Self-Operating Flood Barrier in Cochin International Airport

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Abstract - *In recent years, flooding became a frequently occurring phenomenon due to change in climate. Although it occurs naturally but it is said to be one of major calamity or disaster that affects both developed and developing countries. In India, Kerala is also facing severe floods for the last few years. One of the major impact is the flooding in Cochin International Airport which is an event unforeseen, resulted in its suspended flight operations. An appropriate defense system is required to tackle this issue. One such effective system is the Self Operating Flood Barrier (SOFB). It can be applicable to both rural and urban areas. The SOFB uses the pressure from approaching flood water to raise its barrier automatically, hence providing protection against extreme high water levels and water incident events. The barrier is so effective in a manner that it can mitigate the hydraulic risks, resist hydrodynamic pressures and are capable of diverting the flow of water from affecting the exposed area. The SOFB is the best alternative when looking for a reliable, cost effective solution where a permanent barrier is not possible. Here, we are aiming to design a SOFB and to carry out its analysis using the ANSYS Software.*

Key Words: **Self Closing Flood Barrier, Cochin International Airport, ANSYS Software**

1. INTRODUCTION

Cochin International Airport, Cochin is an international airport serving the city of Kochi, in the state of Kerala, India. Located at Nedumbassery, about 25 kilometres (16 mi) northeast of the city, Cochin International Airport is the first airport in India developed under a Public-Private Partnership (PPP) model and was funded by nearly 10,000 non-resident Indians from 30 countries.

It is the busiest and largest airport in the state of Kerala. As of 2019, the Cochin International Airport caters to 61.8% of the total air passenger movement in Kerala. It is also the fourth busiest airport in India in terms of international traffic and eighth busiest overall. In fiscal year 2018-19, the airport handled more than 10.2 million passengers with a total of 71,871 aircraft movements. The airport is a primary base for Air India Express operations which is also headquartered in the city.

The airport operates three passenger terminals and one cargo terminal. With over 150,000 square metres (1,614,587 sq. ft.) in area, the airport's Terminal 3 is one of the largest terminals in India. On 18 August 2015, Cochin International Airport became the world's first fully solar powered airport with the inauguration of a dedicated solar plant. On 26 July 2018, the airport was selected for the coveted Champion of the Earthward, the highest environmental honour instituted by the United Nations.

As a consequence of 2018 Kerala floods, the airport was closed for several days. Water in the Periyar, which flows 500 metres (1,640 ft.) away from the airport, rose to 1,433 mm (4.7 ft.) during these days. The runway and other facilities were non-functional due to excessive flooding and inclement weather.

Fig 1: Flooded Airport

1.1 SELF OPERATING FLOOD BARRIER

The Self Operating Flood Barrier is a unique effective flood defence system which can be installed in any length, to protect people and property from inland waterway floods caused by heavy rainfall, gales or rapid melting snow. This system has been developed in the Netherlands to provide optimal protection against extreme high water levels.

The barrier systems has already been built and installed in several countries around the globe since 1998. The success can be attributed to the simple, but ingenious concept of using the approaching floodwaters to automatically raise the barrier; effectively using the problem to create the solution. In resting position the barrier is invisible and fully self-protected at the location in a basin in the ground. In case of a flood the floating wall of the barrier will raises instantly though the rising water level and give a full protection against the hinterland.

1.2 NEED FOR THE STUDY

Airport plays a substantial role on the economic growth and development of the country. It is possible only when it is properly protected and maintained. The Cochin International Airport is frequently subjected to floods. The impact of flood cause major damages to the airport. During the 2018 flood, the Cochin International Airport Limited (CIAL) has suffered an estimated loss of over Rs 220 crores on damaged infrastructure including collapse of 2.5 km long airport wall when the tributary of Periyar River, Chengal thodu overflowed. The runway, taxi bay, duty free shops and other areas of international and domestic terminals were also submerged, causing damage to electrical equipment including runway lights. The solar power system of the world's first solar-powered airport has also suffered damage in the floods. Moreover the flight operations were suspended for several days.

Our project aims to find a proper and practical solution for the problems that exist in the Airport due to floods. The adverse effect of floods can be minimized by constructing a Self-Operating Flood Barrier at the entrance point of Chengal thodu to airport. The self-operating Flood barrier will act as a protective barrier which will protect the airport from the massive effects of floods. Thus the damages can be minimized and shutting down of airport can be avoided. Hence flight operations remain unaffected even if flood occurs.

