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Design and Optimization of Mangalore Clay Roofing Tile

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Abstract: ***Mangalore tiles had worldwide reputation. But now a day's these industries are getting in to closure states owing to the several reasons. One of the prominent reasons may be short supply of exhaustible raw material i.e. clay. With the introduction of decorative tiles, these products are slowly getting the due market share. The application area of the clay roofing tiles are expanded now as they can be used to lay over the RCC building to prevent the building from overheating. These tiles are the best strategies to counter the seepage problem of RCC building during rainy season. In this investigation an attempt is made to study and analyze the Mangalore clay roofing tiles using SolidWorks software model and validating it with Ansys workbench. First we make the model of tile using SolidWorks software after that analyze this model using Ansys Workbench software considering different load parameters. The possible outcome of the project is stress distribution over the tile. The main objective of this study is checking the possibility of saving exhaustible material clay through redesign the model. The re designed model again analyzes using the same load parameters.***

Keywords: Mangalore clay tile, Ansys workbench, RCC, SolidWorks**.**

1. Introduction

Mangalore roof tiles are of flat pattern and they are provided with suitable projections so that they interlock with each other, when placed in position. These tiles are in red in colour and made of double channeled Basel mission Mangalore pattern. The special Mangalore tiles are available for hip, ridge and valley portion of the roof. It is found that about fifteen Mangalore tiles are required for covering one square meter of roof area [1]. These tiles are manufactured on large on large scale in south India especially at Mangalore, Cochin, and Calicut. This industry was established in the early 19th century by German Missionaries. The first unit manufactured Mangalore pattern tiles were started 1951 and at present, more than 200 units are working in this area (Indian coastline).

The Mangalore pattern roofing tiles are becoming popular in rural and semi urban areas and they are used by middle and low income group people because of various reasons such as architectural effect, scarcity and rising prices of other substitutes, growth of population etc. the life of these roofing tiles is as about 25 years with replacement of 5% per year. But now a day so many these industries are in a closure state owing to the several reasons. Short supply of exhaustible raw material i.e. clay is one of the prominent reasons. With the introduction of decorative tiles these tiles are getting now the due market shares. Even these tiles can used to lie over the RCC building to prevent the building from overheating and also these tiles are best strategies to counter seepage problem of RCC building during rainy season [2]. In this investigation an attempt is made to study and analyze the design of roof tiles considering the influencing parameters. The tiles may be defined as thin slabs of brick [3]. Which are burnt in kiln. They are thinner than brick and hence they should be carefully handled to avoid any damage to them. The tiles can be classified in the following two groups:-

a) Common tiles
These tiles have different shapes and size; they are mainly used for paving, flooring and roofing.

b) Encaustic tiles
These tiles are used for decorative purpose in floors, walls, ceilings and roofs.

1.2 Objectives

- The overall Mangalore tile design is to be carried out by modelling according to the given dimension and to analyze using Ansys workbench considering loads acted on tile and check the possibility of saving exhaustible material clay through re design the tile model.
- Collecting various data related to Mangalore roofing tile for prepare software model of Mangalore roofing tile using SolidWorks and analyzing using Ansys workbench, considering all possible load conditions.
- To check the safety of the present design.

1.3 Scope for future work

As a scope for future work a study of effect of different firing temperature on the performance of the roofing tiles can be undertaken. This will give basis for clear strength analysis of the tile. Same types study i.e. modelling and analysis could be extended to the other types of clay products decorative tiles, hollow clay bricks, bricks etc.

With the help of above mentioned studies we can redesign these works and process can implement Business process Reengineering (BPR) to these industries.

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2. Methodology

2.1 Modelling

Developing software model for clay roofing tile using SolidWorks software, Solid works software is very user friendly software. SolidWorks is a 3D mechanical CAD (computer-aided design) program that runs on Microsoft Windows and is being developed by Dassault System SolidWorks Corp. It is very helpful software in modelling point of view; tools are very useful to model any kind of design. Considering the dimension of clay roofing tile, analysing the tile model considering loads i.e. Wind load, Rain load and Dead load, but here wind pressure is taken for ease of applying. Major dimension of this model 420x250 mm and thickness is around 8 mm at curves, overall thickness is 15 mm. The software model is shown below,

