Effects of Shear Studs and Opening in the Mechanical Performance of the Composite Floor Deck – Numerical Modelling

by

Abdul Rais bin Abdul Rashid

18003096

Dissertation submitted in partial fulfilment of

the requirements for the

Bachelor of Engineering (Hons)

(Civil Engineering)

FYP II January 2022

Universiti Teknologi PETRONAS
Bandar Seri Iskandar,
32610 Seri Iskandar,
Perak Darul Ridzuan.

CERTIFICATION OF APPROVAL

Effects of Shear Studs and Opening in the Mechanical Performance of the Composite Floor Deck – Numerical Modelling

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A project dissertation submitted to the
Civil & Environmental Engineering Programme
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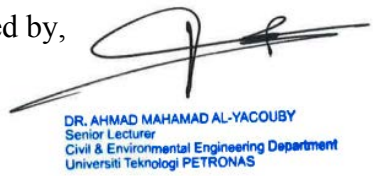
Approved by,



(Dr Ahmad Mahamad Al-Yacouby)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
January 2022

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

Abdul Rais bin Abdul Rashid

ABSTRACT

Composite floor deck system is the most popular floor system used in the construction industry especially in offshore structures. Composite floor deck is a floor system that consist of steel deck bonded with concrete. The shear-bond between the steel deck and the concrete normally controls the shear capacity of a composite floor deck system. In current construction industry especially in offshore structures, shear stud is normally used to improve shear performance for the structure but there is no proper test to identify the efficiency and strength of the shear studs and the effect to the mechanical performance of the structure. Besides, other than shear stud, there are always opening for M&E equipment also in any floor deck system which need analysis to identify their effect to the mechanical performance of the floor deck system. The main objective of this study is to identify the effects of shear studs and openings on the mechanical performance of the composite floor deck. Shear stud is a stud that transfers shear stress between metal and concrete in composite structural members in which the stud is welded to the metal component whereas openings are usually provided on the composite floor deck for mechanical and electrical equipments. The method used to complete this study is by using SOLIDOWRKS software to model and carry out analysis on ANSYS software of the composite floor deck with shear studs and openings. The ANSYS software will give results on the total deformation, maximum shear stress and also equivalent stress of the composite floor deck under different conditions. There will be a total of eight different models that will be designed and analysed for this project. All the models will be interpreted and discussed in detail on the mechanical behavior of the composite floor deck system. As a conclusion for this project, it can be concluded that presence of shear stud does improve the mechanical performance of composite floor deck while presence of opening reduce the mechanical performance of a composite floor deck system.

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CHAPTER 1: INTRODUCTION

1.1 Background of study

Composite floor deck is defined as a floor system that consist of steel and concrete bond to achieve high strength of stress to withstand high pressure and load. The bond between steel and concrete is very important in order to ensure that the floor system has high load and compressive strength. The bond between the steel deck and the concrete normally determines the load-bearing capacity of a composite deck (TREMBLAY et al., 2002). The shear bond is mainly due to the presence of mechanical gears, which are created by the use of embossing in the webs of the deck during the rolling process; however, the level of shear strength between concrete and steel can also vary depending on deck profile, steel thickness and grade, coating, as well as the deck position, i.e. normal or inverted (TREMBLAY et al., 2002). Furthermore, The P-3606 (P-3615 in Canada) composite deck is one of the more popular products manufactured by the Canam Manac Group for the construction of floors in steel buildings. The deck panels are 1 W' (38 mm) deep with a nominal width of 36" (914 mm) and with flutes spaced at 6" (152 mm) on centre as shown in **Figure 1.1** (TREMBLAY et al., 2002).

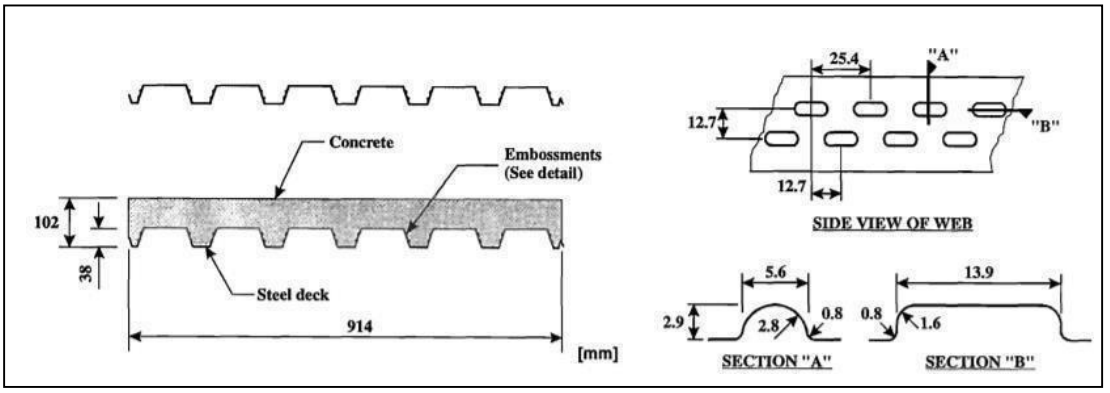


FIGURE 1.1: Typical Composite Floor Deck Cross-Section (102 mm slab shown with deck in upright position)

Next, shear stud is a stud that transfers all the shear stress and load between the steel and the concrete in a composite floor deck system. The shear studs are usually welded to the to the metal component which is the steel of the composite floor deck system. Shear studs are usually used in composite floor deck system to strengthen the floor deck and to improve the load bearing capacity of the floor deck system. There are many factors that affects the strength behaviour of the shear studs such as the size of shear studs, arrangement of shear studs and also the number of shear studs on the

composite floor deck. The most widely used shear connectors in building construction are headed shear studs, typically with a diameter of 19 mm, a height of 100 mm, and a tensile strength of 450 N/mm2 (SHEN et al., 2020). **Figure 1.2** below shows the application of shear studs in the composite floor deck system.

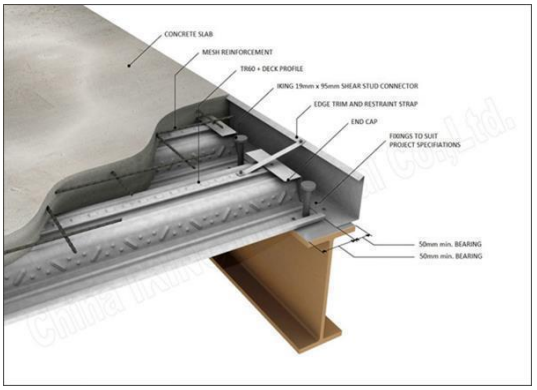


FIGURE 1.2: Application of shear studs in the composite floor deck system.

Furthermore, openings are also one of the important structure in a composite floor deck system. Openings on composite floor deck are usually for mechanical and electrical equipments such as wiring, piping and also manholes for services and maintenance. Therefore, it is important to study on the effects of openings in the mechanical performance of the composite floor deck system to identify the changes in stress and load bearing capacity of the composite floor deck.

In this paper, the mechanical performance of the composite floor deck that consist of openings and shear studs will be analyse by using numerical method. The numerical method used is by designing a model of composite floor deck in ANSYS software with different conditions and running an analysis to calculate the total shear strength and load bearing capacity. ANSYS is a finite element analysis software used to simulate different computer designed models of structures for analysing strength, toughness, load bearing capacity and other attributes. **Figure 1.3** below shows the example of composite floor deck system model in ANSYS software.

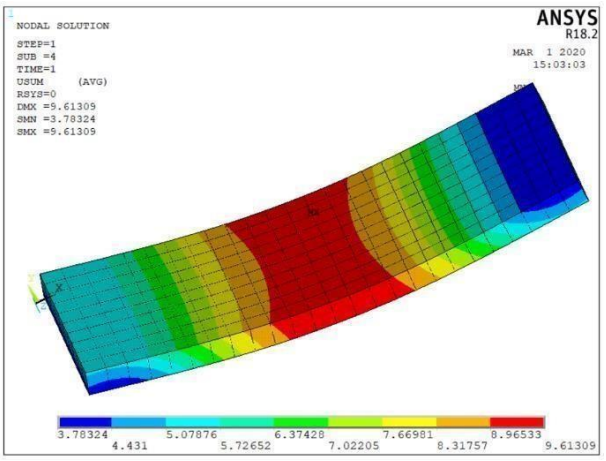


FIGURE 1.3: Example of composite floor deck system model in ANSYS software.

The results from the ANSYS software will be validated by comparing the results of main composite floor deck and the composite floor deck with varying parameters of opening and shear studs. The purpose of validation is to ensure that the objective of this project is achieved which is to study on the effect of shear studs and opening on the mechanical behavior of composite floor deck. In addition to that, validation of results will help to improve the credibility of this research study which is the effects of shear studs and openings in the mechanical performance of composite floor deck system.

1.2 PROBLEM STATEMENT

In current construction industry especially in offshore structures, shear stud is normally used to improve shear performance for the structure. Besides, openings are also used widely in construction for mechanical and electrical equipments. The main problem of this study is there is no proper test to identify the efficiency and strength of the composite floor deck that has shear studs and also opening in it. A proper test on the efficiency and strength of the composite floor deck is important as it is to ensure that the structure is able to achieve maximum load bearing capacity without causing any failures and damage to the structures. Next, the purpose of this study is to study the effects of shear studs and openings in the mechanical performance of composite floor deck by using finite element analysis on ANSYS software. The ANSYS software is the most effective way and it is a proper test to identify the strength and load bearing capacity of the structure. This is because the test can be done based on computer simulation and no prototype is need to be constructed.

Furthermore, Civil Engineering structures may be exposed to dynamic loads such as explosions and impacts during their useful life. In the development of wide-span supportingstructures and high-rise buildings, researchers and planners have paid more and more attention to the progressive structural collapse caused by extreme loads. Extensive research has been carried out on the progressive collapse of steel structures in order to develop design methods with the aim of preventing or mitigating the progressive collapse. (HUO et al., 2019). These problems can be solved by using finite element analysis on ANSYS software to calculate and identify the strength and load bearing capacity of the structure by modelling before proceeding with the construction works.

In addition to that, the failures on the composite floor deck system or any structure can cause a huge lost to the construction industry. The failures can be in form of compressive, buckling, tensile and also bending. Based on previous studies, it is proved that shear studs is one of the solutions for all these failures but there must be a proper test to evaluate the strength of the composite floor deck before proceeding with construction works. **Figure 1.4** below shows the example of failure on composite floor deck with shear studs. **Figure 1.5** below shows the example of failure for the design of opening in composite floor deck.

FIGURE 1.4: Example of failure on composite floor deck with shear studs

FIGURE 1.5: Example of failure for the design of opening in composite floor deck.

In conclusion, the main cause of failure to most of the construction works on structures are caused by improper test done on the structure itself. After completing this paper, it will prove that finite element analysis by using ANSYS software is one of the best method to test the strength and load bearing capacity of a structure mainly composite floor deck system that consist of shear studs and also openings.

1.3 OBJECTIVES

The primary objective of this project and research is to study on the effects of shear studs and openings in the mechanical performance of composite floor deck system by using numerical method which is finite element analysis by modelling and analysing using ANSYS software. The objectives of this project is detailed as below:

1. To investigate the effect of shear studs on the mechanical performance of the composite floor deck system by varying parameters such as number of shear studs and arrangement of shear studs.
2. To determine the effect of openings on the mechanical performance of the composite floor deck system by varying parameters such as location and size of the opening.

As mentioned above, there are two main objectives of this study that is related to the shear studs and openings on the mechanical performance of the compositefloor deck system. These objectives can be achieved by the end of this study by creating model of composite floor deck system in ANSYS software and then running an analysis to identify the shear strength of the composite floor deck that is subjected with shear studs and also openings. The result from ANSYS software will then be validated by comparison between the composite floor deck systems.

1.4 SCOPE OF STUDY

The main scope of study for this project is finite element analysis by using ANSYS software to evaluate the effects of shear studs and openings in the mechanical performance of composite floor deck. The following are other scope of study this project will limit itself to:

1. Perform an analysis on the model of composite floor deck created in the SOLIDWORKS in the ANSYS software.
2. Perform an analysis to measure and evaluate the ultimate strength capacity of the composite floor deck system with four different conditions:
    - Normal composite floor deck system.
    - Composite floor deck system with shear studs.
    - Composite floor deck system with openings.
    - Composite floor deck system with shear studs and openings.
3. The parameters that will be variable for shear studs are the number of shear studs and arrangement of shear studs.
4. The parameters that will be variable for openings are the location of openings and size of openings.

CHAPTER 2: LITERATURE REVIEW

The literature review part of this project report will discuss on the effects of shear studs and opening in the mechanical performance of the composite floor deck by referring to past research and studies. The main important points that will be discussed in this literature review is composite floor deck, shear studs, opening, design modelling using SOLIDWORKS software and also numerical modelling by finite element analysis using ANSYS software.

2.1 Composite Floor Deck

Composite floor deck is defined as a floor system that consist of steel and concrete bond to achieve high strength of stress to withstand high pressure and load. The shear-bond between the steel and concrete is highly critical to ensure the floor system has a high resistance of load and pressure. In composite members, stud shear connectors of various forms are used to transmit longitudinal shear forces at the steel-concrete interfaces (SHEN et al., 2020). The structural behaviour of these connectors has a direct influence on the effectiveness of the composite members in acting as integral members in resisting the applied loads. The most widelyused shear connectors in building construction are headed shear studs (SHEN et al., 2020).

