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# Numerical Investigation in Thermal Behaviour with Various Ceramic Coatings on Metal Roof Sheet by Ansys

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**ABSTRACT:** The use of thermal coatings on metal roof sheets is gaining popularity as a result of these coatings' capacity to lessen the amount of heat that is transferred into buildings, enhance buildings' energy efficiency, and give cost savings. Unfortunately, it is not fully recognised how effective these coatings are in decreasing the heat stress on the metal roof sheet itself. By employing Ansys software to carry out a numerical assessment of the heat stress index with a variety of thermal coatings applied to a metal roof sheet, the purpose of this study was to fill the knowledge gap that had been identified. With the use of ceramic coatings like alumina, titania, and zirconia, the results of the simulations demonstrated that the thermal conductivity of the coating has a substantial effect on the heat stress index of the metal roof sheet. A lower heat stress index was the result of a thicker coating and a higher thermal conductivity. This indicates that these characteristics can effectively minimise the amount of heat that is absorbed by the metal roof sheet. In addition, the findings showed that the effectiveness of a thermal coating in lowering heat stress can be further improved by include both reflective and insulating qualities in the coating. Overall, this research sheds light on the possible advantages of applying thermal coatings to metal roof sheets, namely the reduction of heat stress and the improvement of buildings' energy efficiency. The findings can be used to guide the selection of appropriate thermal coatings for diverse applications, which can eventually lead to cost savings and better comfort for people living in and working in buildings.

## I. INTRODUCTION

Since the early 1900s, asbestos has been mined and used worldwide. Natural fibrous materials are called asbestos. Asbestos' inflammability, strong tensile strength, corrosion resistance, and low electrical conductivity in some fibres contributed to its commercial success. Three asbestos fibres are utilised to manufacture AC sheets. Due to their toxicity, crocidolite and amosite are banned, leaving just chrysotile. Asbestos cement sheets are made from low-toxicity chrysotile fibres[1]. Commercial and industrial structures use metal roofs due to their durability, easy maintenance, and low cost. In hot weather, metal roofs can transport too much heat into buildings due to their high thermal conductivity. Thermal expansion and contraction can create discomfort for residents, increased air conditioning energy demand, and roof damage[2]. Thermal coatings on metal roof sheets can reduce heat transmission and improve energy efficiency. These coatings reflect sunlight and infrared rays to reduce metal roof sheet heat. Thermal coatings can also insulate the roof and limit heat transmission[3]. Despite their benefits, thermal coatings' effectiveness in reducing heat stress on metal roof sheets is unknown. High heat stress index values, which measure surface thermal load, can cause thermal fatigue and metal roof sheet deformation. Heat stress index evaluates surface thermal load. Thus, thermal coating research on metal roof sheets is crucial to lowering heat stress index[4]. This study examines the heat stress index of a metal roof sheet with various thermal coatings using Ansys software. Various coating thicknesses and thermal conductivities will be tested to reduce the heat stress index on the metal roof sheet. This investigation can provide the best thermal coating for metal roof sheets and building energy efficiency. NREL conducted the study[5]. These fibres were processed into asbestos cement sheets. Cement sheet production wastes some. Drum sticking, shrinkage during curing, and other waste concerns are most common. Superplasticizer and kaolin were added to reduce losses and preserve cure times. Hatschek machines can perfectly bind green sheets with minor adjustments. The Paraffin Wax combined Green and cured asbestos sheets were compared for temperature. Paraffin Wax is a good Phase Change



Material for lowering temperatures, however its binding nature requires its insertion in the Green sheet. RAMCO Industries Limited compiled junk data. This material reduces curing shrinkage, asbestos sheet heat absorption, and drum sticking waste during green sheet manufacture. The paper continues as follows. Section III discusses garbage and temperature management, whereas Part II reviews the literature. Section IV discusses sheet thermal analysis, and Section V 2. concludes with research proposals[6.7].

## **II. PROBLEM IN ASBESTOS ROOF SHEET**

Asbestos sheet is durable, affordable, and fire-resistant, making it a popular building material. Asbestos sheet is dangerous to human health because to its asbestos fibres. Inhaling asbestos fibres can cause lung cancer, mesothelioma, and other respiratory illnesses.

As a result, many countries have banned asbestos sheet and other asbestos-containing materials. Asbestos sheet offers health and environmental risks if improperly disposed of. If asbestos-containing materials are improperly handled and disposed of, asbestos fibres can become airborne and contaminate the environment.