2. METHODOLOGY

2.1 OVER VIEW OF METHODOLOGY

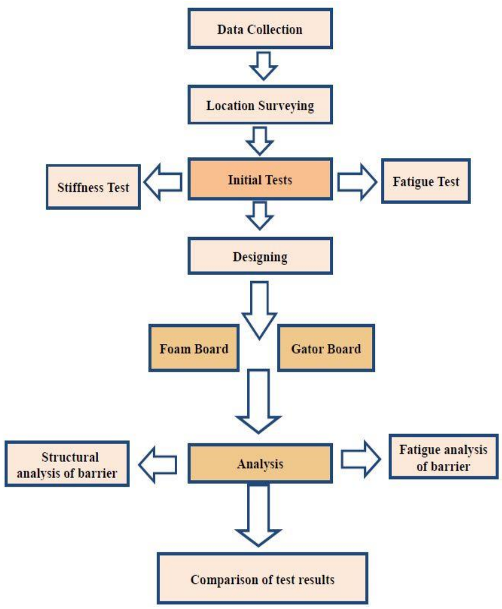

Fig 2: Methodology Flow Chart

2.1.1 DATA COLLECTION

The Preliminary step is the collection of sufficient data regarding the intensity of flood in previous years from Regional Metrological Department, Trivandrum. And it is also important to collect necessary information regarding every outlet in the form of natural streams or river & the accurate rainfall data which will provide immense help in the design of barrier.

2.1.2 LOCATION SURVEYING

The location surveying is necessary for:

- Surveying the source & quantities of water to be handled near the airport site.
- To determine whether the soil is suitable for construction.
- To determine the location & extent of areas, from which desirable construction can be done

Fig 3: Geographical Location of Airport

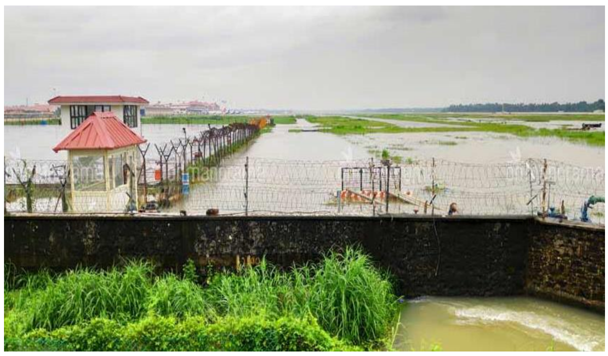

Fig 4: Flooding caused by Chengal Thodu

2.1.3 Initial Tests

Initial tests are performed as part of material testing, which is a measurement of characteristics and behavior of materials under various conditions. It helps us to understand and quantify whether a specific material or treatment is suitable for a particular application. With the wide variety of materials and treatments available, testing can help narrow down the choices to the most appropriate selection for the intended use.

MATERIALS USED

I. Gator Board

Gator Board is extruded polystyrene foam encased between layers of a melamine and wood fiber veneer. It has a very rigid poly surface which is resistant to moisture and it will not easily break or warp. The wood fibres veneers are infused with resin which prevents stain and water damage. Gator board will maintain its strength regardless of length of time. It is an excellent choice to replace plywood in applications. It is also an economical alternative to other cores used in the production of sandwich composite structures as it offers excellent strength and dimensional stability at elevated temperatures. Gator Board is ideal for a wide range of marine, road/rail transportation, aerospace and industrial applications. Gator Board kits speeds the manufacturing process, save labour costs and virtually eliminate material waste.