According to previous studies and experiment as discussed by SHEN et al. (2020), the shear resistance of a stud shear connection in a composite beam with a profiled deck largely depends on the following factors:

- Concrete compressive and tensile strengths as well as elastic modulus;
- Tensile strength of headed shear studs as well as their shapes and sizes;
- Welding quality of shear studs and dimensions of welding collars at stud roots;
- Arrangements of headed shear studs within the troughs of profiled decks including position and spacing;
- Yield and tensile strengths of profiled decks and their cross-sectional shapes and dimensions, as well as sizes of longitudinal stiffeners in deck troughs, if present;
- Spanning direction of profiled decks, if present;
- Sizes and arrangement of steel reinforcement in the vicinity of the shear studs.

The modelling of the composite floor deck with shear studs and opening for this project will be done by considering several factors. For shear studs, there will be several variables such as number of shear studs, location of shear studs and arrangement of shear studs. Next, for the openings on the composite floor deck, the parameters that will be variables are location and size of the openings. The composite floor deck that will be model in this project consist of several components such as concrete slab, steel section, shear studs, slab reinforcement, steel section-slab interface and also openings. **Figure 2.1** below shows the finite element model of the composite floor deck system that is adapted from the article by (HASSANIN et al., 2020). **Figure 2.2** below shows the composite floor deck that consist of shear stud.

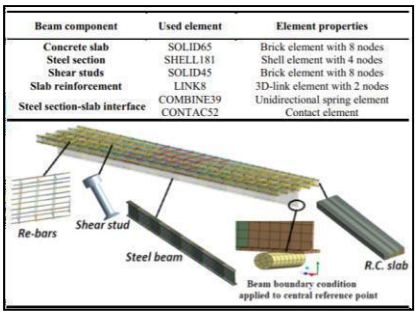


FIGURE 2.1: Finite element model of the composite floor deck system

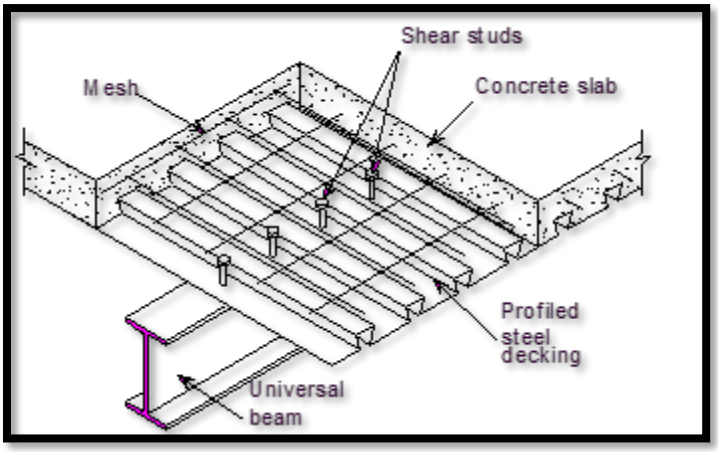


FIGURE 2.2: The composite floor deck that consist of shear stud.

2.2 Shear Studs on Composite Floor Deck

Shear stud is a stud that transfers all the shear stress and load between the steel and the concrete in a composite floor deck system. The shear studs are usually welded to the to the metal component which is the steel of the composite floor deck system. Shear studs are usually used in composite floor deck system to strengthen the floor deck and to improve the load bearing capacity of the floor deck system. HASSANIN et al., (2020) stated that shear connector studs are the key tool to connect the steel I-beam to the concrete slab to achieve the required bond effect. Most of the researchers in the literature review must use single strand elements to model shear anchors. as a three-dimensional body with several elements consisting of knob body and knob root connection with a material connection with structured welding sleeve with brittle material properties The arrangement of the shear studs on the composite floor deck can be done in pairs or staggered depending on the design and specifications.

There are several type of shear connectors in the construction industry such as headed studs, perfobond ribs, t-rib connector, t connectors, channel connector and also rectangular-shaped collar connectors. In this project, the headed shear studs is used as the shear connectors for the composite floor deck. According to Muhit, (2015), This type of connector contributes to the shear transfer and prevents uplift, as it is designed to work as an arc welding electrode, and, simultaneously, after the welding, acts as the resisting connector with a suitable head. As a result of the high degree of automation in the workshop or on site, this type of connector is commonly used worldwide. Much research has been carried out on headed stud shear connectors and various equations have been proposed to estimate the strength of studs. They carried out the initial studies on stud shear connectors, where full-scale push out specimens were tested with various sizes and spacing of the studs. The push-out and composite beam tests were used in studies on stud shear connectors to evaluate shear capacities. **Figure 2.3** below shows the Headed Shear Stud used in the construction industry.

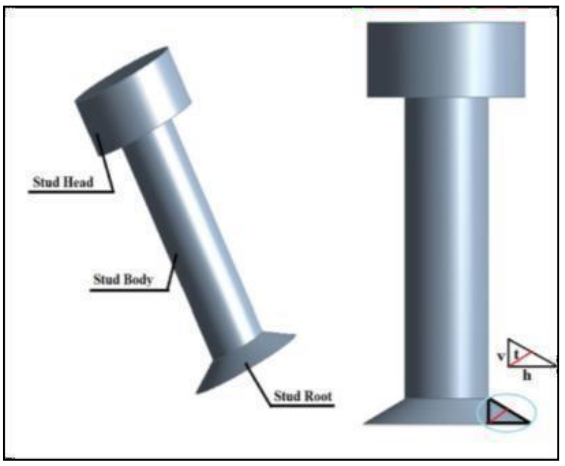
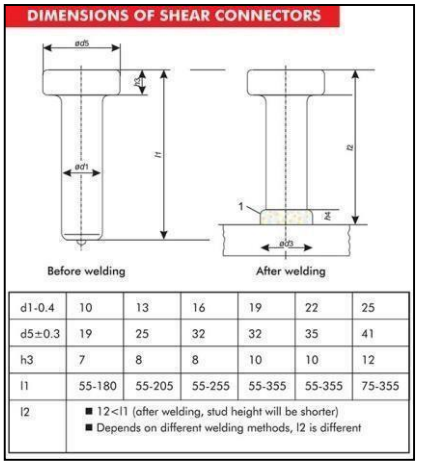


FIGURE 2.3: Headed Shear Stud used in the construction industry

The shear studs will be designed in the SOLIDOWRKS and analysed in ANSYS software and applied to the composite floor deck system. There are many different sizes of shear stud in the market. **Figure 2.4** below shows the different sizes of headed shear studs available in the market. For this project, there will be only one size of shear stud chosen and the variable parameters will be the number of shear studs and also the arrangement of the shear studs. Both of these variable parameters will be also undergo analysis on ANSYS software and the result will then be compared with the main composite floor deck model. **Figure 2.5** below shows the headed shear studs model on ANSYS software.



d1-0.4	10	13	16	19	22	25
d5±0.3	19	25	32	32	35	41
h3	7	8	8	10	10	12
l1	55-180	55-205	55-255	55-355	55-355	75-355
l2	■ 12<l1 (after welding, stud height will be shorter) ■ Depends on different welding methods, l2 is different					

FIGURE 2.4: The different sizes of headed shear studs available in the market.

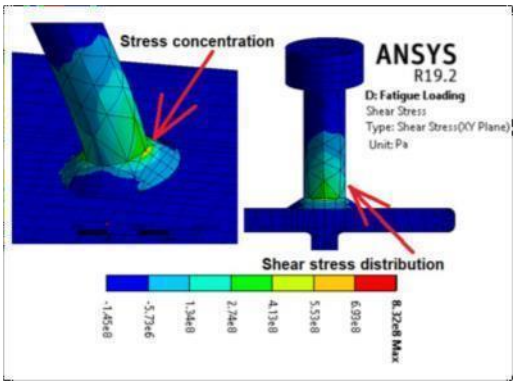


FIGURE 2.5: The headed shear studs model on ANSYS software.

2.3 Openings on Composite Floor Deck

Besides having shear studs on the composite floor deck, this project also includes opening on the composite floor deck and study the mechanical performance of the composite floor deck. According to Mota & Kamara, (2014), The openings in the slabs are usually required forplumbing, fire protection pipes, ventilation ducts and heatingand air conditioning technology. The position and size of the required openings are usually specified in the early design stages and adjusted accordingly. The openings will also be model by using ANSYS software for this project. The parameters of openings that will be variable is the location and size of the openings provided on the composite floor slab.

Next, according to Mota & Kamara, (2014), For the purposes of design, a two-way slab system is divided into column and middle strips in two perpendicular directions. The column strip width on each side of the column center line is equal to one quarter the length of the shorter span in the two perpendicular directions. The middle strip is the stripbounded by two column strips. As an alternative to detailed analysis for slabs with openings the ACI 318 gives the following guidelines for opening size in different locations for slabs without beams:

- In the area common to intersecting middle strips, openings of any size are permitted (13.4.2.1).
- In the area common to intersecting column strips, maximum permitted opening size is one-eighth the width of the column strip in either span (13.4.2.2).
- In the area common to one column strip and one middle strip, maximum permitted opening size is limited such that only a maximum of one-quarter of slab reinforcement in either strip may be interrupted (13.4.2.3).

In this project, all the specifications of openings will be considered when designing the opening for the composite floor slab. The openings need to designed accordingly to ensure all the mechanical and electrical equipments can fit to it perfectly. **Figure 2.6** below shows the openings provided on a composite floor deck.

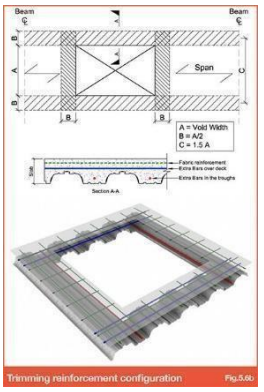


FIGURE 2.6: The openings provided on a composite floor deck.

2.4 Numerical modelling by finite element analysis using ANSYS software

The effect of shear studs and opening on the mechanical performance of the composite slab in this project will be analysed by using finite element analysis using ANSYS software. First, the composite floor deck will be designed and then the shear studs and openings will be included in the model of the composite floor deck system. There will be 4 models that will be designed for this project which are Normal composite floor deck system, Composite floor deck system with shear studs, Composite floor deck system with openings, Composite floor deck system with shear studs and openings. All these conditions will be analysed one by one to get the load bearing capacity and strength of the composite floor deck system.

Then, after the analysis of all the four main models is done, there will be another four models which is the variables for composite floor deck with opening and also composite floor deck with shear studs. The variables for composite floor deck with opening will be the size of the opening and also the location of the opening. Next, for the composite floor deck with shear studs, the variables will be the number of shear studs and also the arrangement of shear studs on the composite floor deck. The final result will then be compared with the main design models.

2.4.1 Numerical Modelling

HASSANIN et al. ,(2020) stated that a nonlinear finite element model will be performed using the software package ANSYS. A three-dimensional (3D) finite element model will be developed to simulate the geometric and material nonlinear behavior of the composite beams. The finite element models for the various components that make up the concrete–steel composite beam are presented next. The details of the modelling using ANSYS software is discussed on detail as below. These numerical modelling is chosen to analyse and get the results of this project due to its efficiency and also it does not require a large cost to build a prototype and test the prototype with destruction test. **Figure 2.7** below shows Finite element model representing the full-scale composite beam.

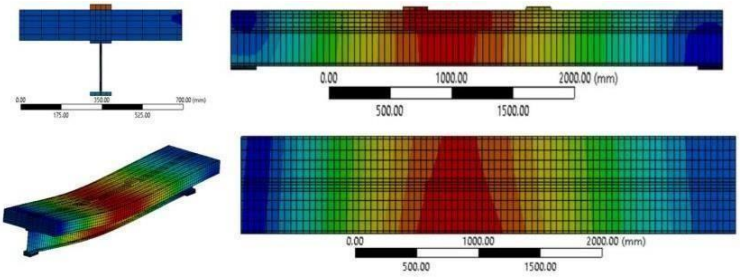


FIGURE 2.7: Finite element model representing the full-scale composite beam.

2.4.1.1 Concrete Modelling

The F.E.M. of the concrete slab must be suitable for representing cracks, crush failures and shear transfer capability of concrete after cracking occurred. Three-dimensional brick element with 8 nodes (SOLID 65) will be the selected element to simulate concrete slab. This element is capable of cracking in tension and crushing in compression. The element also consists of eight nodes with three degrees of freedom that controlled each node behaviour (HASSANIN et al., 2020). By referring to the article, it helps to decide which concrete modelling is the most suitable to be used for the modelling of composite floor deck.

2.4.1.2 Shear Connectors Modelling

Shear connector is the key tool to link steel I-beam to the concrete slab in order to achieve the needed composite action. Most of the researchers in the literature review have to use single-line elements to model shear connectors. In this study, shear connectors were modelled as a three-dimensional body with multiple elements consisting of stud body and stud root which connect with bonded connection with welding collar modelled with a brittle material property (HASSANIN et al., 2020). The shear connectors that will be used in this project is headed shear stud.

