International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 05 Issue: 12 | Dec - 2021 ISSN: 2582-3930

Review on Pneumatic Structures and Case Study on

'The Eden Project'

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Abstract

Pneumatic structures, in which pressure differentials entirely or largely provide stability, have the potential to be considered as efficient alternatives to traditional structural forms where strong constraints on ease and rate of construction, and possibly more, are placed. Most critically, structural mass Recent advances in new engineering materials. The Eden Project is a popular tourist destination as well as a learning environment. The informal learning experiences created for children are meant to provide them with joy, purpose, and ecological importance. It aims to reach individuals by engaging and resonating with them in a variety of complimentary and unconventional ways. It's an edutainment exercise. This research explores design, fabrication, and assembly. It is based on an examination of numerous research articles concerning the Eden Project.

Key Words: Eden Project, interpretation, learning, sustainability.

1. Introduction

A pneumatic structure is traditionally characterised as a structure in which gas or air pressure differentials control and assure form stability. Although air is the most commonly used term, the term has come to represent a structure in which any fluid pressure differential sustains the structure's shape. Any applied loads are supported by an initially stressed membrane, with internal pressure providing the first stress. As a result, membrane structures in general, and pneumatic structures in particular, are among the most structurally efficient

forms. The development of PTFE-coated nylon textiles and other high-performance structural membrane media has resulted in these lightweight constructions have sparked a lot

of interest. As a result, air-supported and air inflated structures have been employed as emergency shelters, transportable structures for the military, and other applications.

2. General Principle

- Air-inflated and air-supported structures are a type of membrane structures. Pressure differential between the enclosed space and the external are responsible for giving the building its shape as well as supporting the shell in pneumatic constructions.
- An internal air overpressure pretensions the fabric. While this may appear to be unsettling to the structure's occupants at first, the pressure differential is no higher than that of normal barometer oscillations. Pneumatic structures are made up of two parts that have extremely different properties: an airtight membrane and compressed air.
- Air is a gas that is primarily composed of nitrogen, oxygen, and carbon dioxide, and its attributes are defined solely by its composition, temperature, pressure, and volume.

3. Materials

The electronically welded components are designed to define the building shape and are made from laminated membranes such as fibreglass, nylon, or polyester that are coated with polyvinyl chloride (PVC), silicon rubber, or Teflon for weather protection. The membrane's durability, heat and light-filtering qualities are determined by the careful selection of surface treatments and inner lining. The

air-supported structure, which combines high-tensile strength materials with the shell form, is one of the most efficient structural forms due to its lightness.

4. Advantages of Pneumatic Structure

- A pneumatic system is fire proof, explosion proof, and non-reactive, making it a safer system. As a result, it can be utilised in fire-prone areas.
- The pneumatic system is clean since the air is dry.
- Because pneumatic systems operate on air, they are less expensive and lighter in weight.

5. Limitation

- High compression cost
- High running cost
- Low pressure application
- Requires additional lubrican

6. Case Study: THE EDEN PROJECT

6.1 Introduction

The Eden project, along with the London Dome and the Ferris wheel, is one of the largest millennium projects in the United Kingdom. The modern Garden of Eden, with an outside area of 15 hectares and two massive greenhouses, depicts diverse temperate zones of the world and their usual plants. The steel construction of the two massive domes was created using the MERO space frame method, in which pipes are fastened together via nodes. Economical constructions, even for complex geometrical shapes, can be realised due to very low tolerances and speedy assembly. The cladding system was designed with very light and transparent air filled foil cushions that are also quite robust.

6.2 Background

Initially intended as a UK Millenium Project for the general public, the Eden Project has evolved to become not just a tourist attraction, but also a research and teaching tool for future generations. The Eden Project's purpose has always been to encourage knowledge and responsible management of the critical link between plants, people, and resources, leading to a sustainable future for all.

The steel framework of the two massive domes was created using the MERO space frame technology, in which pipes are welded together via nodes. Economical constructions, even for complicated geometrical shapes, may be realised due to very low tolerances and rapid assembly. The cladding system was designed with very light and transparent air filled foil cushions that are also quite robust. This scale of cushion system had never been created before.