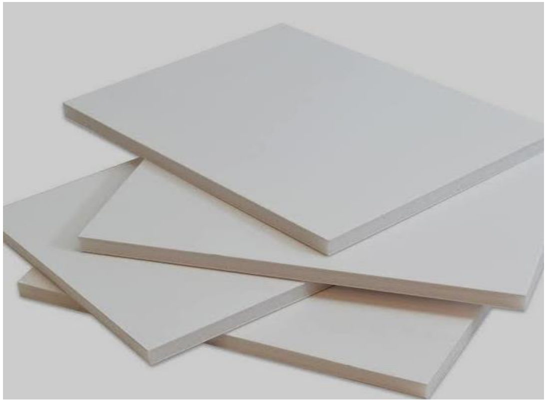

Fig 5: Gator Board

ii. Foam Board

Foam board is a lightweight and easily cut material used for mounting of photographic prints, as backing for picture framing, for making scale models, and in painting. It consists of a board of polystyrene foam clad with an outer facing of paper on either side. Foam board is commonly used to produce architectural models, prototype small objects and to produce patterns for casting. Self-adhesive foam boards can be unforgiving when it comes to mounting some items. Foam Board is also often used by photographers as a reflector to bounce light, in the design industry to mount presentations of new products, and in picture framing as a backing material, the latter use includes some archival picture framing methods, which utilise the acid free versions of the material. Another use is with aero-modellers for building radio-controlled aircraft.

Fig 6: Foam Board

2.1.4 DESIGNING

Design of barrier is done using Autodesk AutoCAD & SOLIDWORKS software as per the requirements of the Airport conditions. Its design uses the approaching floodwaters to automatically raise the barrier. Single barriers are available up to 4m in length and 3m in height. Multiple units can be linked together to create long runs where required, with permanent or removable intermediate posts.

I. Overview of Model

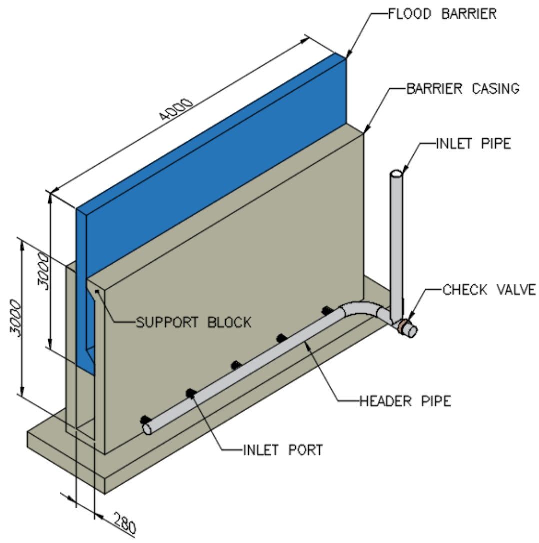

Fig 7: Design of Self Operating Flood Barrier

The SOFB mainly consists of a float wall as flood barrier, provided with a height of 3m & width of 0.28m which is embedded between barrier casing of height 3m which acts as an enclosed basin during its operation. The whole structure rests on a foundation or a concrete base. Length of the barrier given is 4m & it can be extended up to the requirements. An inlet pipe is provided up to a length below ground level, considering the depth of water channel nearby and it is then connected to the header pipe having series of inlet port through which water entered to the enclosed basin. A support block is provided adjacent to one side of the casing to keep the whole structure water tight.

Following are the main parts of SOFB:

- **Inlet pipe**: It is the component of SOFB through which water entered from activation basin to enclosed basin.

- **Header pipe**: It is the main pipe connected to the inlet pipe.

- **Inlet port**: It is the series of openings provided in header pipe which facilitates movement of water to the enclosed chamber or basin.

- **Check valve**: It is used for ensuring unidirectional movement of water and prevents backflow of water.

- **Support block**: It helps to lock the raised barrier in position and also it prevents water leakage from enclosed basin to the ground surface and makes the structure water tight.

- **Barrier casing**: It is an enclosed chamber holding the flood barrier, serves as an enclosed basin for the smooth functioning of the system.

- **Flood Barrier**: It is the most important component of the system. It raises as protective shield during the flood time and is buried in the ground at rest of the time.

ii. Principle of Operation

In non-flood conditions all operational parts of the barrier are invisibly concealed in the ground inside its basin. When floodwater rises above the inlet pipe, pre-flood level enclosed basin which houses the floating wall starts to fill up through the inlet ports in header pipe. When the pressure inside the enclosed basin equals the hydrostatic pressure of inlet pipe, the flood wall floats and rises. When the basin is totally filled, the support block keeps the raised barrier in position making it water tight. The flood water can now continue to rise without flooding the protected area. As the water level subsides back to its normal level, the flood water in the basin is drained by a pump. As the water leaves the basin, float wall returns to its rest in position within the basin. In its closed resting position, the lid of the barrier is sealed to prevent the inflow of flood waste or debris.

iii. Stages of SOFB

➢ **Lowered State**

Fig 8: Sectional View of SOFB in Lowered State

Once the flood barrier has been installed, the floating entrenched wall is practically invisible under normal water level conditions. The wall is reinforced for impact strength. On top, a steel lid locks in the entrenchment space under normal (non flood) conditions.