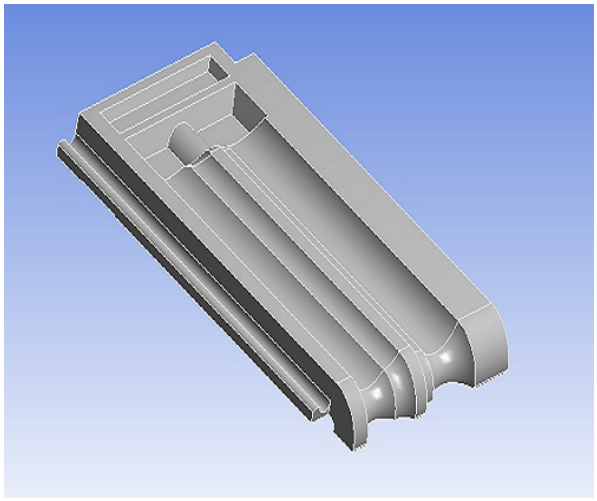

Figure 1: Model

2.2 FE model

Import IGS file to Ansys workbench and meshed while meshing 4127 elements are used. No of nodes are 7976. In this work we are using SolidWorks software making for modelling.

2.3 Fixed supports

Three faces are fixed here that portions are seen in blue colour. Fig 3 is representing the fixed model geometry. Three face at the back side of roofing tile is fixed, the tile s situated on reapers and it is fixed also by this face we will get a arrangement like the real condition.

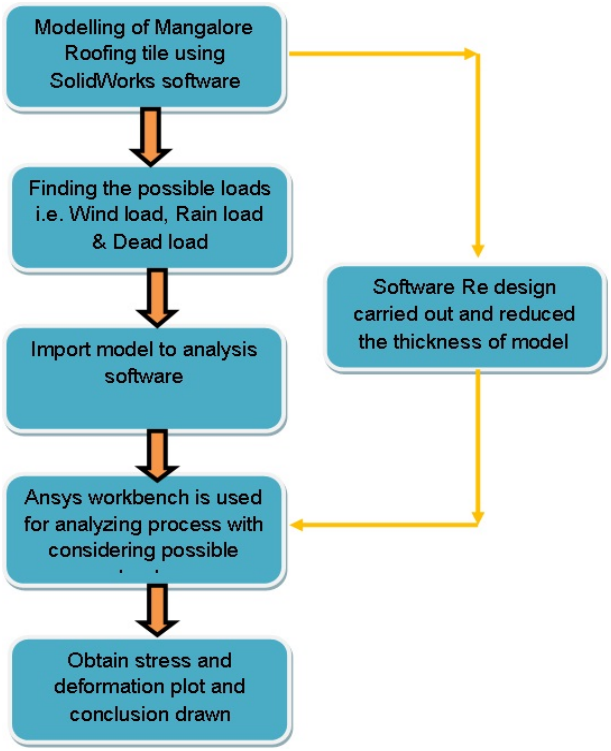

Figure 2: Flow chart of the work

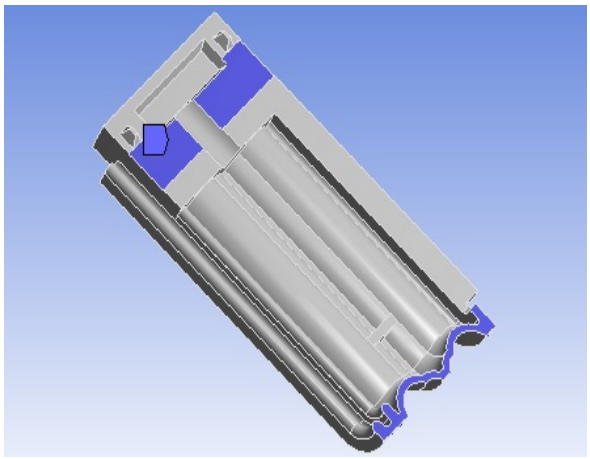

Figure 3: Boundary condition

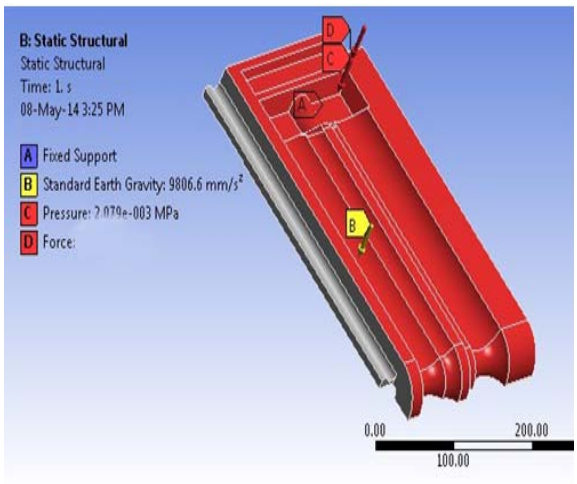

Figure 4: Boundary condition with loads

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2.4 Consideration of Loads

In this study basically three kinds of loads are considered i.e. dead load, wind pressure& rain load [7],[8],[9]. From IS code book 875(part1-3) Dead load (22,54N), Wind pressure (0.002079MPa) and Rain load (60.015 N) are taken.