2.4.1.3 Openings Modelling

The openings will be designed on the composite floor deck by referring to the actual design in the construction industry. There are several functions of openings in the construction mainly for the mechanical and electrical equipments. The modelling of opening will have variable parameters such as the location of the opening and also the size of the openings. The decision of size and location of the openings will be decided by referring to an actual building that has openings for electrical and mechanical equipments. The ANSYS modelling of composite floor deck will be designed first as a normal composite floor deck. Then, the openings will be designed on the composite floor deck by cutting through the composite floor deck model in the ANSYS software. The openings can be in vertical or horizontal position according to the design but for this project, the openings that will be designed and modelled in the ANSYS software will only vertical position openings. **Figure 2.8** below shows the modelling of opening in the ANSYS software.

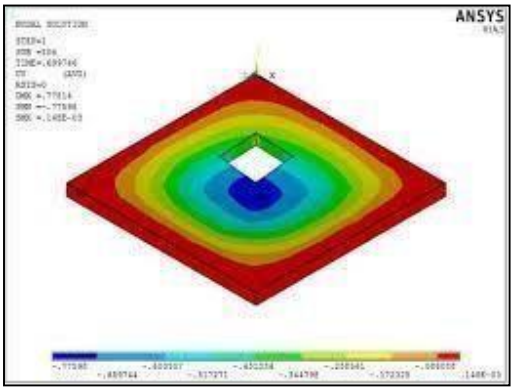


FIGURE 2.8: The modelling of opening in the ANSYS software.

2.5 Design model using SOLIDWORKS software

SOLIDWORKS is a computer software that can be used to design any 3-D geometry model easily. The purpose of using this software is because it is hard to design the model of composite floor deck in ANSYS and it requires more time and effort. There are few advantages of designing using SOLIDOWORKS such as increase productivity, design better, cost efficient, enhanced collaboration and also innovative designs. All these advantages are proved as this project is done by using SOLIDWORKS software for all the moedlling of the composite floor deck system.

In this project, there are a total of eight different models of composite floor deck which are designed by using this software which are:

1. Composite floor deck.
2. Composite floor deck with opening.
3. Composite floor deck with shear studs.
4. Composite floor deck with opening and shear studs.
5. Composite floor deck with opening with different size. (200mmx 200mm)
6. Composite floor deck with opening at different location. (Centre of the deck)
7. Composite floor deck with different number of shear studs. (10 shear studs)
8. Composite floor deck with different shear stud arrangement.

After completing all these design models, it is then exported to the ANSYS software for the analysis of the model to generate different solutions which are total deformation, maximum shear stress and also equivalent stress. **Figure 2.9** below shows the example of composite floor deck with shear studs and opening in SOLIDOWRKS.

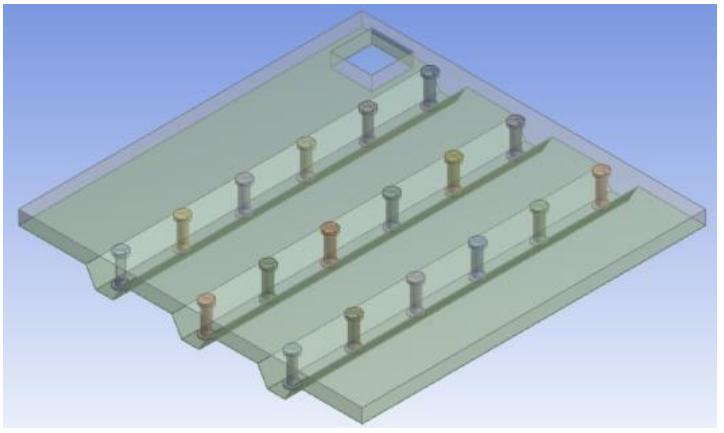


FIGURE 2.9: The example of composite floor deck with shear studs and opening in SOLIDOWRKS.

2.6 Summary of literature review

Table 2.1 below shows the literature review summary of this project. The main articles information including the problem statement and also research gap is explained in detail.

TABLE 2.1: The literature review summary of this project

No.	Author	Year	Country	Title	Problem Statement	Research Gap
1.	AHMED I.HASSANIN et al.	2020	Saudi Arabia	The effects of shear stud distribution on the fatigue behavior of steel-concrete composite beams.	Despite improved understanding of their behavior, several composite structures failed in satisfying their structural and functional demands due to stud shearing of or concrete crushing as a direct result of fatigue .	This article studies on the effects of shear studs on the fatigue behaviour whereas this project discuss the effects of shear studs and opening on the mechanical performance of the composite floor deck.
2.	JINGSI HUO et al.	2019	China	Experimental study on impact behavior of stud shear connectors in composite beams with profiled steel sheeting.	Civil engineering structures are possibly subjected to dynamic loadings, such as blast and impact during their service life. With the development of long span structures and high-rise buildings, researchers and designers have paid more and more attention to structural progressive collapse caused by the extreme loadings.	This article studies the impact behaviour of stud shear connectors in composite beams whereas this project focuses on the effect of shear studs and openings on the mechanical performance of the composite floor deck.
3.	MIKE MOTA et al.	2014	Portland	Floor Openings in Two-Way Slabs	Modifications to an existing structure, although not frequent, occur in almost every structure. New slab openings or penetrations in an existing concrete building are easily accommodated in the majority of instances.	This articles only discussed on the openings on a two-way slab whereas this final year project discuss on the mechanical performance of composite floor deck subjected to openings.
4.	MIN-HUI SHENA et al.	2020	China	Structural behavior of stud shear connections in composite floors with various connector arrangements and profiled deck configurations.	The structural behavior of these shear stud connectors has a direct influence on the effectiveness of the composite members in acting as integral members in resisting the applied loads.	This article studies on the shear studs structural behaviour with various connector arrangements and profiled deck configurations whereas this project also includes openings in the composite floor deck and study the effect of shear studs and opening to the mechanical performance of the composite floor deck.
5.	TREMLAY R. et al	2002	USA	Variables Affecting the Shear-bond Resistance of Composite Floor Deck Systems	Failure of longitudinally unrestrained composite floor slab specimens subjected to gradually incremented gravity load generally occurs by longitudinal shear-bond failure.	This articles only focuses on the variables affecting the shear bond resistance of composite floor deck whereas this final year project studies on the effects of shear studs and also opening on the mechanical performance of the composite floor deck system.

CHAPTER 3: METHODOLOGY

The methodology part of this project will discuss on the methods and procedure in achieving the goal of this project which is to study on the effect of shear studs and opening on the mechanical behavior of the composite floor deck and it is a numerical modelling project. In this methodology part, the writer will explain in detail the modelling of the composite floor deck by using SOLIDWORKS software and also analysis of the composite floor deck by using ANSYS software. Then, the writer will also describe the flow chart and also Gantt Chart of this project.

3.1 Modelling of composite floor deck by using SOLIDWORKS

The modelling of the composite floor deck is done by using SOLIDWORKS software. First the main model is design on the software which is the composite floor deck. The main model consists of the metal deck plate and also concrete for the composite floor deck system. The main model is then edited to create another eight models of composite floor deck which are:

1. Composite floor deck.
2. Composite floor deck with opening.
3. Composite floor deck with shear studs.
4. Composite floor deck with opening and shear studs.
5. Composite floor deck with opening with different size. (200mmx 200mm)
6. Composite floor deck with opening at different location. (Centre of the deck)
7. Composite floor deck with different number of shear studs. (10 shear studs)
8. Composite floor deck with different shear stud arrangement.

All the composite floor deck has dimensions of 1000mm x 1000m. The dimension of the main opening on the composite floor deck is 120mm x 120mm. Next, for the shear stud the diameter of the head is 25mm and the height is 10 mm where as for the leg, the dimension is 20mm and height is 5mm. The length of the shear connector is 80mm. The total height of the shear stud is 110mm. All the dimensions and parameters of the composite floor deck is designed based on the actual design that is available in the construction industry and the dimensions are been adapted from past research papers. **Table 3.1** below shows all the components of the composite floor deck system that will be used in the ANSYS software for Finite Element Analysis. **Table 3.2** below shows the variables of main components of the composite floor deck system. **Table 3.3** below shows all the eight models of composite floor deck.

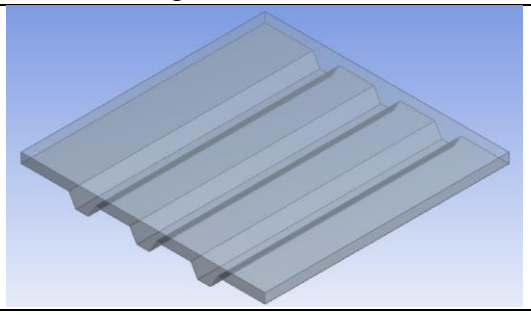
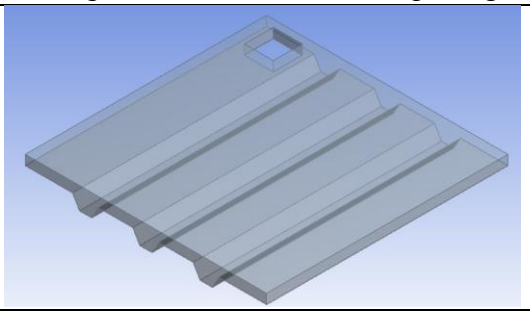
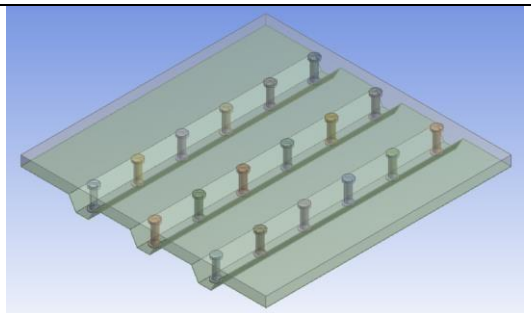
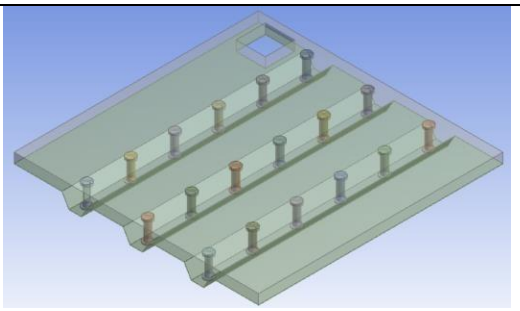
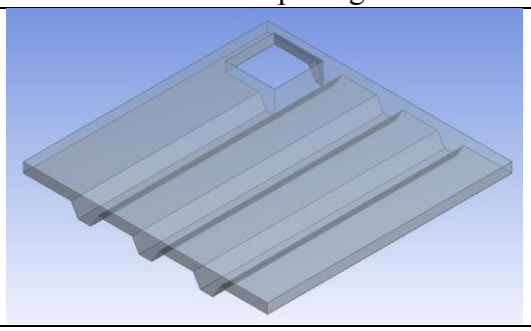
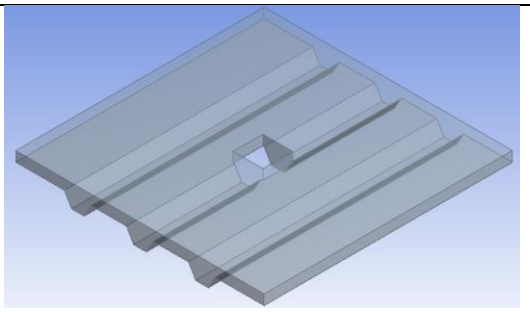
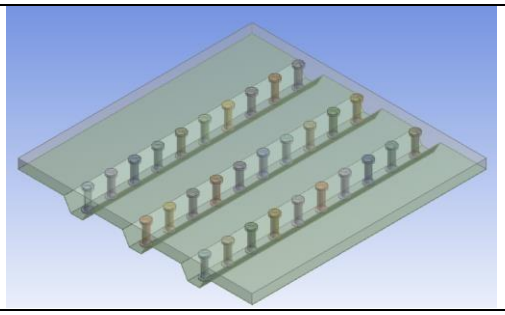
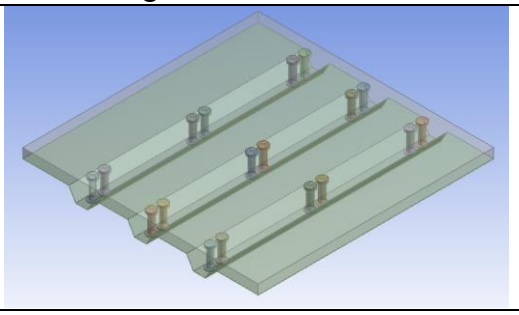
TABLE 3.1: The components of the composite floor deck system that will be used in the ANSYS software for Finite Element Analysis.

Composite Floor Deck Component	**Used Elements in ANSYS**
Concrete Slab	Concrete
Shear Studs	Structural Steel

TABLE 3.2: The variables of main components of the composite floor deck system.

Composite Floor Slab		
Dimension	1m x 1m	
Shear Stud		
Number of Shear Studs	6	10
Arrangement of Shear Studs	Arranged in order on the slab	Arranged 2 shear studs close to each other on different locations
Opening		
Size of opening	0.12m x 0.12m	0.2m x 0.2m
Location of opening	Edge of slab	Centre of slab

TABLE 3.3: The eight models of composite floor deck that is design in the SOLIDWORKS software.