➢ **Activated State**

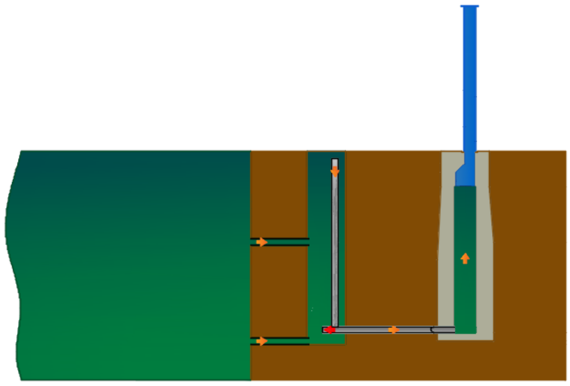

Fig 9: Sectional View of SOFB in Activated State

Once the water rises to approximately 10 cm beneath the flood level, the basin of the barrier fills up through a filling-pipe in a pit. The wall rises and floats. As soon as the basin is totally filled, the closing surface will "lock" the barrier into a watertight position.

➢ **Raised State**

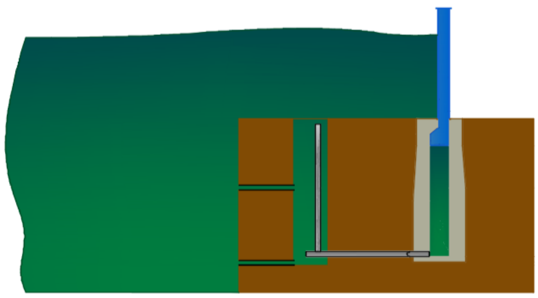

Fig 10: Sectional View of SOFB in Raised State

Now the water can rise further without flooding the protected area. Once the water level subsides to a normal level, the basin is drained through a drain pipe with nonreturn valves or by a pump. Once the water has left the basin, the wall returns to its resting position within the basin. The lid on top of the wall then closes to prevent the inflow of waste or debris.

3. RESULTS AND DISCUSSION

3.1 RESULTS

In this software various solutions are obtained: deformation, equivalent elastic strain, equivalent stress & fatigue life. The structural design for study was modelled to analyse the deflection & fatigue behaviour of barrier. The results obtained are interpreted in form of graphs and images. The comparative study is done with barrier made of foam board & gator board, then the suitable material is adopted by analysing the minimum deflection & fatigue life.

Case 1: Barrier Made of Foam Board

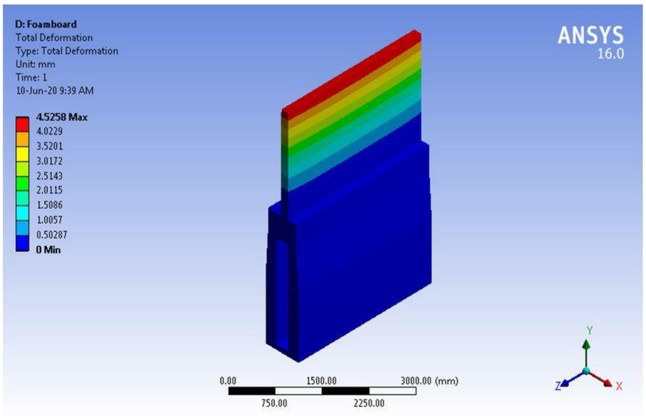

Fig 11: Deformation Diagram of Foam Board

From the figure 11, the maximum deflection obtained is 4.5258 mm.