2.5 Material properties used

Material properties: Clay is used for manufacturing Mangalore Pattern roofing tile [5],[6]. The material properties of Mangalore roofing tile are shown in table 1.

Table 1: Clay material properties

Material	*Properties*	*Values*
Clay	Density	0.0000017 kg/mm^3
	Young's Modulus	13789.514 MPa
	Poisson's Ratio	0.2
	Compressive Ultimate Strength	7.80 MPa

2.6 Analysis

Static analysis done for mangalore roofing tile considering three major loads wind load(pressure), rain load and dead load. First iteration is done with dead load only. .Second iteration is based on dead load, wind load and the third is based on all the three types of loads. Last case is redesigned & tested with the same loads.

2.7 Software Redesign of current model

For the re design, again taking the help of SolidWorks software and reducing the thickness of tile by 3/4 of the original thickness and analyzed using Ansys workbench for results. Below fig is the re designed model of MP Tile.

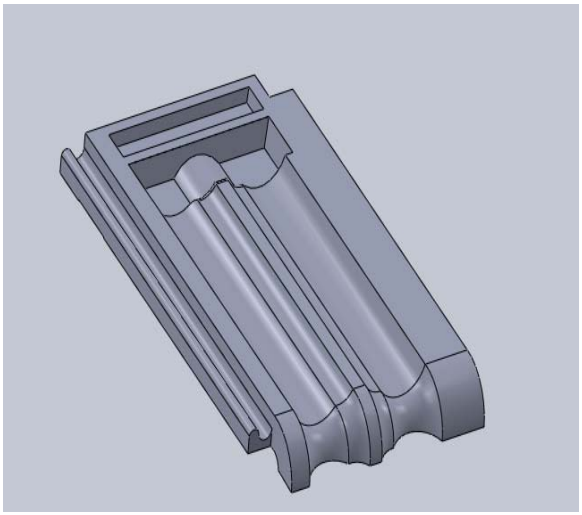

Figure 5: Re designed model

3. Results and Discussions

3.1 First case

In the first case only wind pressure and dead load considered Wind pressure is taken as 0.002079 MPa & self weight is 2.3 kg. Wind pressure is applied not the wind load because of ease of applying. The below fig 6 shows the stress plot of mangalore pattern roofing tile. Maximum stress obtained in analysis is 0.68391 MPa and minimum stress is 0.00030583 Mpa. Deformation plot of Mangalore roofing tile is given below in fig 7, maximum deformation obtained is 0.009947 mm. If we observing the table 2 stress was found s very less compared to the properties of the tile.

Table 2: Stress and deformation results in first case

Stress & Deformation results obtained from Ansys		
Maxi	0.68391 MPa	0.009947 mm
Mini	0.00030583 MPa	0