Composite Floor Deck	Composite Floor Deck with Opening
	
Composite Floor Deck with Shear Studs	Composite Floor Deck with Opening and Shear Studs
	
Composite Floor Deck with 200mm x 200mm Opening	Composite Floor Deck with Opening at Centre
	
Composite Floor Deck with 10 Shear Studs	Composite Floor Deck with different Arrangement of Shear Studs
	

3.2 Analysis on the model of composite floor deck in the ANSYS software

Structural analysis is thus a key part of structural engineering. The process to determine the response or behavior of a structure under some specified loads or combinations of loads is known as structural analysis. Response means to find out support reactions, bending moment, rotation, stresses, strains, shear force, and deflection that, the particular member would undergo due to the application of different types of loads. Analysis of a structure involves its study from the viewpoint of its strength, stiffness, stability, and vibration. For this project, the analysis of the composite floor deck will be done by using ANSYS software. The Static Structural analysis will be chosen for this project. There are a few steps to complete the analysis of all the eight models of composite floor deck in the software. In this report, the writer will explain the methods and procedure of the analysis one by one.

3.2.1 Import the geometry from SOLIDWORKS software.

The first step of the analysis is to import the design of composite floor deck that has been designed in the SOLIDOWORKS software into the ANSYS. The geometry will be imported into the ANSYS software and the parameters will be checked. The design model will be edited if there is any mistake in designing the model**. Figure 3.1** below shows the geometry that has been imported from SOLIDWORKS software to the ANSYS software.

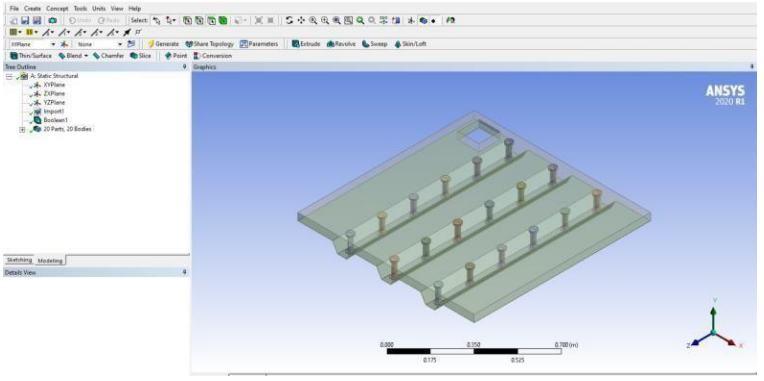


FIGURE 3.1: Geometry that has been imported from SOLIDWORKS software to the ANSYS software.

3.2.2 Select the material of the composite floor deck

After the geometry has been imported into the ANSYS software, the next step is to input the materials that will be used for the composite floor deck. For this project, there will be only two materials that will be included which is the concrete and also structural steel. The deck will use concrete as its material and for the metal deck and also shear studs, structural steel will be used. The bonding of these two materials will be done in detail during the analysis part of this project. The material will be selected in the engineering data of the ANSYS static structural tool bar. **Figure 3.2** below shows the selection of material for the composite floor deck. **Figure 3.3** shows the properties of concrete and **Figure 3.4** shows the properties of structural steel.

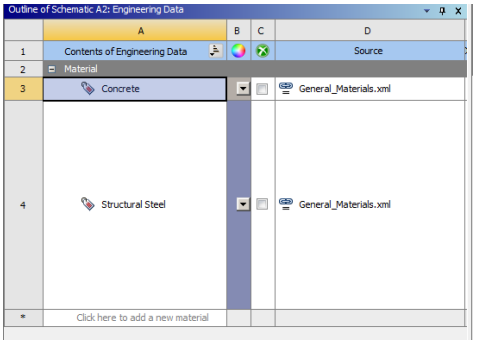


FIGURE 3.2: The selection of material for the composite floor deck

Properties of Outline Row 3: Concrete

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	2300	kg m^-3
4	Isotropic Secant Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
12	Tensile Yield Strength	0	Pa
13	Compressive Yield Strength	0	Pa
14	Tensile Ultimate Strength	5E+06	Pa
15	Compressive Ultimate Strength	4.1E+07	Pa

FIGURE 3.3: The properties of concrete

Properties of Outline Row 4: Structural Steel

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	7850	kg m^-3
4	Isotropic Secant Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
12	Strain-Life Parameters		
20	S-N Curve	Tabular	
24	Tensile Yield Strength	2.5E+08	Pa
25	Compressive Yield Strength	2.5E+08	Pa
26	Tensile Ultimate Strength	4.6E+08	Pa
27	Compressive Ultimate Strength	0	Pa

FIGURE 3.4: The properties of structural steel.

3.2.3 Input the required parameters for the analysis of the Composite Floor Deck

After selection of materials is completed, the next step is to prepare the composite floor deck for analysis purposes. The main parameters that will be included is the connection of the model, the meshing of the model, input the forces and pressures on the model and also the support of the composite floor deck system. For the first parameters, which is the connection of the composite floor deck materials which are the concrete floor slab, metal deck and also the shear studs. The connection is done individual for each of the components of the composite floor deck system. **Figure 3.5** below shows the example of connection for the shear stud and the composite floor deck slab.

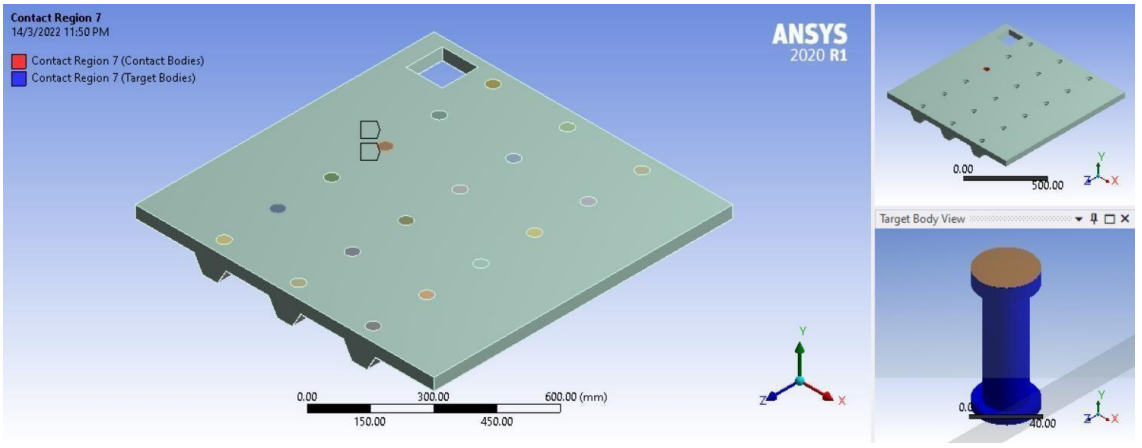


FIGURE 3.5: The example of connection for the shear stud and the composite floor deck slab.

As shown in **Figure 3.5** above, the connections of all the materials are done individually and specifically to avoid any misplace materials and to ensure the analysis can be done smoothly. Next, after completing the connection for all the components of the composite floor deck, the next step is to create a proper meshing on the composite floor deck before proceeding with the analysis of the model. For this project, there were several type of meshing used which are multizone meshing, inflation meshing, face meshing and also edge sizing meshing. Multizone meshing is the main meshing in this project model as it is used for the composite floor deck slab, metal deck and also the shear studs. **Figure 3.6** below shows multizone meshing on the composite floor deck slab and **Figure 3.7** shows the multizone meshing on the shear studs.

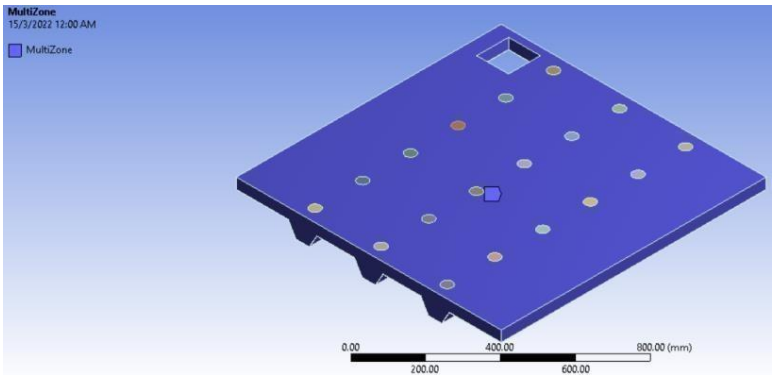


FIGURE 3.6: Multizone meshing on the composite floor deck slab

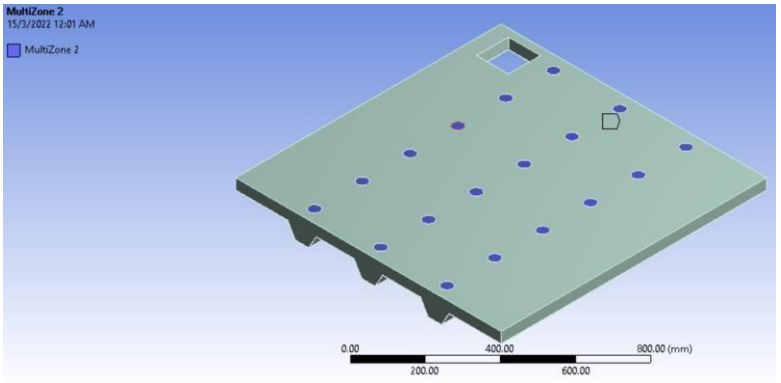


FIGURE 3.7: The multizone meshing on the shear studs.

Furthermore, the next three meshings are for the shear studs only, the first one is the inflation meshing. The inflation meshing is done on all the shear studs of the composite floor deck. **Figure 3.8** below shows the inflation meshing done on the shear studs.

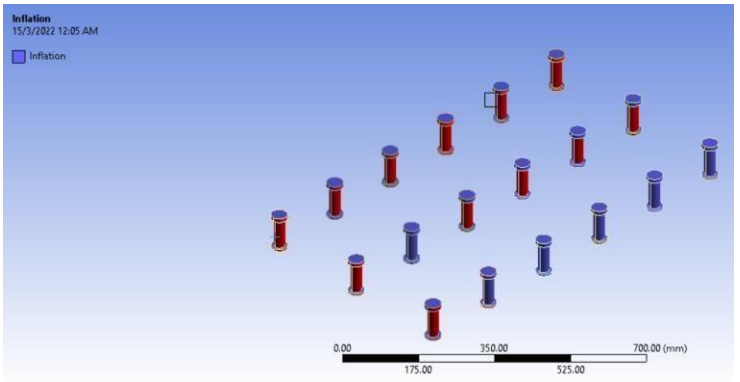


FIGURE 3.8: The inflation meshing done on the shear studs.

The next meshing is the face meshing which is done on the surface of the shear studs. The face meshing is done on the top and also bottom part of the shear studs. **Figure 3.9** below shows the face meshing done on the shear studs.

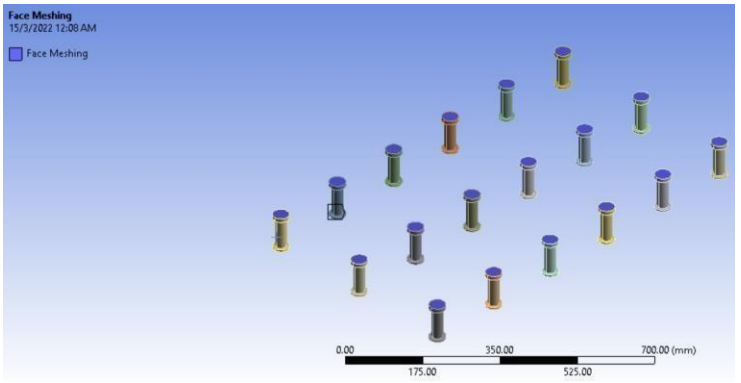


FIGURE 3.9: The face meshing done on the shear studs.

In addition to that, the final meshing done on the shear studs is the edge sizing meshing. The edge size meshing is also done on all of the edge of the shear studs of the composite floor deck. **Figure 3.10** below shows the edge sizing meshing on one of the shear studs.

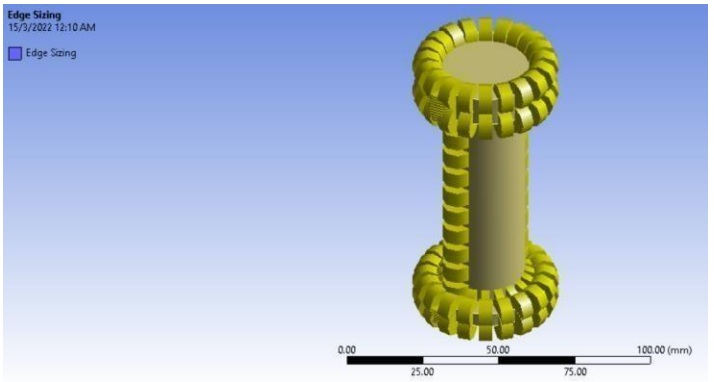


FIGURE 3.10: The edge sizing meshing on one of the shear studs.

After completion of the meshing procedure, the next step is to input the support for the composite floor deck system. For this project, the composite floor deck has been set to fixed support on all of the edges of the composite floor deck. The fixed support is chosen because it is assumed that the composite floor deck will be fixed as a floor deck system that will have fixed support on all of the edges. **Figure 3.11** below shows the fixed support system applied to the edge of the composite floor deck.