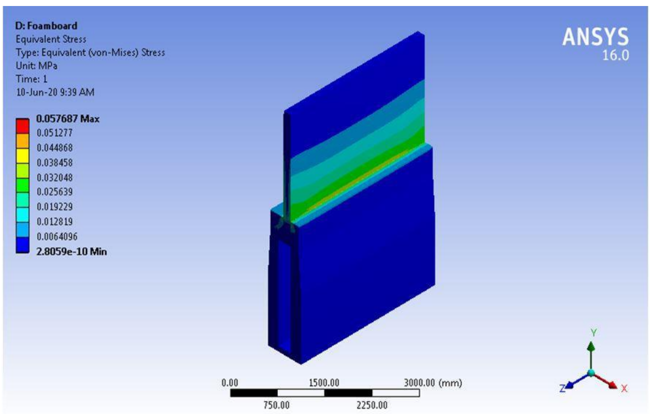

Fig 12: Equivalent Stress Diagram of Foam Board

From fig 12, the maximum stress obtained is 0.057687 MP

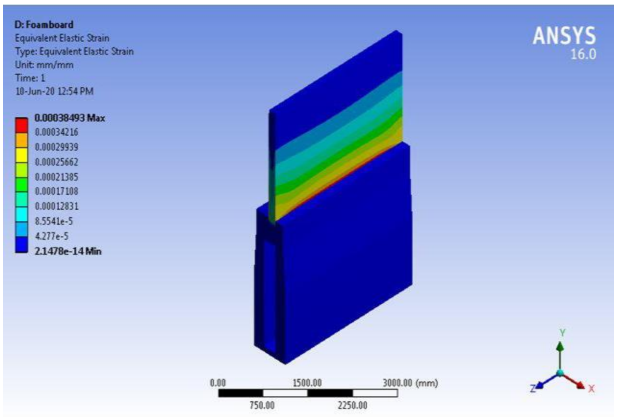

Fig 13: Equivalent Elastic Strain Diagram of Foam Board

From the fig 13, the maximum strain obtained is 0.00038493

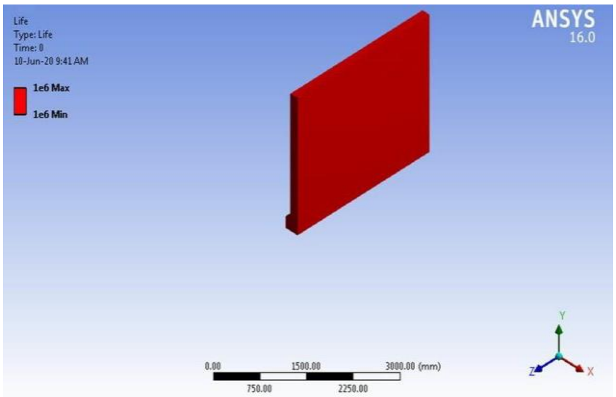

Fig 14: Fatigue Diagram of Foam Board

From the fig 14, the maximum number of cycles obtained is 6.

Case 2: Barrier Made of Gator Board

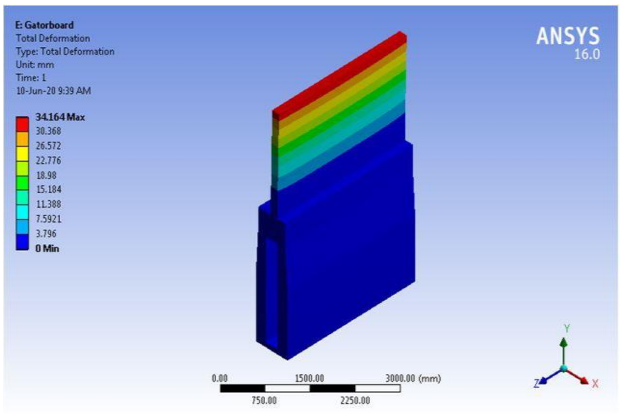

Fig 15: Deformation Diagram of Gator Board

From the fig 15, the maximum deformation is 34.164 mm.