Asbestos sheeting is fragile, weak, and easily breaks. This could harm asbestos roofing or other buildings, causing leaks and structural difficulties.

Asbestos exposure can harm one's health and poison the environment, making its usage in building a major concern. Safe handling and disposal of asbestos-containing goods reduces exposure to asbestos fibres.

Asbestos roof sheet is affordable, durable, and fire-resistant, making it a popular building material. However, asbestos roof sheet poses a serious health risk due to its asbestos fibres. Inhaling asbestos fibres can cause lung cancer, mesothelioma, and other respiratory illnesses.

Asbestos roof sheeting can grow brittle and break over time. This can cause roof leaks, structural issues, and safety problems.

Asbestos roof sheet cannot be recycled and can pollute the environment if improperly disposed of. This can pollute water, land, and other areas.

Metal roof sheeting can contaminate the environment and harm humans, making it a major concern for the building and construction sector. Safe handling and disposal of asbestos-containing products reduces exposure to asbestos fibres. Asbestos-free roofing materials should also be used.

## **III. RESEARCH GAP**

The assessment of previous research conducted for this study found several other studies that have looked into the usage of ceramic coatings on metal sheets for the purpose of providing thermal insulation. Unfortunately, there is a lack of research into the application of ceramic coatings on metal roof sheets for energy-efficient building applications, particularly in compared to asbestos metal sheets. This is a significant research gap.

In addition, the majority of the previous research has been on conducting experimental tests of thermal coatings on metal sheets, but the application of numerical simulation software such as Ansys has not been widely investigated within the framework of these studies. A numerical investigation conducted with the software Ansys can provide a more in-depth understanding of the thermal behaviour of metal roof sheets that have been coated with a variety of thermal materials. Additionally, this type of investigation can be a helpful tool in determining which thermal coatings are the most effective.

As a result, the purpose of this study is to fill in the research gap by carrying out a numerical inquiry with the help of the Ansys programme to analyse the heat transfer properties of metal roof sheets that have been coated with a variety of thermal materials. The heat stress index of the metal roof sheet will also be investigated in this study from the perspective of the effect that varying coating thicknesses and material qualities have on it. This will allow the study to provide insightful information regarding the behaviour of metal roof sheets that have thermal coatings, which will help improve the comfort of buildings, reduce energy consumption and expenses, and promote environmental sustainability.



#### IV. AIM

Using numerical modelling with Ansys, the main aim of this study is to determine how the application of different thermal coatings influences the heat stress index of a metal roof sheet.

##### Objectives:

- To create a numerical model in Ansys of a metal roof sheet with a variety of thermal coatings, we will use this information.
- In order to assess the heat transmission properties of the metal roof sheet with and without thermal coatings in a variety of temperature environments.
- The purpose of this activity is to analyse the heat stress index of the metal roof sheet coated with a variety of thermal coatings and to determine which coating offers the highest level of thermal insulation.
- In order to determine how the heat stress index of the metal roof sheet is affected by the various coating material qualities, research will be conducted.
- In order to provide suggestions for the use of thermal coatings on metal roof sheets for applications that promote energy efficiency, the results of numerical simulations will be used.

#### V. NEED AND IMPORTANCE

Ansys' numerical investigation in heat stress index with various thermal coatings on metal roof sheet is necessary and important:

**Energy-efficient building applications** Metal roofs, a common building component, can raise the building's internal temperature in hot weather. Thermal coatings on metal roofs reduce heat flow into the structure, reducing cooling energy. Thus, to establish the best thermal coating for energy-efficient building applications, it is necessary to study how different thermal coatings affect the heat stress index of metal roof sheets.

**Financial savings:** electricity-efficient buildings reduce carbon emissions and electricity bills. The most efficient thermal coating for a metal roof sheet can cut monthly energy expenditures and help the environment.

In hot weather, roofs with a high heat transmission rate can make buildings uncomfortable, reducing productivity and health. Thermally efficient roof coatings limit heat transfer, making the building's interior more comfortable.

**Material choice:** The computational study can show how coating thicknesses and roofing material characteristics affect the heat stress index of the metal roof sheet. This information can help choose the best coating materials for specific applications, improving material efficiency and cost.