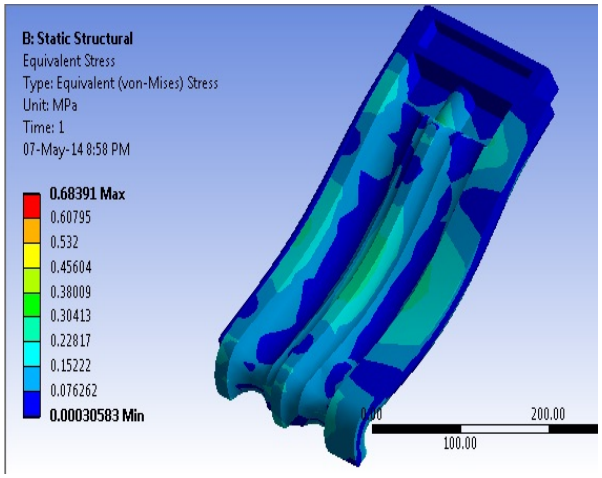

Figure 6: Stress plot obtain in first case

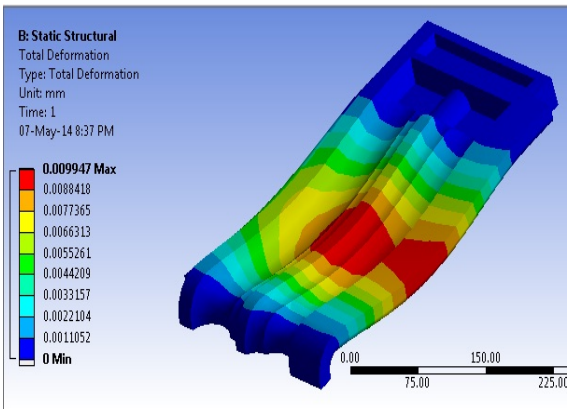

Figure 7: Deformation plot in first case

Maximum stress is 0.68391 MPa is seen in the fixed region of the tile that portions are less harmful region of the tile. Dark blue colour portions are the safest region that we can see in the above figures, Maximum deformation occurs at the middle portion of the tile & that is 0.009947 mm. It is very less. But this is brittle material, even less deformation also affects the quality of the tile. In this figure minimum stress is 0.0003058 MPa & most of the region shows the dark blue colour those regions which are safest regions.

3.2 Second case

Here we considered major three loads wind pressure, rain load and dead load & following results are obtained.

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Table 3: Stress and Deformation plot in second case

Stress & Deformation results obtained from Ansys		
Maxi	0.85576 MPa	0.01264 mm
Mini	0.00033979 MPa	0

In this case one more load is considered i.e. rain load it is consider with remaining two loads wind load and dead load. The rain load does not make huge variation in the results it is very small considering wind load. Wind load is the heavy load acting on the tile so the support of the tiles should be a good quality. The deformation plot is shown below

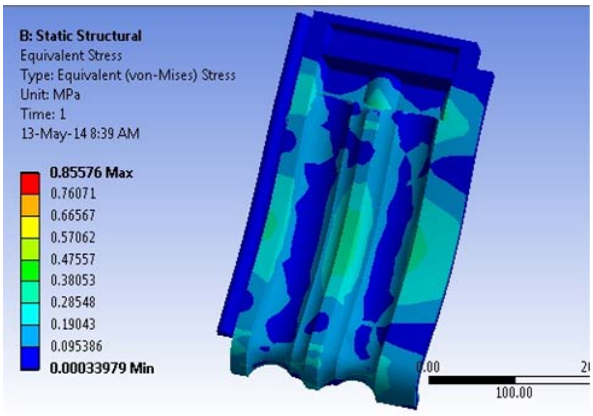

Figure 8: Stress plot of second case

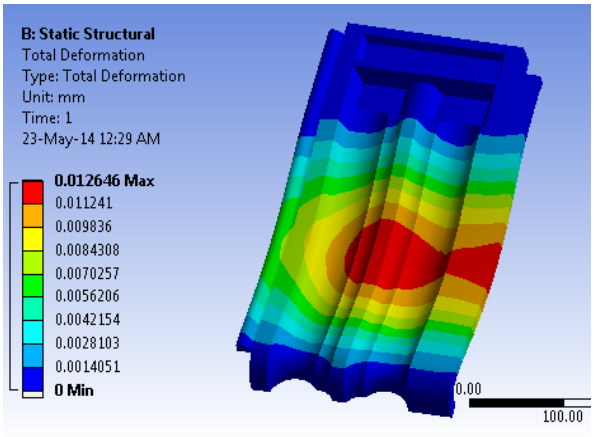

Figure 9: Deformation plot of second case

While considering the previous case here we can see that there is variation in the stress and deformation results, maximum stress obtained is 0.85576 Mpa and maximum deformation obtained is 0.01264 mm. in the case of a tile it should be great deviation of results but the stress and deformation figures are not have much more difference.

3.3 Third case

In this case there only one difference from the previous case i.e. maximum Wind pressure is taken rest of the two loads same as previous. Results obtained in the third case are shown below.

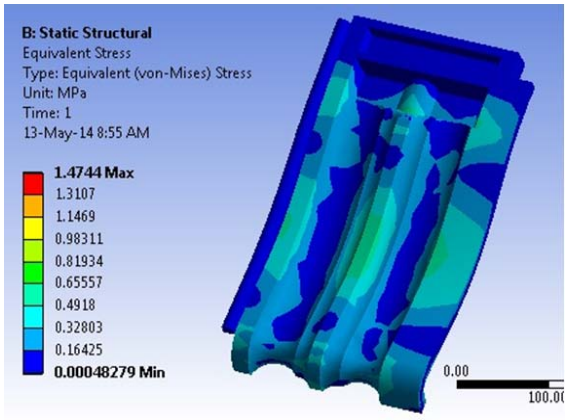

Figure 10: Stress plot in the third case

Table 4: Stress and Deformation results in the third case

Stress & Deformation results obtained from Ansys		
Maxi	1.4744 MPa	0.02180 mm
Mini	0.0004827 MPa	0