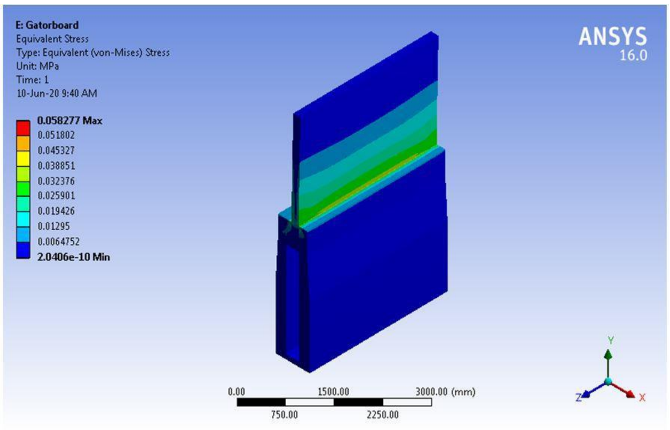

Fig 16: Equivalent Stress Diagram of Gator Board

From fig 4.6, the maximum stress obtained is 0.058277 MPa.

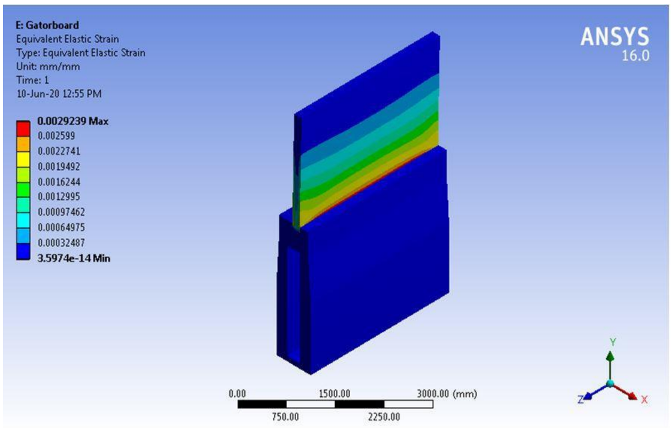

Fig 17: Equivalent Elastic Strain Diagram of Gator Board

From the fig 17, the maximum strain obtained is 0.0029239.

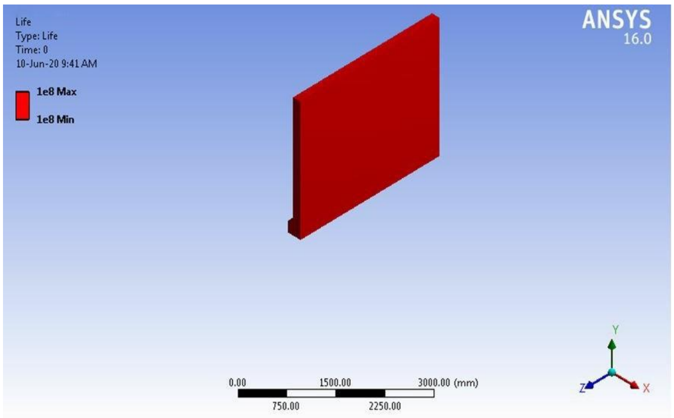

Fig 18: Fatigue Diagram of Gator Board

From the fig 18, the maximum number of cycles obtained is 8.

3.2 DISCUSSION

Bar charts for deformation, equivalent stress, equivalent elastic strain & fatigue are plotted for different material and their values are compared and studied.

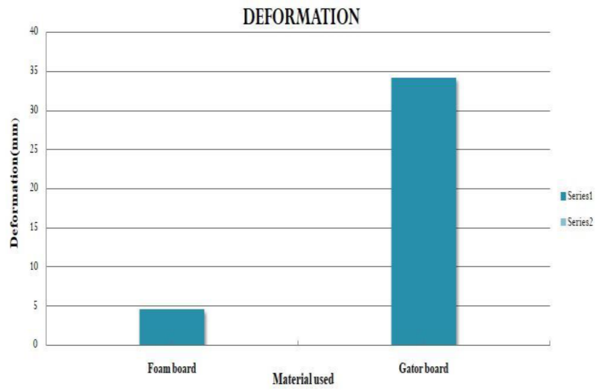

Fig 19: Graph for Deformation vs Material used

From the graph, it is clear that foam board has least deformation, ie 4.5258 mm.