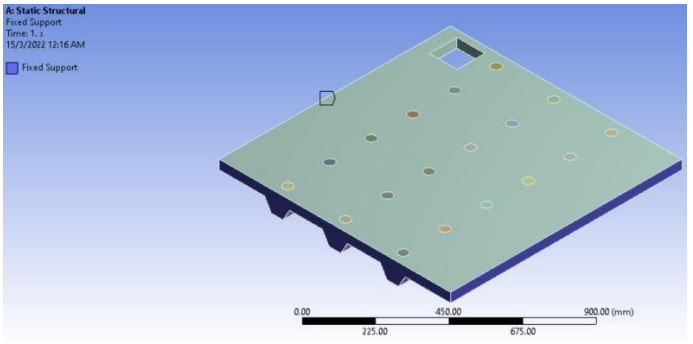


FIGURE 3.11: The fixed support system applied to the edge of the composite floor deck.

Next, after completion of support system, the next step is to apply forces or pressure on the composite floor deck system before proceeding to run an analysis on the composite floor deck. For this project, after conducting a research, the most suitable pressure to apply on a composite floor deck is 1MPa. In this project, the pressure of 1MPa is applied on the centre of the composite floor deck. The project only uses one value of pressure because the main objective of his project is to study on the effect of shear studs and opening on the mechanical performance of a composite floor deck system. **Figure 3.12** below shows the 1MPa pressure applied on the composite floor deck.

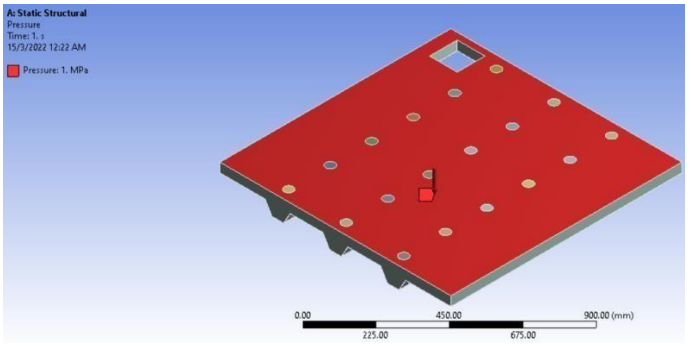


FIGURE 3.12: The 1MPa pressure applied on the composite floor deck.

3.2.3 Run the analysis to get the solutions

After inputting all the parameters required for the analysis, the next step is to run the anlysis and get the results. In ANSYS, there are many different solutions for the design model such as deformation, strain, stress,energy, damage, linearized stress and others. For this project, as the objective is to study on the effect of shear studs and opening on the composite floor deck mechanical behavior, the writer chosed three different solutions to be discussed in detail. The solutions are total deformation, maximum shear stress and also equivalent or total stress of the composite floor deck. **Figure 3.13** below shows one of the example of the results obtained from ANSYS.

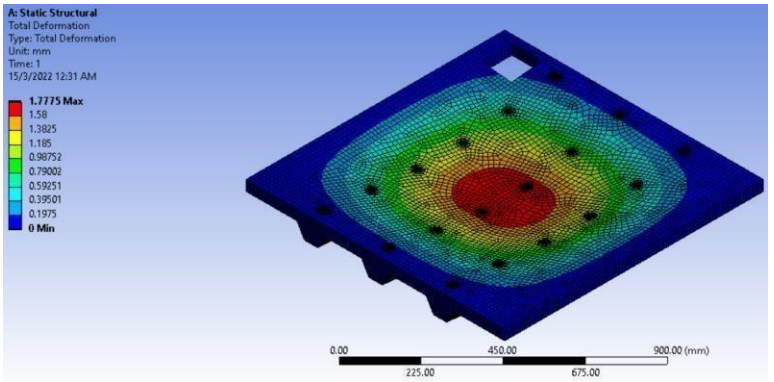


FIGURE 3.13: The example of the results obtained from ANSYS.

3.3 Project flow chart

The project flow chart will show the exact procedure and method of completing this project according to the objective and scope of work for this project. **Figure 3.14** below shows the project flow chart for research activities which is the effect of shear studs and openings in the mechanical performance of the composite floor deck.

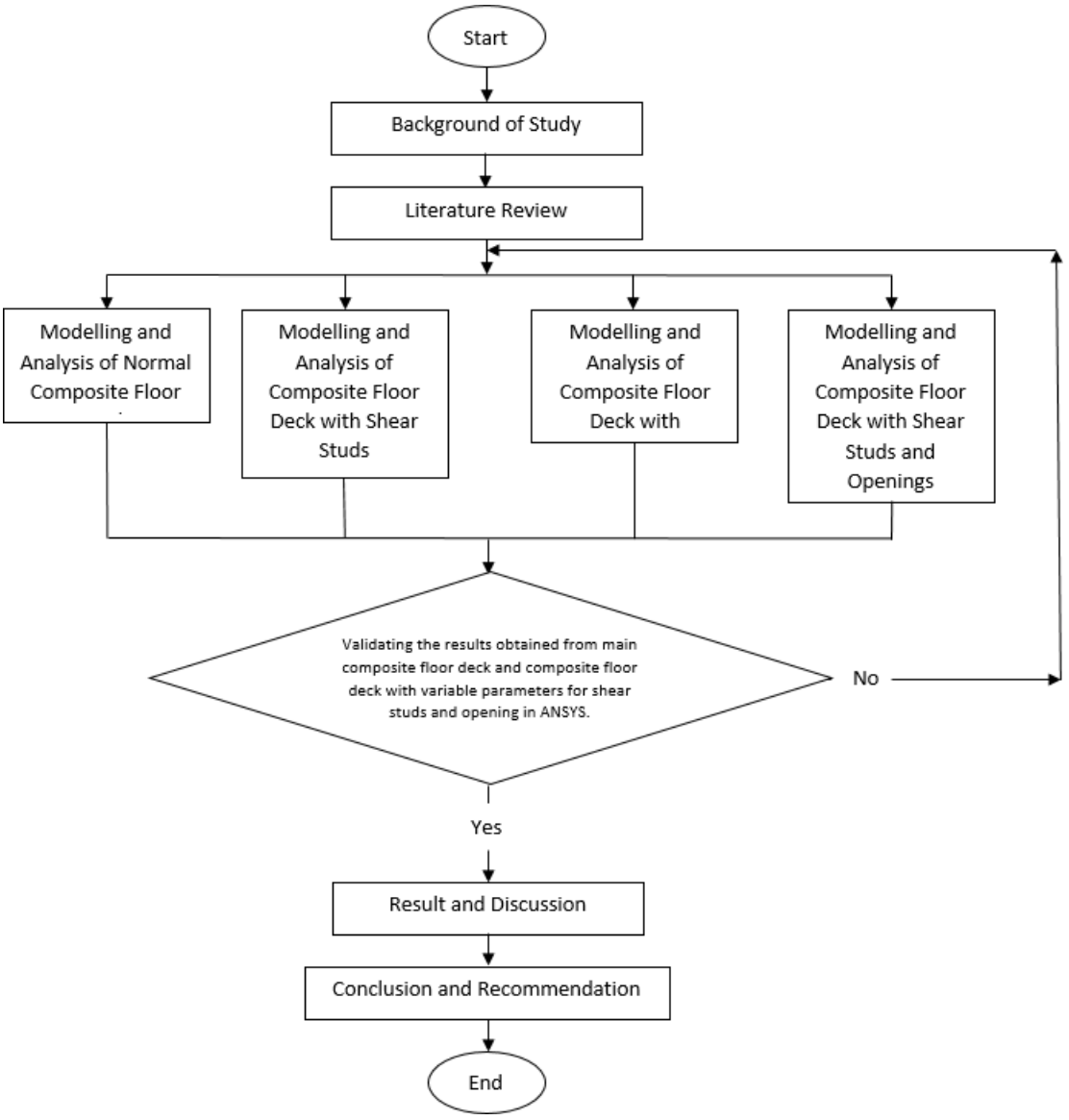


FIGURE 3.14: The project flow chart for research activities

CHAPTER 4: RESULTS AND DISCUSSIONS

In this result and discussion chapter, the writer will explain in details all the results obtained for this project. The results are all generated from the ANSYS software and interpreted by using graphs. The writer will explain on all of the eight models of composite floor deck on the results which are the total deformation, maximum shear stress and also equivalent or total stress.

4.1 Composite Floor Deck

For the first part of the result and discussion, the writer will explain in details the result of four different composite floor deck systems which are normal composite floor deck, composite floor deck with opening, composite floor deck with shear studs and composite floor deck with opening and shear studs. Before proceeding with the results, the writer will explain in details on the three different results that will be discussed for this project. First, the deformation refers to modifications of the shape or size of an object due to applied forces. Deformation is usually caused by forces such as: Tensile (pulling) Compressive (pushing) whereas in total deformation, it gives a square root of the summation of the square of x-direction, y-direction and z-direction. Next, maximum shear stress is the maximum concentrated shear force in a small area. Furthermore, Equivalent stress is actually a scalar derivative of shear strain energy per unit volume measured at different points in a stressed material and helps in determining the likelihood of the failure of the said material according to the Von Mises failure criteria. It is commonly used for ductile materials. The results of ANSYS presented in this results and discussions part is in small figure and not clear due to the limitations but the larger and more clear figures of the result of analysis from ANSYS can be referred in **APPENDIX 1**.

Next, for the results of this project, **Figure 4.1** below shows the result generated from ANSYS software for the normal composite floor deck. It can be observed that the maximum total deformation is 2.064 mm, the maximum shear stress is 382.85 MPa and the maximum equivalent stress is 704.34 MPa. In **Figure 4.1** below, it shows the details of results generated from the ANSYS software for all the three results and the colour indicates the intensity of the results.

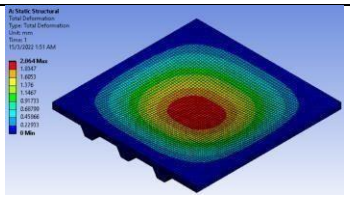
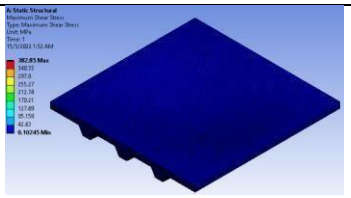
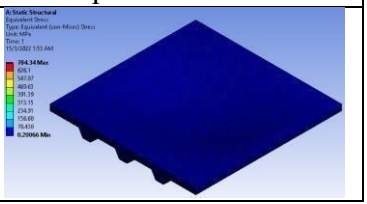
Composite Floor Deck		
Total Deformation	Maximum Shear Stress	Equivalent Stress
		

FIGURE 4.1: The result generated from ANSYS software for the normal composite floor deck.

Furthermore, for the composite floor deck with opening, **Figure 4.2** below shows the result generated from ANSYS software for the composite floor deck with opening. It can be observed that the maximum total deformation is 2.0899 mm, the maximum shear stress is 386.86 MPa and the maximum equivalent stress is 709.67 MPa. In **Figure 4.2** below, it shows the details of results generated from the ANSYS software for all the three results and the colour indicates the intensity of the results.

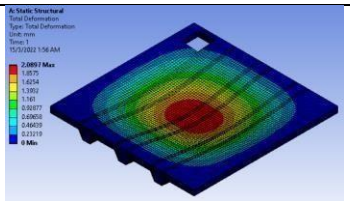
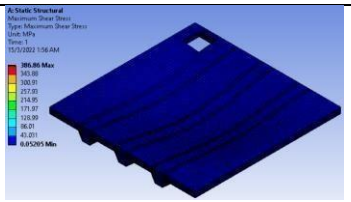
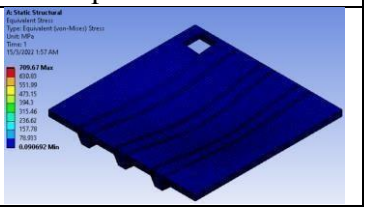
Composite Floor Deck with Opening		
Total Deformation	Maximum Shear Stress	Equivalent Stress
		

FIGURE 4.2: The result generated from ANSYS software for the composite floor deck with opening.

Moreover, for the composite floor deck with shear studs, **Figure 4.3** below shows the result generated from ANSYS software for the composite floor deck with shear studs. It can be observed that the maximum total deformation is 1.7525 mm, the maximum shear stress is 333.68 MPa and the maximum equivalent stress is 603.56 MPa. In **Figure 4.3** below, it shows the details of results generated from the ANSYS software for all the three results and the colour indicates the intensity of the results.

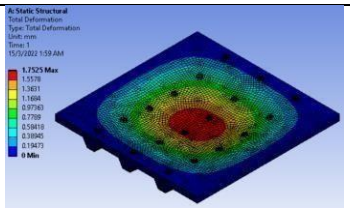
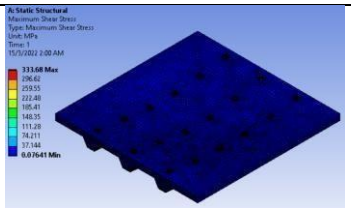
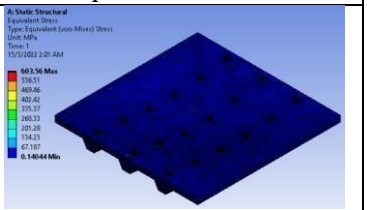
Composite Floor Deck with Shear Stud		
Total Deformation	Maximum Shear Stress	Equivalent Stress
		

FIGURE 4.3: The result generated from ANSYS software for the composite floor deck with shear studs

Also, for the composite floor deck with shear studs and opening, **Figure 4.4** below shows the result generated from ANSYS software for the composite floor deck with shear studs and opening. It can be observed that the maximum total deformation is 1.7775 mm, the maximum shear stress is 337.59 MPa and the maximum equivalent stress is 610.61 MPa. In **Figure 4.4** below, it shows the details of results generated from the ANSYS software for all the three results and the colour indicates the intensity of the results.