Numerical simulation with Ansys can accurately forecast the heat transfer parameters of metal roof sheets with various thermal coatings. This can save time and money on physical testing and give a better understanding of how the metal roof sheet behaves to different temperatures.

#### VI. COATING TECHNIQUE: PLASMA SPRAY TECHNIQUE

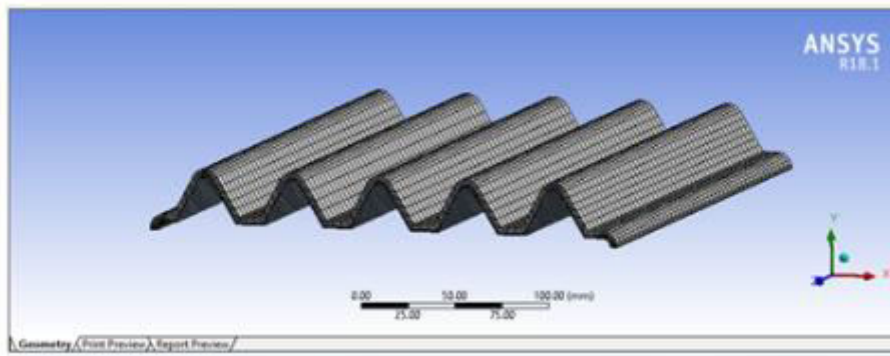
Thermal spray deposits a finely distributed metal or non-metallic coating material, such as wire or powder, on the substrate while it is molten or semi-molten. Coatings might be metallic or non-metallic. Thus, a layer is deposited. After heating to a plastic or molten state, the thermal spray component is accelerated [9-11]. The substrate pressure distorted these particles. They formed a multilayer sheet that adhered to the substrate as a result. They stack up, forming a layered coating eventually. Coating materials can fulfil many functions. These include thermal insulation, ceramic insulation, erosion and abrasion resistance, and others. Thermal spray is employed in many industries and applications today. These include aerospace, automotive, energy, metallurgy, paper production, machinery repair, municipal construction, and more. Thermal spray technology is the best, cheapest, and easiest way to improve surface functions and characteristics in engineering and mechanical surface treatment. Thermal spray technique heats surfaces with a spray pistol. Thermal spraying can increase surface performance, lengthen machinery or spare component life, and lower production and maintenance expenses. These advantages are simultaneous. Thermal spray can affect



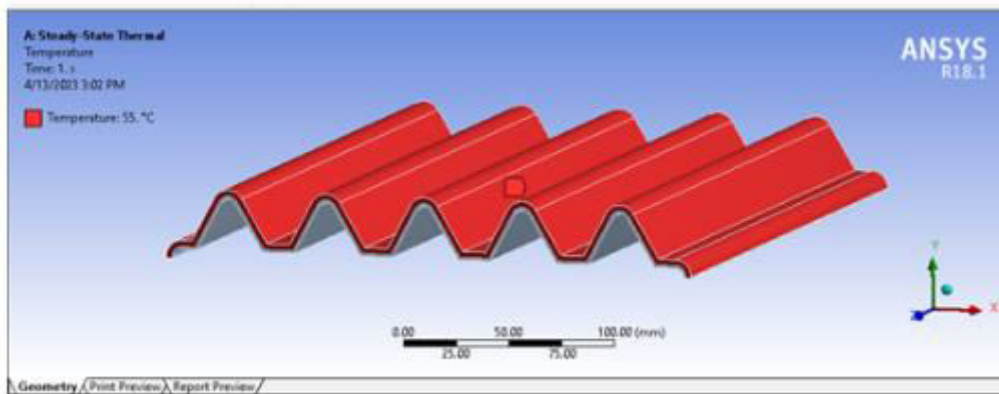
electrical conductivity, create a heat-resistant barrier, and resist abrasion. Gap control, size restoration, and erosion prevention are other benefits[12-14].