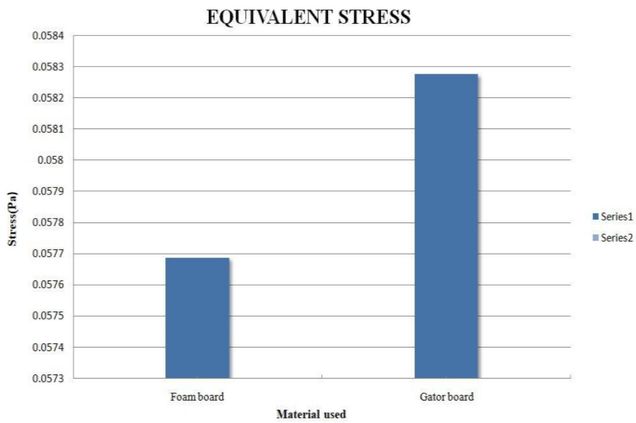

Fig 20: Graph for Stress vs Material used

We can see that stress on foam board is least.ie 0.057687 MPa.

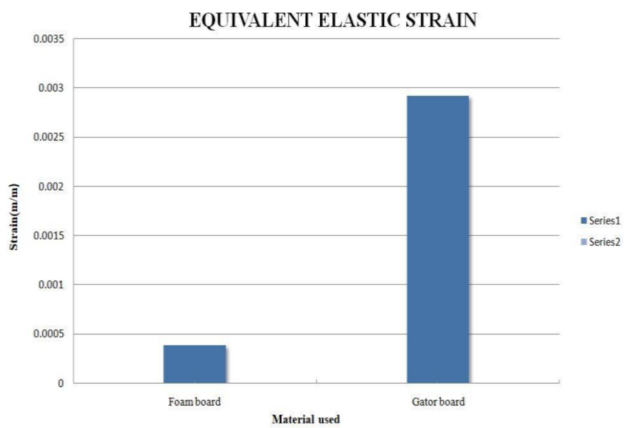

Fig 21: Graph for Strain vs Material used

The graph shows that the minimum strain occurs on foam board, ie 0.00038493.

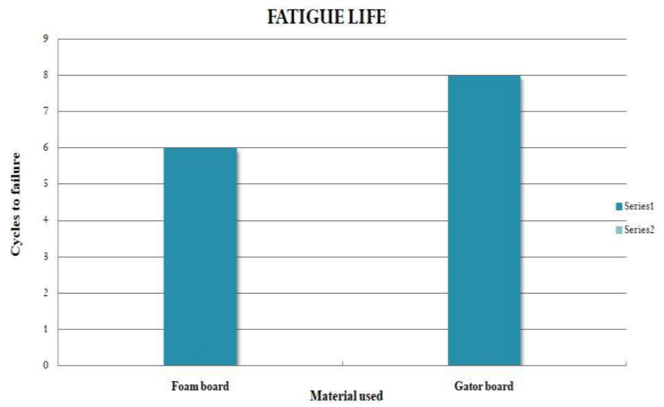

Fig 22: Graph for Cycle to Failure vs Material used

From the graph, it is clear that foam board has least cycles to failure, ie 6.

4. CONCLUSION

A self-operating flood barrier is designed as an effective solution against flooding in Cochin International Airport by using ANSYS Workbench. The structural analysis is carried out for SOFB by using two materials namely, Gator board and Foam board respectively. For this, initial tests including stiffness test & fatigue test were done on these materials to find out its structural properties which are essential to carry out the analysis process. ANSYS Fluent is used for determination of pressure on the barrier faces. Various forces such as hydrostatic pressure, sludge load & dynamic loads were tested to evaluate its performance against these loads. The maximum hydrostatic pressure generated is imported to ANSYS static structural for the derivation of results.

From the analytical investigation, the graph shows that Gator board has more deflection, equivalent stress & strain, even though it is in the limit of safety. As we mentioned in the beginning, we are strictly focussed on replacing the currently used Foam board for the project, although Gator board is satisfactory for this need to some extend since it is more durable and light weight compared to foam board.

4.1 FUTURE SCOPE

Here we looked for an alternative material in the construction of flood barrier. Even though the obtained result is satisfactory, but instead of using normal Gator Board it will be better to consider heavy duty gator board which will provide more serviceability. Moreover further study can be carried out using any other economical materials. Also the Self-Operating Flood Barrier can be easily implemented to flood prone areas. It will be a huge relief for the people living nearby any water bodies. Thus, we can reduce impact of flooding and destructions caused from it. Also it will provide evacuation time during any emergency situations such as flash floods, cyclonic rainfalls etc.

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