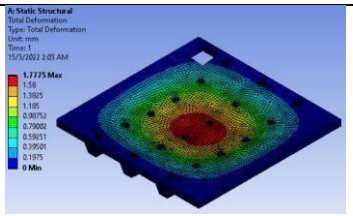
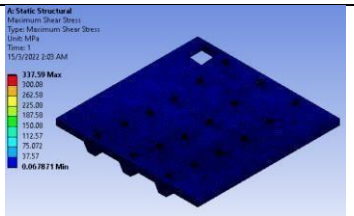
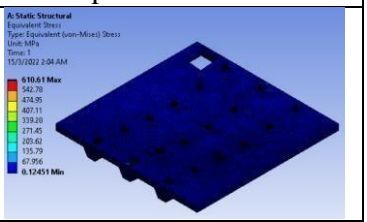
Composite Floor Deck with Shear Stud and Opening		
Total Deformation	Maximum Shear Stress	Equivalent Stress
		

FIGURE 4.4: The result generated from ANSYS software for the composite floor deck with shear studs and opening

For the next part of the results and discussion, the writer will explain in details on all the results obtained by displaying the graphs that compares all the four different model of composite floor decks. There are three different graphs which will interpret the results on the total deformation, maximum shear stress and also the equivalent stress of the different composite floor deck models.

Figure 4.5 below shows the graph for the total deformation of all the four different models of composite floor deck. It can be observed that the composite floor deck with opening has the highest value of total deformation. These shows that this composite floor deck with opening has the lowest strength among all the four models. Next, the second highest model is the composite floor deck followed by the composite floor deck with shear studs and opening and the model that has the lowest total deformation is the composite floor deck with shear studs. In this case, it can be concluded that the composite floor deck system strength and endurance is definitely increased when the shear studs are present and will decrease if there is opening on the composite floor deck system. It can be observed, if the composite floor deck system requires opening for construction, the presence of shear studs are important to ensure the composite floor deck system has high strength and high endurance to avoid any failure or damage on the construction in future.

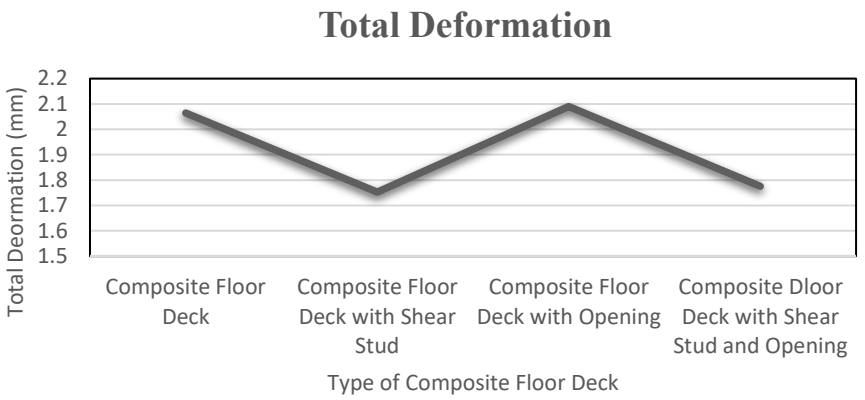


FIGURE 4.5: The variation of the total deformation for different models of composite floor deck.

Figure 4.6 below shows the graph for the maximum shear stress of all the four different models of composite floor deck. It can be observed that the composite floor deck with opening has the highest value of maximum shear stress. These shows that this composite floor deck with opening has the lowest strength among all the four models. Next, the second highest model is the composite floor deck followed by the composite floor deck with shear studs and opening and the model that has the lowest maximum shear stress is the composite floor deck with shear studs. The higher the maximum shear stress, the higher the force and pressure need to be endured by the composite floor deck system. In this case, it can be concluded that the composite floor deck system strength and endurance is definitely increased when the shear studs are present and will decrease if there is opening on the composite floor deck system. It can be observed, if the composite floor deck system requires opening for construction, the presence of shear studs are important to ensure the composite floor deck system has high strength and high endurance to avoid any failure or damage on the construction in future.

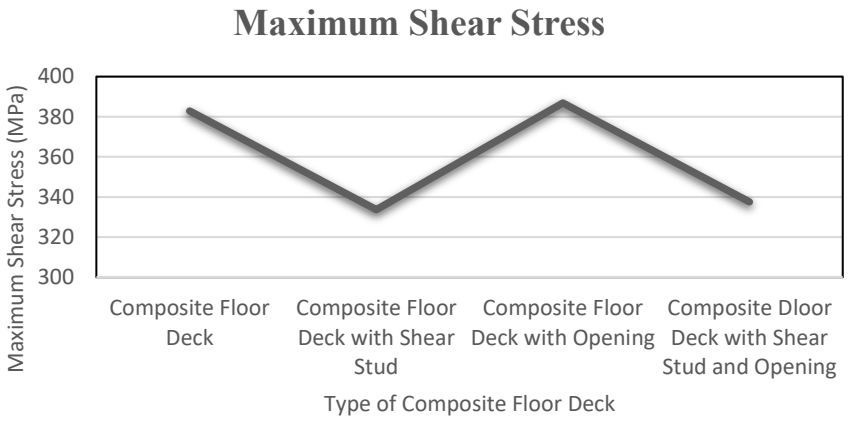


FIGURE 4.6: The variation of maximum shear stress for the different models of composite floor deck.

Figure 4.7 below shows the graph for the equivalent stress of all the four different models of composite floor deck. It can be observed that the composite floor deck with opening has the highest value of equivalent stress. These shows that this composite floor deck with opening has the lowest strength among all the four models. Next, the second highest model is the composite floor deck followed by the composite floor deck with shear studs and opening and the model that has the lowest equivalent stress is the composite floor deck with shear studs. The higher the equivalent stress, the higher the force and pressure need to be endured by the composite floor deck system. For equivalent stress, it does indicates the total stress applied on all of the models of composite floor deck sytems. In this case, it can be concluded that the composite floor deck system strength and endurance is definitely increased when the shear studs are present and will decrease if there is opening on the composite floor deck system. It can be observed, if the composite floor deck system requires opening for construction, the presence of shear studs are important to ensure the composite floor deck system has high strength and high endurance to avoid any failure or damage on the construction in future.

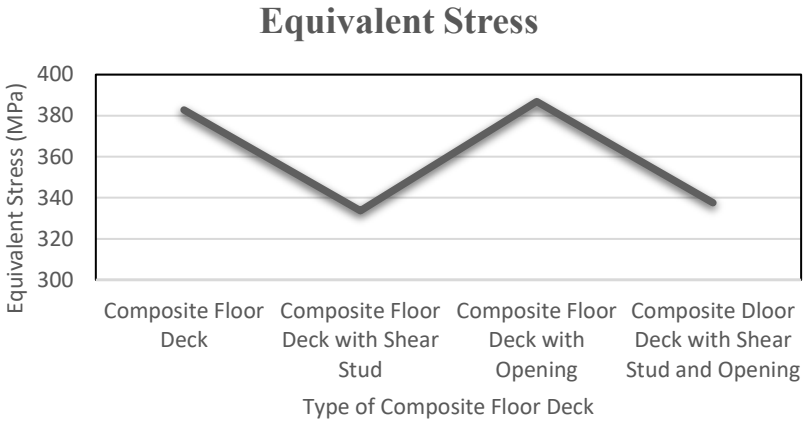


FIGURE 4.7: The variation of the equivalent stress for different models of composite floor deck.

As a conclusion for the first part of results and discussion, it can be concluded that the presence of shear studs on the composite floor deck does improve the strength and endurance of the composite floor deck systems. The main objective of this project is to study on the effect of shear studs and opening on the composite floor deck system mechanical behavior. It can be concluded that the presence of opening will reduce the strength and endurance of the composite floor deck system whereas the presence of shear studs will increase the strength and endurance of the composite floor deck systems.

4.2 Composite floor deck with opening

In this part of the result and discussion, the writer will explain and interpret the results obtained from ANSYS software for different variables of the composite floor deck with opening. As mentioned in the report, the main composite floor deck has an opening which dimension is 120mm x 120mm and the location of the opening is at the edge of the deck. To study and analysis in more details, the project scope is widened and the composite floor deck with openings has two different other variables that has been analysed. The first one is composite floor deck that has an opening which dimension is 200mm x 200mm and the second one is the composite floor deck which has an opening at the centre of the deck. Both of this variables will be compared to the main composite floor deck with opening as shown in **Figure 4.2** above. The comparison will be on three different analysis which are the total deformation, maximum shear stress and also the equivalent stress of the composite floor deck system.

First, for the composite floor deck with 200mm x 200mm opening**, Figure 4.8** below shows the result generated from ANSYS software for the composite floor deck with 200mm x 200mm opening. It can be observed that the maximum total deformation is 2.1062 mm, the maximum shear stress is 390.92 MPa and the maximum equivalent stress is 715.16 MPa. In FIGURE 4.8 below, it shows the details of results generated from the ANSYS software for all the three results and the colour indicates the intensity of the results.

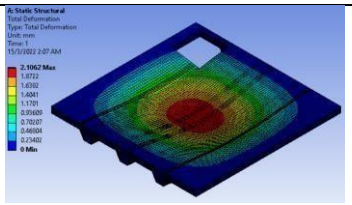
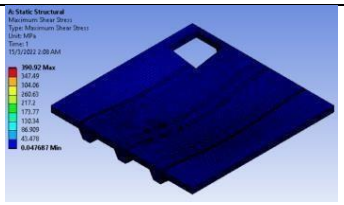
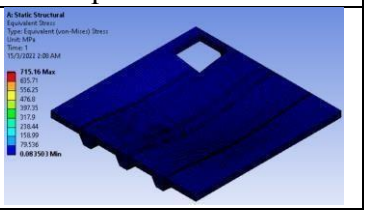
Composite Floor Deck with 200mm x 200mm opening		
Total Deformation	Maximum Shear Stress	Equivalent Stress
		

FIGURE 4.8: The result generated from ANSYS software for the composite floor deck with 200mm x 200mm opening.

Next, for the composite floor deck with opening at center, **Figure 4.9** below shows the result generated from ANSYS software for the composite floor deck with opening at center. It can be observed that the maximum total deformation is 2.38 mm, the maximum shear stress is 446.41 MPa and the maximum equivalent stress is 821.71 MPa. In **Figure 4.9** below, it shows the details of results generated from the ANSYS software for all the three results and the colour indicates the intensity of the results.

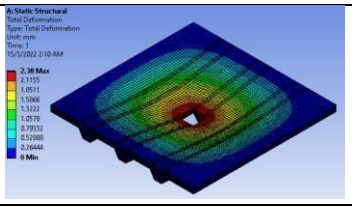
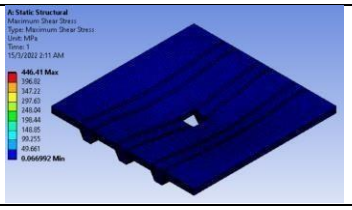
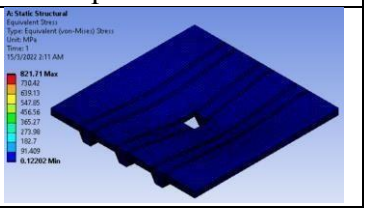
Composite Floor Deck with opening at center		
Total Deformation	Maximum Shear Stress	Equivalent Stress
		

FIGURE 4.9: The result generated from ANSYS software for the composite floor deck with opening at center.

For the next part of this result and discussion, the writer will compare and explain in details by interpreting the graphs generated from the results of analysis. The comparison will be divided into two different sections, the first one will be the comparison between the main composite floor deck with opening and the composite floor deck with 200mm x 200mm opening and the second comparison will be between the main composite floor deck with opening and the composite floor deck with opening at center.

Figure 4.10 below shows the graph for the total deformation of all the three different models of composite floor deck with opening. It can be observed that between the main composite floor deck with opening and the composite floor deck with 200mm x 200mm opening, the total deformation is lower on the main composite floor deck with opening. It can be concluded that the size of opening does affect the strength and endurance of the composite floor deck. The larger the size of the opening, the lower the strength and endurance of the composite floor deck. Next, it can be observed that between the main composite floor deck with opening and the composite floor deck system with opening at center, the total deformation is lower on the main composite floor deck with opening. It can be concluded that the location of opening does affect the strength and endurance of the composite floor deck. The composite floor deck that has opening at center has a very low strength and endurance due to its distance from the edges of the deck that has fixed support system. These problems can be solved by providing shear studs as it may increase the strength and endurance of the composite floor deck with opening.

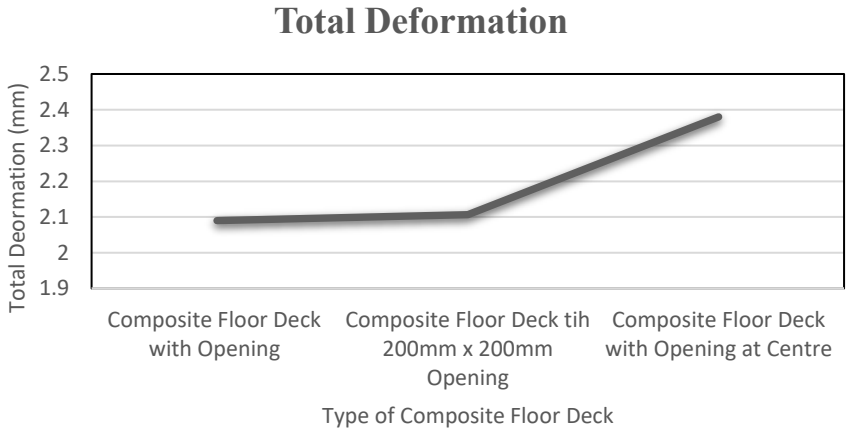


FIGURE 4.10: The variation of total deformation for different models of composite floor deck with opening.