## VII. DESIGN AND ANALYSIS RESULTS

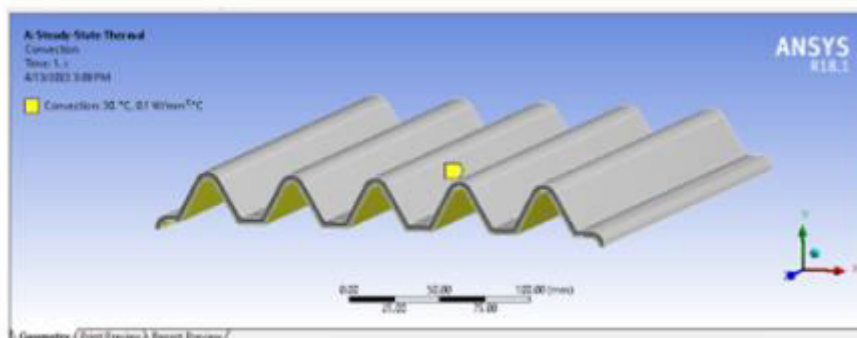
### MESH



### Temperature

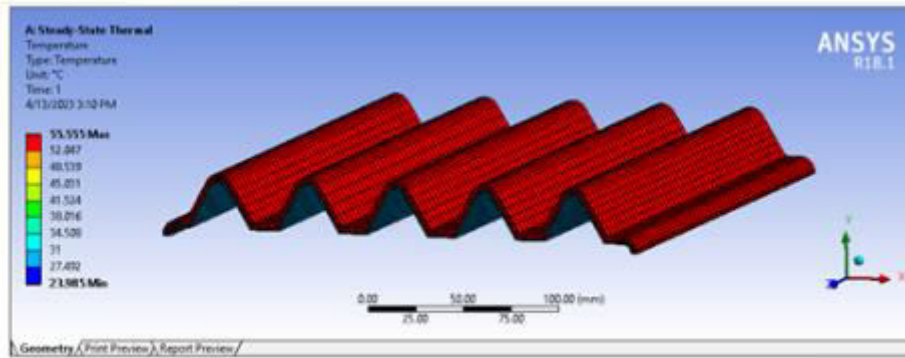


### COVECTION

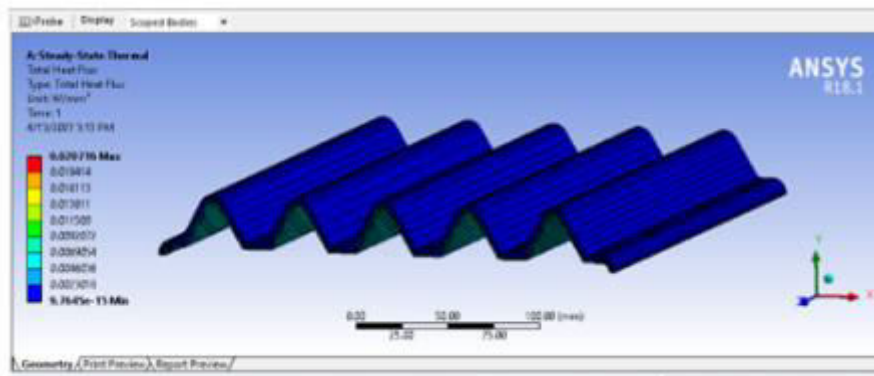


## RESULT FOR STRUCTURAL STEEL

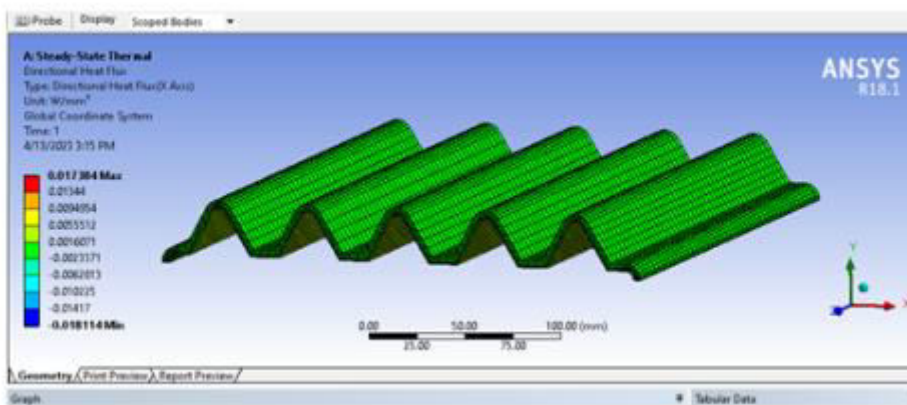
### Temperature



### Total Heat Flux

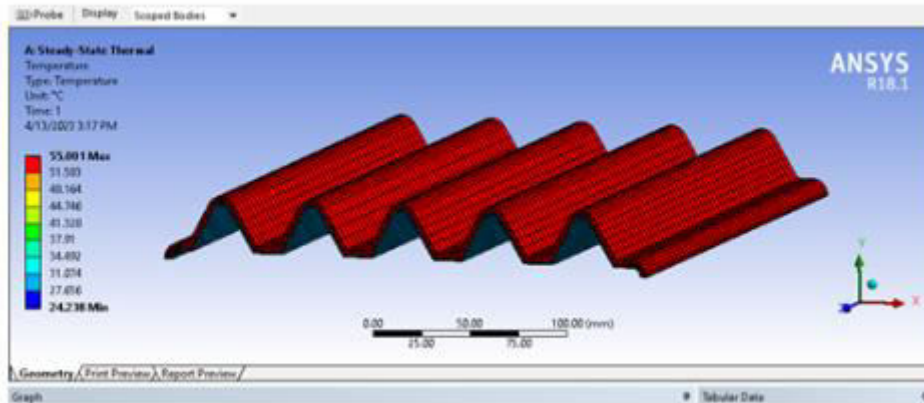


### Directional Heat Flux

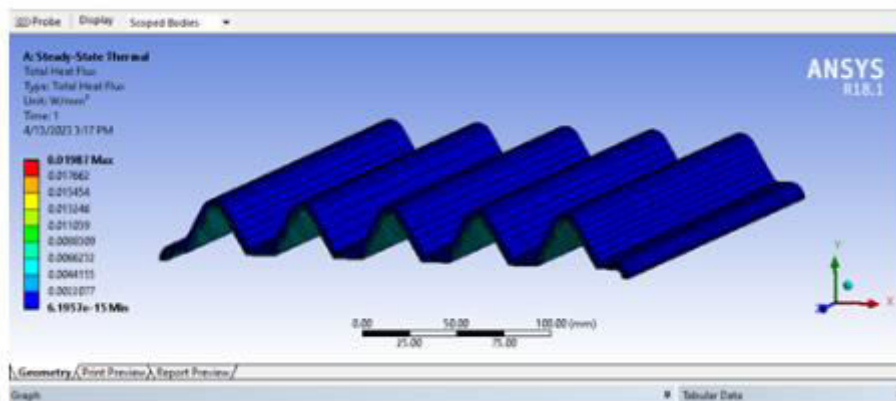


## RESULT FOR COATED WITH ALUMINA

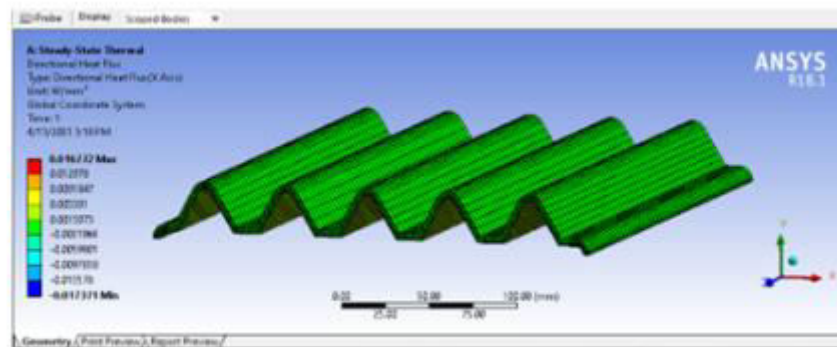
### Temperature



### Total Heat Flux

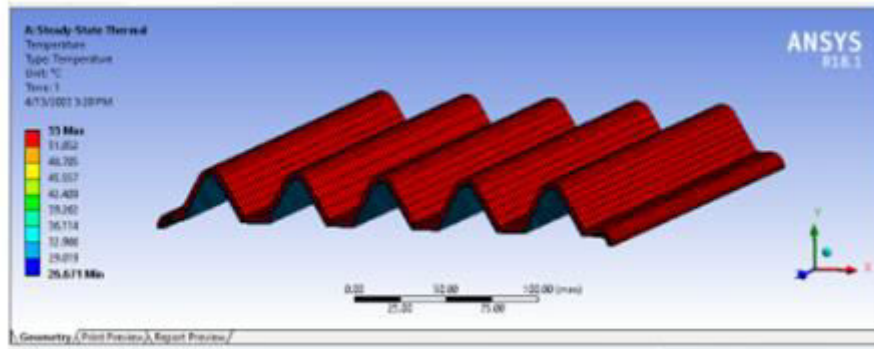


### Directional Heat Flux

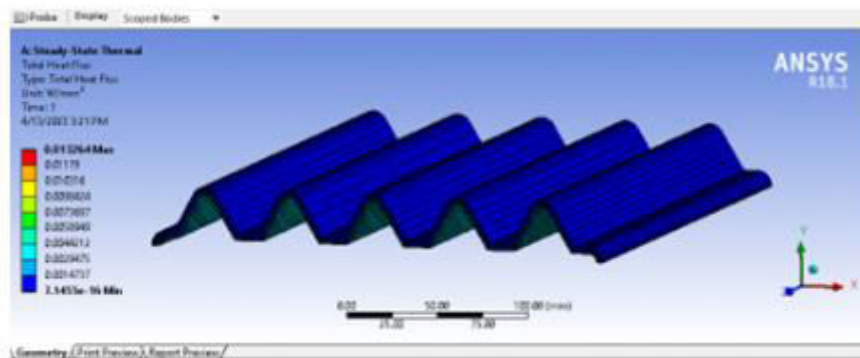


## RESULT FOR COATED WITH TITANIA

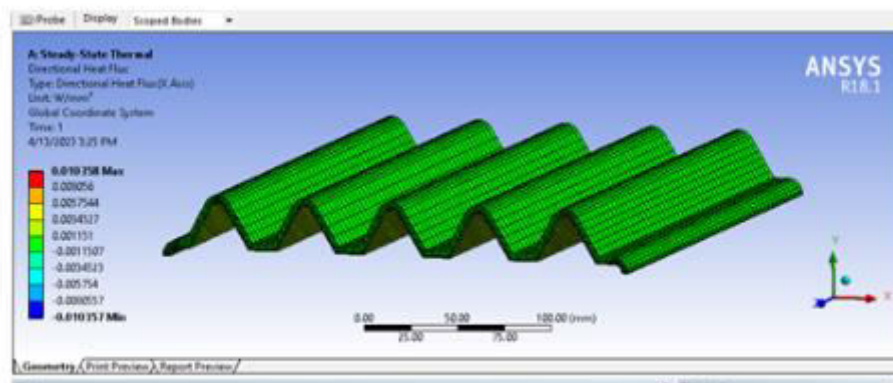
### Temperature



### Total Heat Flux



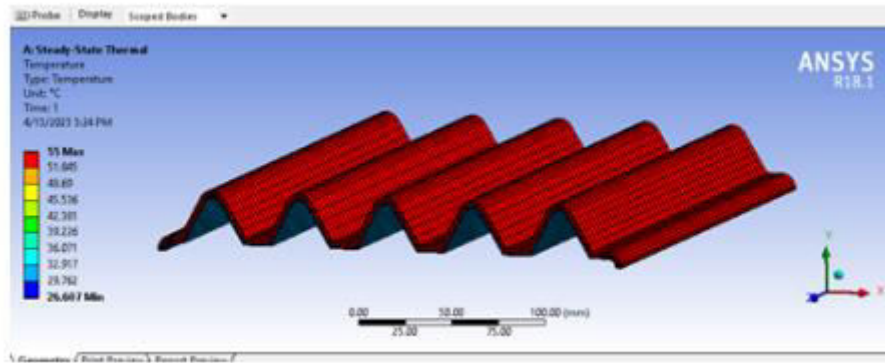
