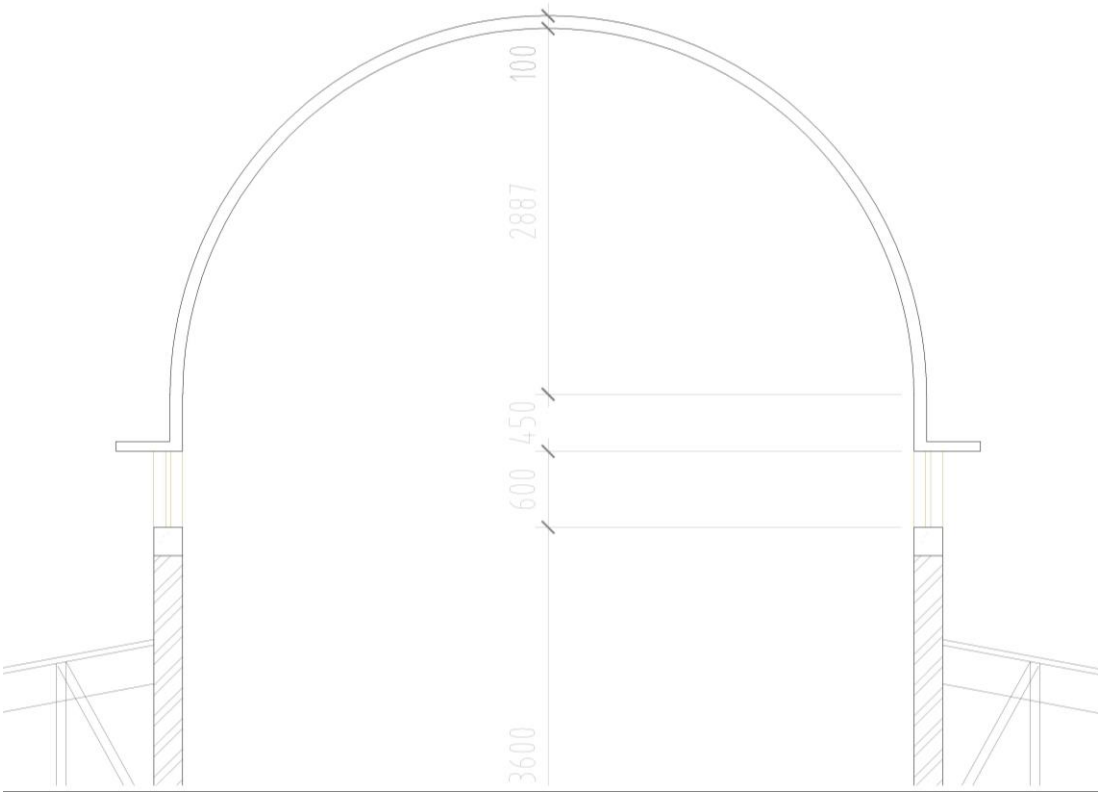

Fig 3: Sectional View of the dome

The material used for the construction of the domes were veneer which has the ability to be bent into curved surfaces, 300 x 25mm wood framework and 50 x 75mm planks as braces. Different nail sizes were used to form the surfaces. The computer aided drafting was also used to model the roof using AutoCAD software for the graphical illustration of development of the dome.

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III. RESULTS AND DISCUSSION

The digital copy of the architectural drawings were obtained from the architect to produce the model of the roof for the construction of the formwork frame. The dome was divided into a geometric layout and broken down into fine segments that depict the surfaces. The plan was divided into eight equal components from which the dimension of the segments making the surfaces were obtained.