Figure 4.11 below shows the graph for the maximum shear stress of all the three different models of composite floor deck with opening. It can be observed that between the main composite floor deck with opening and the composite floor deck with 200mm x 200mm opening, the maximum shear stress is lower on the main composite floor deck with opening. The higher the maximum shear stress, the higher the force and pressure need to be endured by the composite floor deck system. It can be concluded that the size of opening does affect the strength and endurance of the composite floor deck. The larger the size of the opening, the lower the strength and

endurance of the composite floor deck. Next, it can be observed that between the main composite floor deck with opening and the composite floor deck system with opening at center, the maximum shear stress is lower on the main composite floor deck. It can be concluded that the location of opening does affect the strength and endurance of the composite floor deck. The composite floor deck that has opening at center has a very low strength and endurance due to its distance from the edges of the deck that has fixed support system. These problems can be solved by providing shear studs as it may increase the strength and endurance of the composite floor deck with opening.

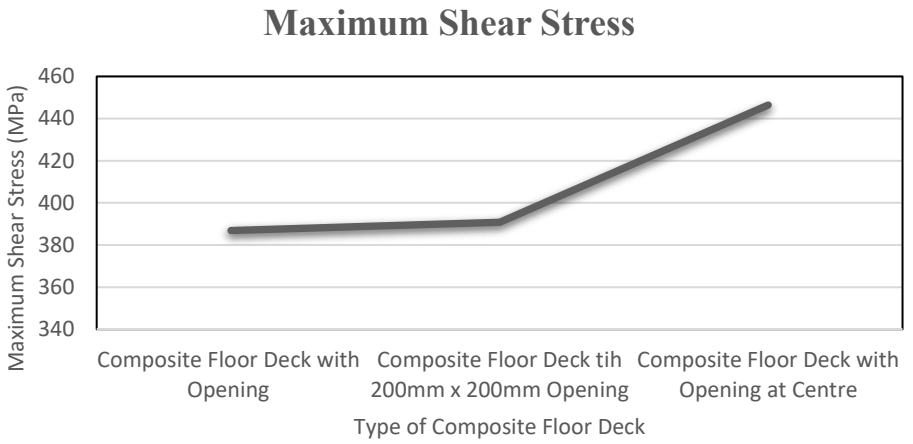


FIGURE 4.11: The variation of the maximum shear stress for different models of composite floor deck with opening.

Figure 4.12 below shows the graph for the equivalent stress of all the three different models of composite floor deck with opening. It can be observed that between the main composite floor deck with opening and the composite floor deck with 200mm x 200mm opening, the equivalent stress is lower on the main composite floor deck with opening. The higher the equivalent stress, the higher the force and pressure need to be endured by the composite floor deck system. It can be concluded that the size of opening does affect the strength and endurance of the composite floor deck. The larger the size of the opening, the lower the strength and endurance of the composite floor deck. Next, it can be observed that between the main composite floor deck with opening and the composite floor deck system with opening at center, the equivalent is lower on the main composite floor deck. It can be concluded that the location of opening does affect the strength and endurance of the composite floor deck. The composite floor deck that has opening at center has a very low strength and endurance due to its distance from the edges of the deck that has fixed support system. These

problems can be solved by providing shear studs as it may increase the strength and endurance of the composite floor deck with opening.

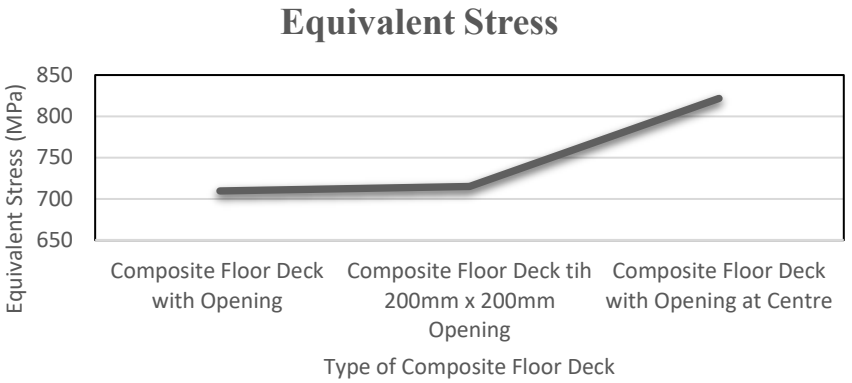


FIGURE 4.12: The variation of the equivalent stress for different models of composite floor deck with opening.

As a conclusion for the second part of results and discussion, it can be concluded that the presence of openings on a composite floor deck system does reduce the strength and endurance of the composite floor deck. The main objective of this project is to study on the effect of shear studs and opening on the composite floor deck system mechanical behavior. It can be concluded that different variables of the opening on the composite floor deck system has different strength and endurance and for this project, the best composite floor deck with opening is the main composite floor deck with opening.

4.3 Composite floor deck with shear studs

In this part of the result and discussion, the writer will explain and interpret the results obtained from ANSYS software for different variables of the composite floor deck with shear studs. As mentioned in the report, the main composite floor deck has a total of six shear studs and the arrangement of shear studs are in order arrangement. To study and analysis in more details, the project scope is widened and the composite floor deck with shear studs has two different other variables that has been analysed. The first one is composite floor deck that has ten shear studs and the second one is the composite floor deck which has the shear studs arrangement where two shear studs are arranged close to each other. Both of this variables will be compared to the main composite floor deck with shear studs as shown in FIGURE 4.3 above. The comparison will be on three different analysis which are the total deformation, maximum shear stress and also the equivalent stress of the composite floor deck system.

First, for the composite floor deck with ten shear studs, **Figure 4.13** below shows the result generated from ANSYS software for the composite floor deck with ten shear studs. It can be observed that the maximum total deformation is 1.6722 mm, the maximum shear stress is 328.55 MPa and the maximum equivalent stress is 593.23 MPa. In **Figure 4.13** below, it shows the details of results generated from the ANSYS software for all the three results and the colour indicates the intensity of the results.

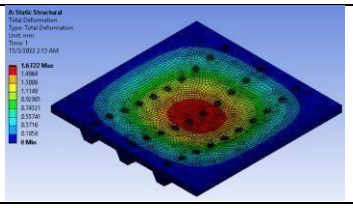
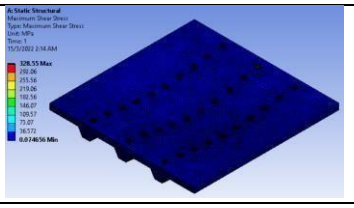
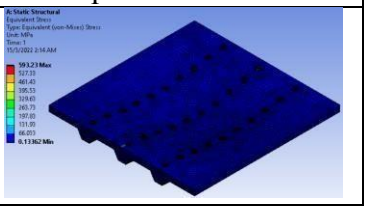
Composite Floor Deck with 10 Shear Studs		
Total Deformation	Maximum Shear Stress	Equivalent Stress
		

FIGURE 4.13: The result generated from ANSYS software for the composite floor deck with ten shear studs.

Next, for the composite floor deck with different arrangement of shear studs, **Figure 4.14** below shows the result generated from ANSYS software for the composite floor deck with different arrangement of shear studs. It can be observed that the maximum total deformation is 1.7248 mm, the maximum shear stress is 347.15 MPa and the maximum equivalent stress is 632.29 MPa. In **Figure 4.14** below, it shows the details of results generated from the ANSYS software for all the three results and the colour indicates the intensity of the result.

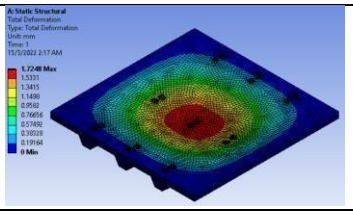
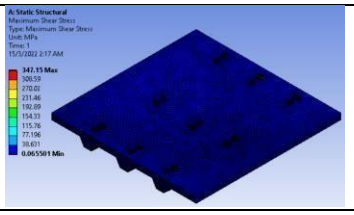
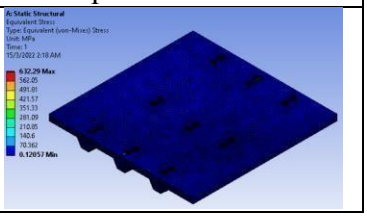
Composite Floor Deck with different arrangement of Shear Studs		
Total Deformation	Maximum Shear Stress	Equivalent Stress
		

FIGURE 4.14: The result generated from ANSYS software for the composite floor deck with different arrangement of shear studs.

For the next part of this result and discussion, the writer will compare and explain in details by interpreting the graphs generated from the results of analysis. The comparison will be divided into two different sections, the first one will be the comparison between the main composite floor deck with shear studs and the composite floor deck with ten shear studs and the second comparison will be between the main composite floor deck with shear studs and the composite floor deck with different arrangement of shear studs.

Figure 4.15 below shows the graph for the total deformation of all the three different models of composite floor deck with shear studs. It can be observed that between the main composite floor deck with shear studs and the composite floor deck with ten shear studs, the total deformation is higher on the main composite floor deck with shear studs. It can be concluded that the number of shear studs does affect the strength and endurance of the composite floor deck. The more number of shear studs, the higher the strength and endurance of the composite floor deck. Next, it can be observed that between the main composite floor deck with shear studs and the composite floor deck with different arrangement of shear studs, the total deformation is higher on the main composite floor deck with shear studs. It can be concluded that the arrangement of shear studs does affect the strength and endurance of the composite floor deck. The arrangement of shear studs must be studied in more details to get the most efficient arrangement of shear studs for the maximum strength and endurance of the composite floor deck system. In this project, it can be concluded that the best composite floor deck system is the composite floor deck that has more shear studs and also shear studs arranged close to one another as it provides higher strength and endurance to the composite floor deck system.

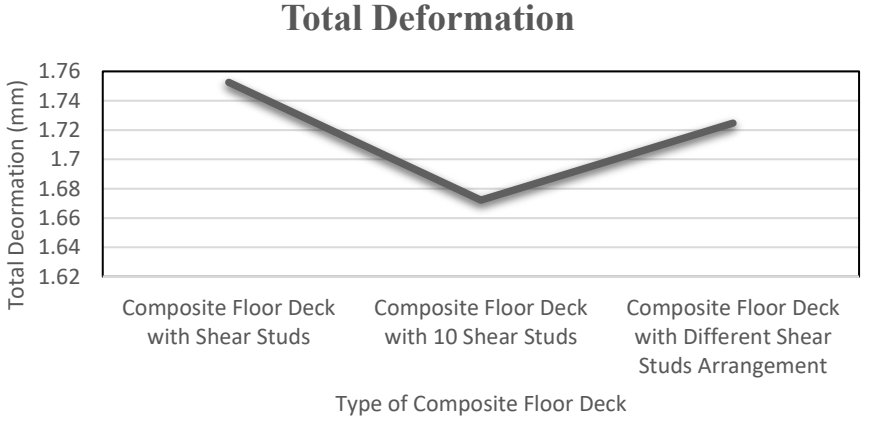


FIGURE 4.15: The variation of the total deformation for different models of composite floor deck with shear studs

Figure 4.16 below shows the graph for the maximum shear stress of all the three different models of composite floor deck with shear studs. It can be observed that between the main composite floor deck with shear studs and the composite floor deck with ten shear studs, the maximum shear stress is higher on the main composite floor deck with shear studs. The higher the maximum shear stress, the higher the force and pressure need to be endured by the composite floor deck system. It can be concluded

that the number of shear studs does affect the strength and endurance of the composite floor deck. The more number of shear studs, the higher the strength and endurance of the composite floor deck. Next, it can be observed that between the main composite floor deck with shear studs and the composite floor deck with different arrangement of shear studs, the maximum shear stress is higher on the main composite floor deck with shear studs. It can be concluded that the arrangement of shear studs does affect the strength and endurance of the composite floor deck. The arrangement of shear studs must be studied in more details to get the most efficient arrangement of shear studs for the maximum strength and endurance of the composite floor deck system. In this project, it can be concluded that the best composite floor deck system is the composite floor deck that has more shear studs and also shear studs arranged close to one another as it provides higher strength and endurance to the composite floor deck system.

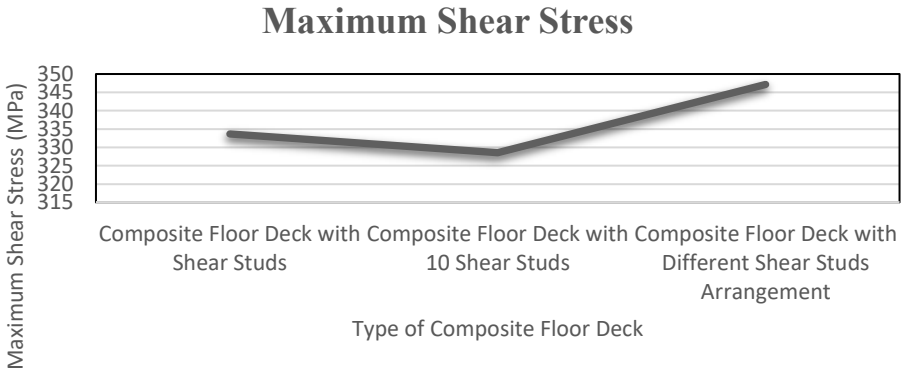


FIGURE 4.16: The graph for the maximum shear stress of all the three different models of composite floor deck with shear studs.