### Directional Heat Flux



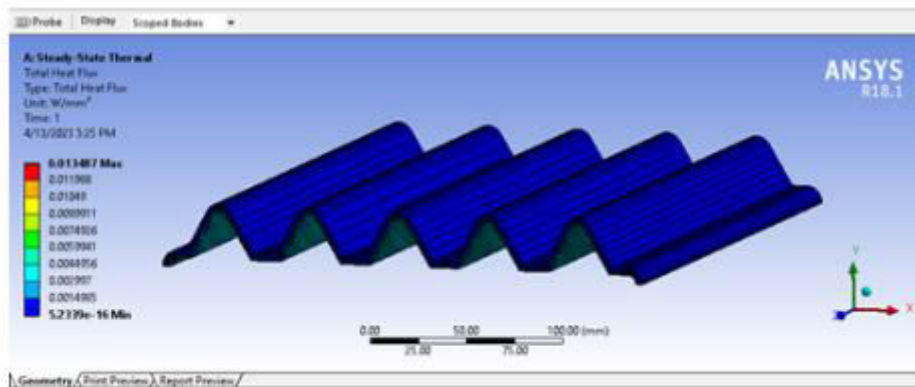


## RESULT FOR COPATED WITH ZIRCONIA

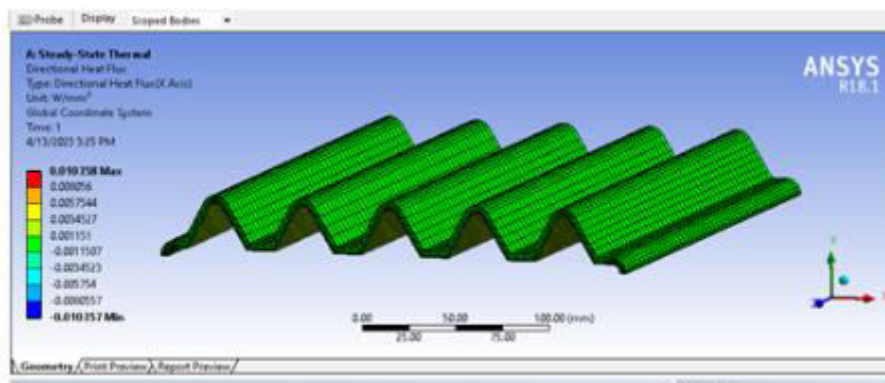
### Temperature



### Total Heat Flux



### Directional Heat Flux





### COMPARISON OF RESULTS

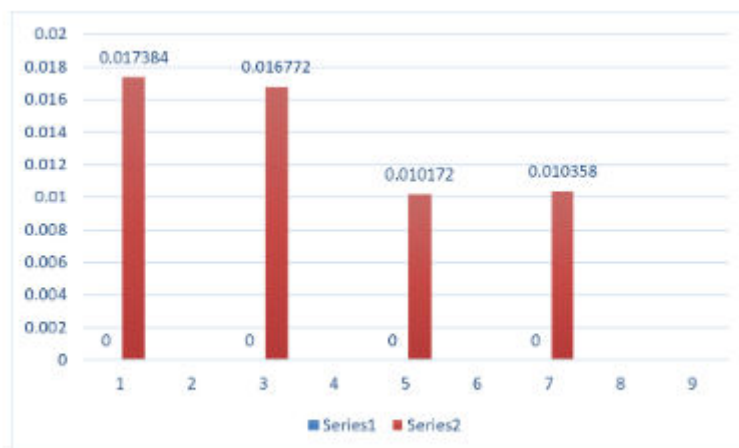
Comparison of Temperature ( $^{\circ}\text{C}$ ):



Comparison of Total Heat Flux ( $\text{W}/\text{mm}^2$ ):



Comparison of Directional Heat Flux ( $\text{W}/\text{mm}^2$ ):



## VIII. CONCLUSION

In conclusion, the numerical investigation in heat stress index with various thermal coatings with alumina, titania, and zirconia on metal roof sheet by Ansys is a valuable study that can provide important insights into the use of thermal coatings on metal roofs for applications relating to energy-efficient building applications. The study is able to evaluate the heat transfer characteristics of the metal roof sheet with and without thermal coatings under a variety of temperature conditions because it uses Ansys software to develop a numerical model of a metal roof sheet with various thermal coatings. This allows the study to compare the performance of the metal roof sheet with and without thermal coatings. Identifying the thermal coating that provides the best thermal insulation can be made easier by comparing the heat stress index of the metal roof sheet to that of a variety of other thermal coatings.

In addition, the inquiry may look into how the heat stress index of the metal roof sheet is affected by a variety of coating thicknesses as well as material qualities. The study has the potential to contribute to the improvement of building comfort, the reduction of energy consumption and costs, and the promotion of environmental sustainability by providing recommendations for the use of thermal coatings on metal roof sheets. These recommendations are based on the results of numerical simulations.

It is essential to point out that the scope of the research was restricted to the use of numerical simulation carried out with the Ansys software as well as the application of a predetermined group of thermal coating materials and thicknesses. Despite this, the findings have the potential to provide useful insights into the behaviour of metal roofs that have thermal coatings and to help to the development of construction materials and methods that are more effective and efficient.

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