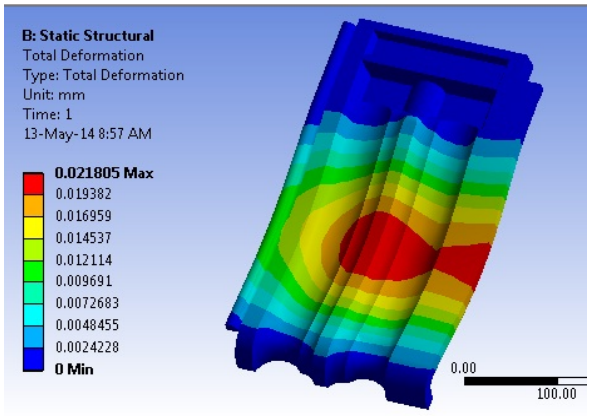

Figure 11: Deformation plot in the third case

While considering the previous case here we can see that there is high variation in the stress and deformation results, maximum stress obtained is 1.4744 Mpa and maximum deformation obtained is 0.02180 mm. in the case of a tile it should be great deviation of results but the stress and deformation figures are not have much more difference. This case maximum pressure is used the maximum results obtained in this case. But the maximum pressure not always acting over the tile, second case is the usual occurring case.

3.4 Fourth case

In this case analysis done on the new model of the MP tile with reduction in thickness at some portion of the tile, including curved portions of the tile and apply the same loads on the second case over it. The results are shown below

Table 5: Stress and Deformation in Fourth Case

Stress & Deformation results obtained from Ansys		
Maxi	1.0892 MPa	0.0018103 mm
Mini	0.00030163 MPa	0

In figures 11 and 12 we can see that maximum stress is

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1.0892 Mpa and the deformation is 0.0018103 mm, projected portion of tile near the fixed portion is the maximum stressed area. If we compare these values with material properties of the re designed product still safe under all possible load conditions. This analysis done after redesign the model in this case reducing the thickness of tile by 3/4 of the original thickness, but the results obtained is well fall within the limit so model is safe under all possible conditions.

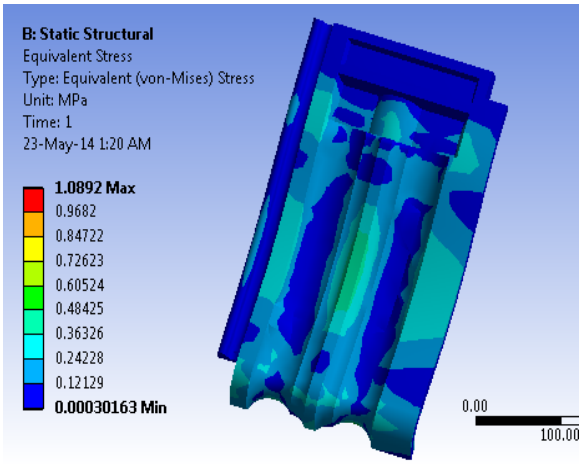

Figure 12: Stress obtained in fourth case

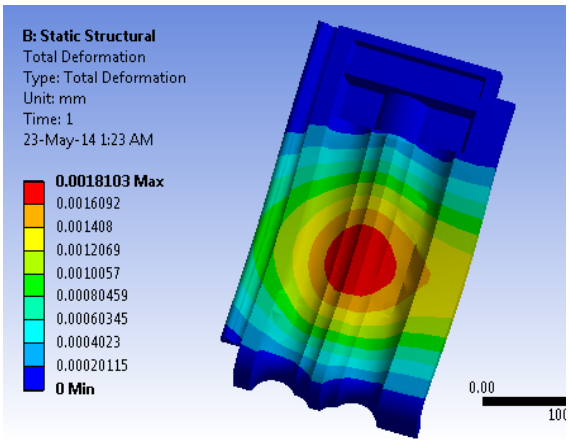

Figure 13: Deformation occurred in fourth case

4. Conclusion

From the analysis done for the original mangalore roofing tile model 420x250 mm it is evident that roofing tile is for the possible load condition. The stress and deformation plots also given the same condition, but it is an over design. The amount of clay per tile for the original manufacturing model is 2.3 kg.

Since clay is exhaustible raw material we tried a new model with less thickness 3/4 of the original thickness and the amount of clay required for the model is 1.98 kg. From the analysis it is found that the new design is also safe with sufficient strength. It is saves about 25% of the total weight raw material than the original model. Besides the time required for drying is also less which enhance the production rate. Burning (firing) temperature required for these tiles also less which saves the fuel consumption. But the strength at the wet condition after a prolonged aging period is questionable. Hence thus need to strength such tiles with technologies of composites materials.

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