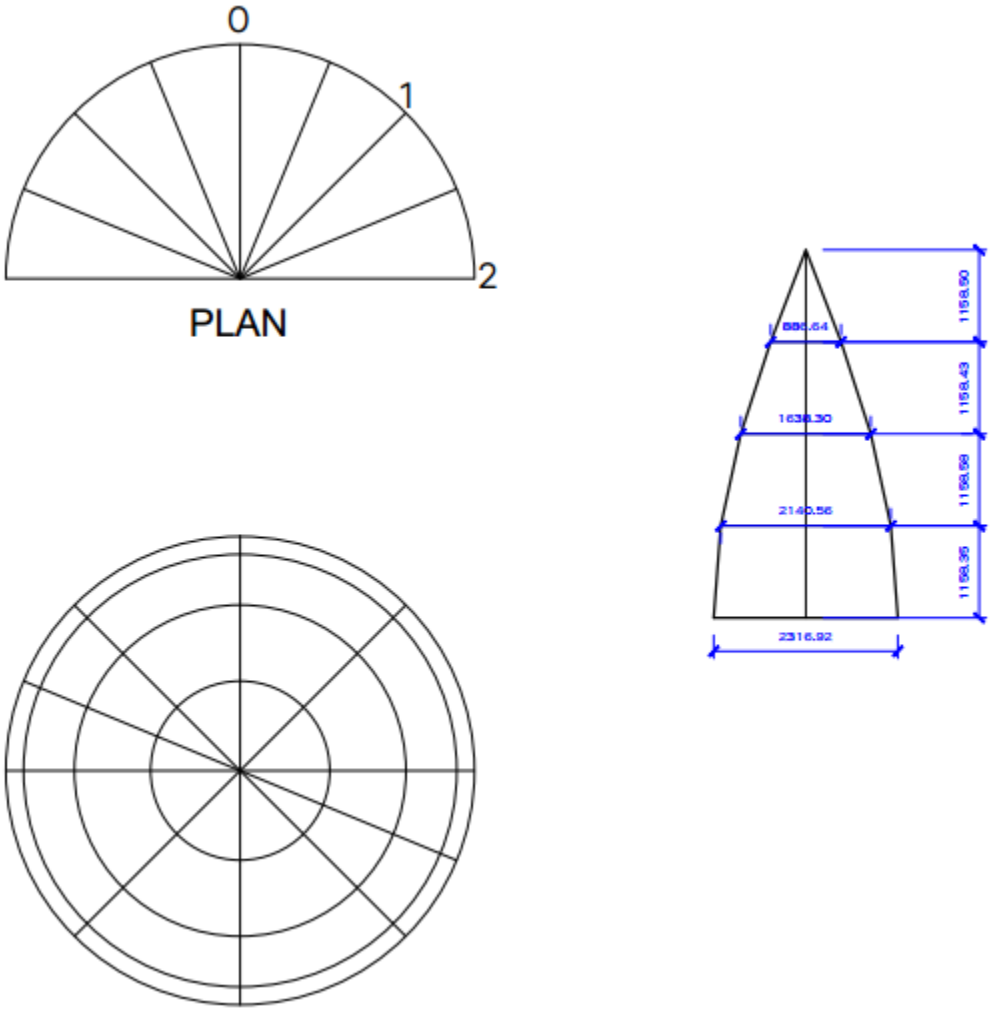

Fig 4: Geometrical analysis of the dome

The eight arcs describing the circle were first produced using 300 x 25mm softwood with nails. The planks were placed on the flat ground and semicircular path constructed on it. The planks were cut along the paths of the semicircle and this was repeated for the remaining curves. The veneer board was used to set out the segments as shown in the drawing. The dimension were orthogonally set out and cutting done. These boards (eight segments) were placed on top of the wood centering prepared and allow the concrete when hardened to take its proper shape and form.

The eight semicircular faces constructed were joined together on the base platform of the dome. The veneer segments were then placed and nailed one after the other. The eight small segments formed the entire complex surfaces of the dome. The doubly curved surfaces were provided with good centering using planks to ensure its rigidity.

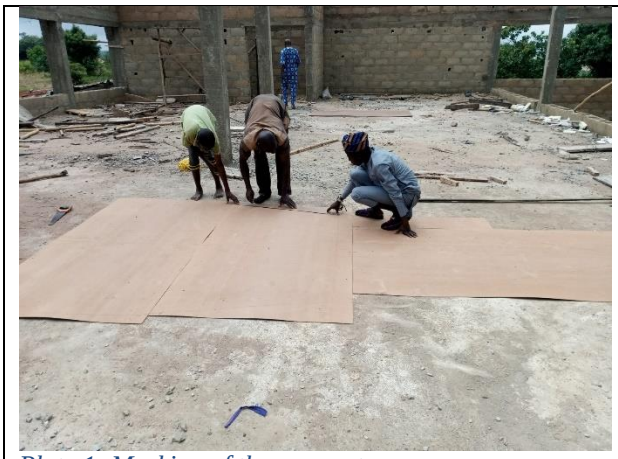

Plate 1: Marking of the segment

Plate 2: Cutting of the segments to form the sphere

Platee 3: Arrangement of the semi-circular skeleton

Plate 4: Covering of the semi-circular skeleton with veneer

Platere 5: Complete covering of the skeleton

Plate 6: Concrete casting of the dome

This study is in line with Jurco et al (2017) which described the use of descriptive geometry method to develop domes with a semi-sphere sitting on cylindrical base and CAD methods which produced more accurate answers. These two techniques were demonstrated using graphical analysis but the real construction of the formwork was not attempted. Holzer (2021) also corroborated this study with the use of plywood and planks for the construction of semicircular domes on segmental basis with the aid of different timber struts that support the plywood structure. Also, the construction of domes in Bahir dar in Ethiopia, the formwork made use of timber boards as sheeting materials with timber planks for supports (Tamer, 2017) but the descriptive analysis of determining the form of the dome was not given. Construction of domes in technologically advanced countries are based on pneumatic form finding which moulds complex and efficient shapes. The finding of Komoser and Kolleger (2016) which made use of pneumatic forming for doubly concrete shells to build the form accurately. Different shapes and greater aesthetics can be realized using pneumatic formwork systems and performs better but not within the reach of the poor.

IV. CONCLUSION

The poor construction of formwork for the construction of domes is due to the lack of appropriate techniques for its descriptive construction before the actual construction on the site. The approximate method of constructing the dome needs

to be mastered so that great aesthetic values of the form will always be achieved. The approximate developments are constructed through the use of conical sections of the object after which the materials are stretched on to the various segments. The appropriate use of this method eliminates the geometric imperfections that are normally witnessed in the timber formwork system and creates architectural symbols it was planned to represent.

RECOMMENDATION

Based on the findings of the study, it is therefore important for the builder to understand geometrical concepts that would assist in developing various forms in construction practice. Appropriate understanding of descriptive geometry that deals with production of unique shapes in construction practice should be studied and applied practically when the need arises especially in the form treated in this study. Basic technical drawing topics that have direct connection with shapes and forms should also be properly mastered in order to achieve the designed objectives of the domes architecture. The double curvature of a dome can only be developed using an approximate method of descriptive geometry or other industrial methods that are available in technologically advanced societies.

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