Figure 1- Over view of complex
Source- thegaurdian.com

6.3 Design Intent

Many design problems came about as a result of the tight standards for such an unusual construction. For starters, the building was supposed to be the world's biggest plant enclosure. This included devising a design system that could cover long distances without requiring the usage of a single interior support. The construction must also be as light as feasible.This was required for transportation purposes, principally because all of the supplies would have to be brought in from other cities, some of which were quite far away.

6.4 Design Strategies

The bubble-like geodesic structure discussed previously is known as a "hex–tri–hex." Despite the fact that the finished construction resembles a half-sphere, the entire structure is made up of straight planes with straight edges.

Figure 2- Domes under construction against one of the side walls
Source- thegaurdian.com

Figure 3- Installation of ETFE pillows
Source- thegaurdian.com

It has an exterior shell made mostly ofhexagonal pieces (some pentagons) that connect to a triangle-based inner network for stability the design is structurally sound enough that it does not require any modifications.Internal supports may be found even in the largest biome's 240m width.

Furthermore, all of the steel tubes that comprise the grid-like network may be readily moved to the site in small pieces, lowering expenses. The structure transmits loads to the ground equally around its base, which helps to minimise the requirement for massive footings that would otherwise be required to sustain such a big enclosure. In terms of energy efficiency, the hemisphere form aids in the conservation of warmth, which is especially important in the humid–tropics biome. This is due to the fact that a sphere has the most volume compared to its surface area of any shape.

Cushions of ETFE (ethyltetraflouroethylene) transparent foil are used for the glazing. This very lightweight material weighs approximately 1% of glass. In addition, its strength and the fact that it is selfcleaning makes it the perfect product to use for this *project.*

6.5 Technical Details

6.5.1 Geometry

The Eden domes are spherical geodesic networks. They are referred to as "spherical" because network elements, often nodal points, are located on the surface of a sphere. These grids are dubbed "geodesic" because they share the form, structure, and symmetrical features, although not all of the members follow genuine geodesic lines. Geodesic lines are curves on any sort of surface that represent the shortest distance between two locations on the surface out of the countless lines that can link two points on the surface.

Figure 4- Hex-tri-hex structure
Source- thegaurdian.com

6.5.2 The bowl node

Bolts hold the tubes together. The top of this connection is flush with the pipes, allowing the cladding to be installed directly on top of it. The bowl node is constructed of cast iron and weighs around 80 kg. The 1100 nodes have a diameter of around 400 mm and a wall thickness of 40 mm. A computer-aided machine cut and drilled each node, keeping tolerance to a minimum.

6.5.3 Archers

Figure 5- Specially designed connecters were designed to connect the ETFE pillow membrances
Source- archdaily.com

A triangular truss girder is used at the junction of the domes. The largest one has a span of up to 100m. The arches' sections are 219.1 mm wide for the top beam, 159 mm wide for the two lower beams, and 101.6 mm wide for the diagonals. The chord beams at the top and bottom are bent. The girders were welded in three parts for manufacture, and the remainder were welded on-site once they were set up. The arches are hinged and supported by massive concrete foundation stones.

6.5.4 Cladding

The more than 800 hexagon elements are covered by air filled cushions. These cushions are made of transparent EFTE (Ethyltetrafluorethylene) foil. The basic material is between 50 µm and 200 µm thick with a width of 1.5 m. The foil material was cut and welded. The normal cushions are made up of three layers. The top and bottom layer form

the cushion and carry the loads. An additional layer between them has the function of enhancing the temperature.

Figure 6 - Restoration
Source- archdaily.com

Figure 6 – Hookup
Source- archdaily.com

6.6 Conclusion

Eden is a must-see stop on the Cornish historical route, an alternative to the beach on a cloudy day, and a spectacular picture opportunity, contention that tourist attractions primarily promote an aesthetically oriented consumerist rather than critical interaction. However, entertainment and education are not mutually incompatible, and effective communication is frequently the key to beginning changes in attitudes, beliefs, and behaviour. So, in attempting to evaluate what Eden is aiming to do and what it may become, it is vital to maintain some critical distance without falling into the trap of criticising it for being something it is not.

7. Future Scope

The review paper is about pneumatic structures it could be relevant in sharing knowledge about the topic which makes it accessible for everyone interested about pneumatics. As discussed and covered in the paper all the major factors related to pneumatic structures have been covered which can be considered by one while designing.

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