Figure 4.17 below shows the graph for the equivalent stress of all the three different models of composite floor deck with shear studs. It can be observed that between the main composite floor deck with shear studs and the composite floor deck with ten shear studs, the equivalent stress is higher on the main composite floor deck with shear studs. The higher the equivalent stress, the higher the force and pressure need to be endured by the composite floor deck system. It can be concluded that the number of shear studs does affect the strength and endurance of the composite floor deck. The more number of shear studs, the higher the strength and endurance of the composite floor deck. Next, it can be observed that between the main composite floor deck with shear studs and the composite floor deck with different arrangement of shear studs, the equivalent stress is higher on the main composite floor deck with shear studs.

It can be concluded that the arrangement of shear studs does affect the strength and endurance of the composite floor deck. The arrangement of shear studs must be studied in more details to get the most efficient arrangement of shear studs for the maximum strength and endurance of the composite floor deck system. In this project, it can be concluded that the best composite floor deck system is the composite floor deck that has more shear studs and also shear studs arranged close to one another as it provides higher strength and endurance to the composite floor deck system.

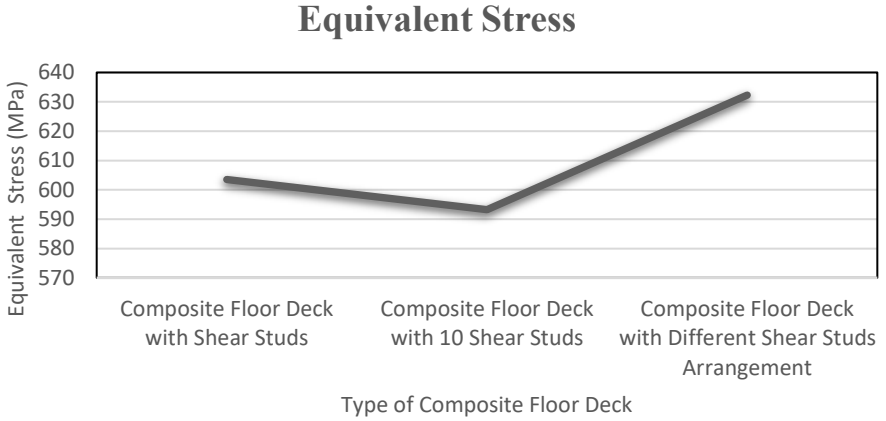


FIGURE 4.17: The graph for the equivalent stress of all the three different models of composite floor deck with shear studs.

As a conclusion for the third part of results and discussion, it can be concluded that the presence of shear studs on a composite floor deck system does increase the strength and endurance of the composite floor deck. The main objective of this project is to study on the effect of shear studs and opening on the composite floor deck system mechanical behavior. It can be concluded that different variables of the shear studs on the composite floor deck system has different strength and endurance and for this project, the best composite floor deck with shear studs is the main composite floor deck with ten shear studs.

CHAPTER 5: CONCLUSION AND RECCOMENDATION

5.1 Conclusion

In construction industry, before proceeding with the fabrication and construction works, all the materials used need to be inspected and approved to avoid any failure in future. The purpose of this study is to solve the current problem in the industry where there is no proper test for the composite floor deck system before proceeding with construction works at site. For this project, the main objective is to investigate the effect of shear studs on the mechanical performance of the composite floor deck system by varying parameters such as number of shear studs and arrangement of shear studs and to determine the effect of openings on the mechanical performance of the composite floor deck system by varying parameters such as location and size of the opening.

Furthermore, the objective of this project is achieved successfully as the author manage to identify the effects of shear studs and openings on the mechanical behavior of composite floor deck system. In nutshell, it can be concluded that the presence of shear studs increases the strength and endurance of the composite floor deck while the presence of opening reduces the strength and endurance of the composite floor deck system as explained in the results and discussion part of this project.

In conclusion, after completing this study, the author had gained a lot of knowledge on the effect of shear studs and opening on the mechanical behavior of the composite floor deck system. In addition to that, the author had also gained more expertise in handling softwares such as ANSYS and SOLIDWORKS while completing this project. All of this knowledge will be very useful and helpful for the author in future as it will help the author to be a better engineer in future.

5.1 Recommendation

Even though the project objective has been successfully achieved by the author, there are still some recommendations for future research and study on this project such as:

1. Provide more variables of parameters for the shear studs and openings on the composite floor deck systems.
2. Use different grades of concretes for the composite floor deck.
3. The composite floor deck system must include the reinforcement bar to achieve higher strength and endurance.
4. The results from the ANSYS software can be varied by including the strain, damage and also linearized stress from the solutions.
5. Improve the presentation of results for the analysis on ANSYS software.

All of these recommendations and improvements will help the future researcher to prepare a more efficient and reliable project. In conclusion, the author of this project has prepared a project report that is efficient but it can be improved by future researchers by including the recommendations in future study.

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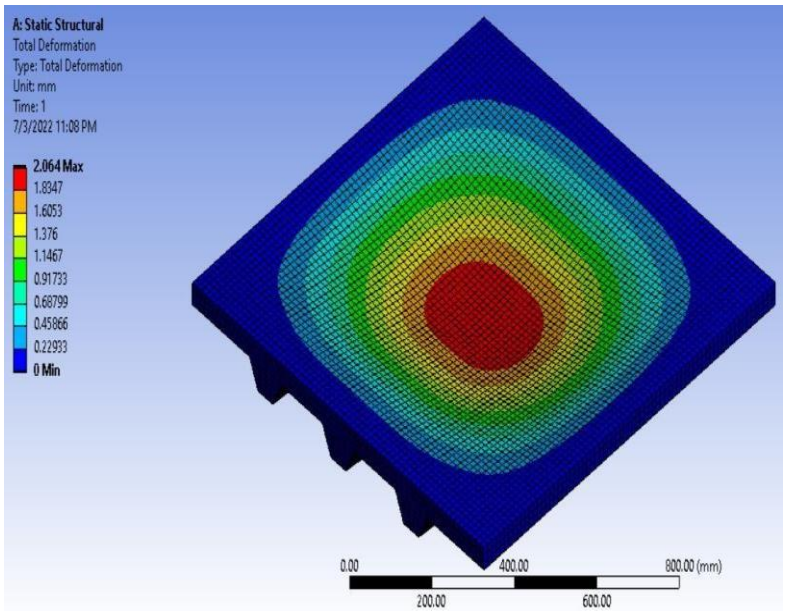
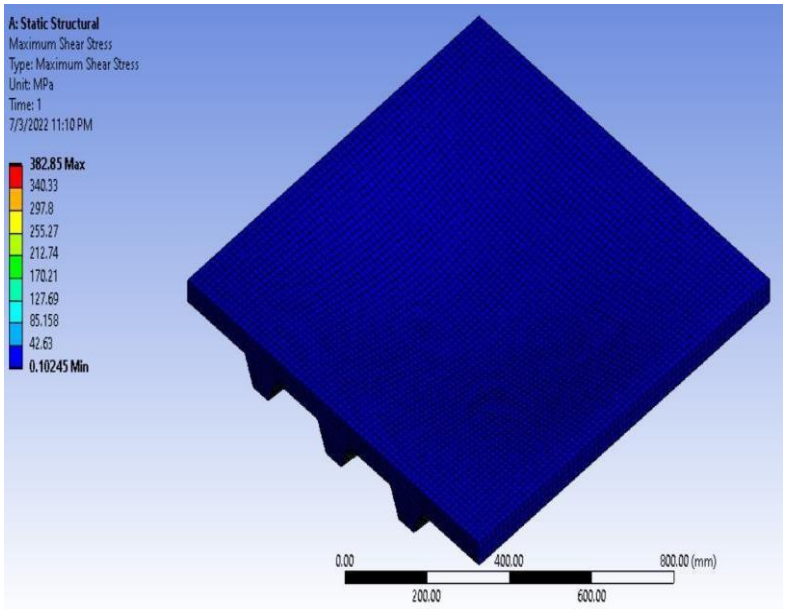
APPENDIX 1

Composite Floor Deck

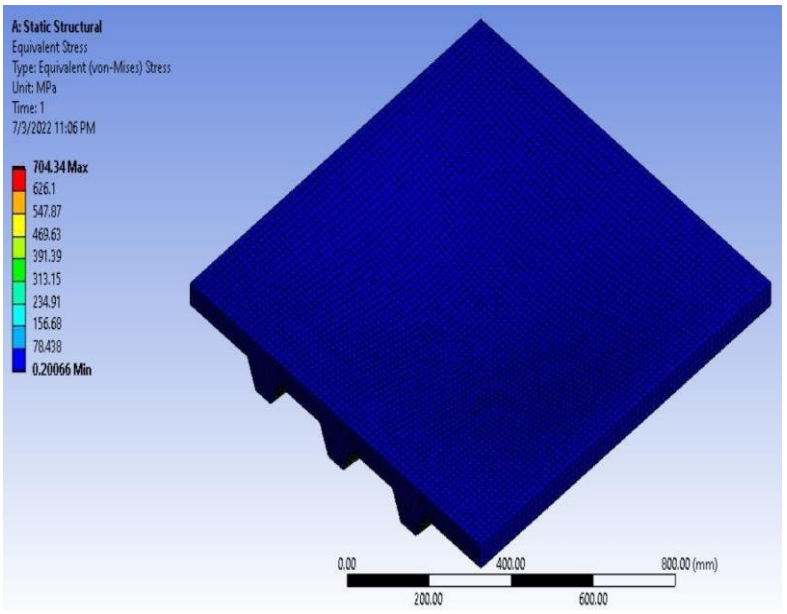
1. Total deformation of Composite Floor Deck.



2. Maximum Shear Stress of Composite Floor Deck.

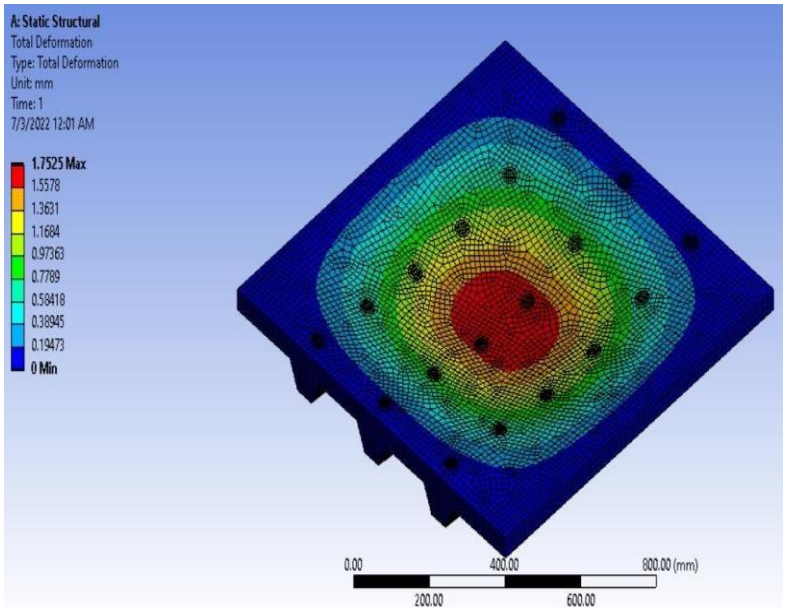


3. Equivalent Stress of Composite Floor Deck.

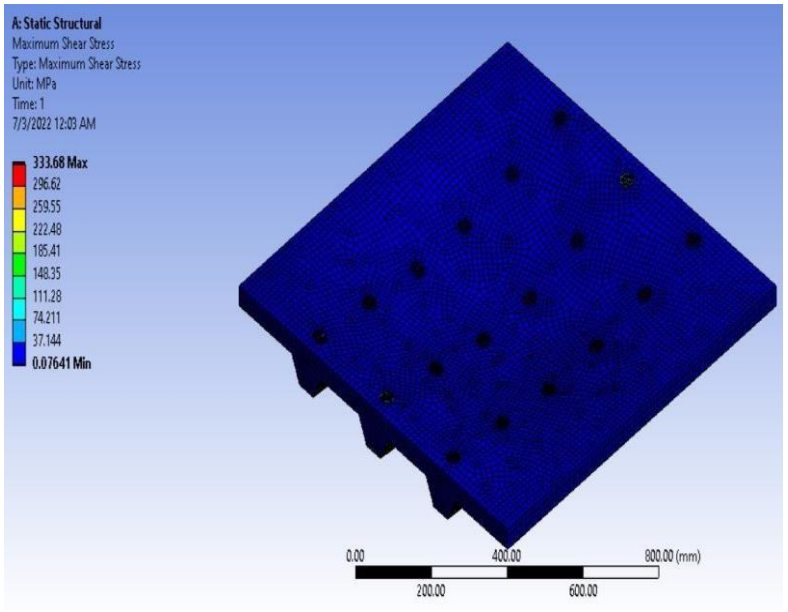


Composite Floor Deck with Shear Studs

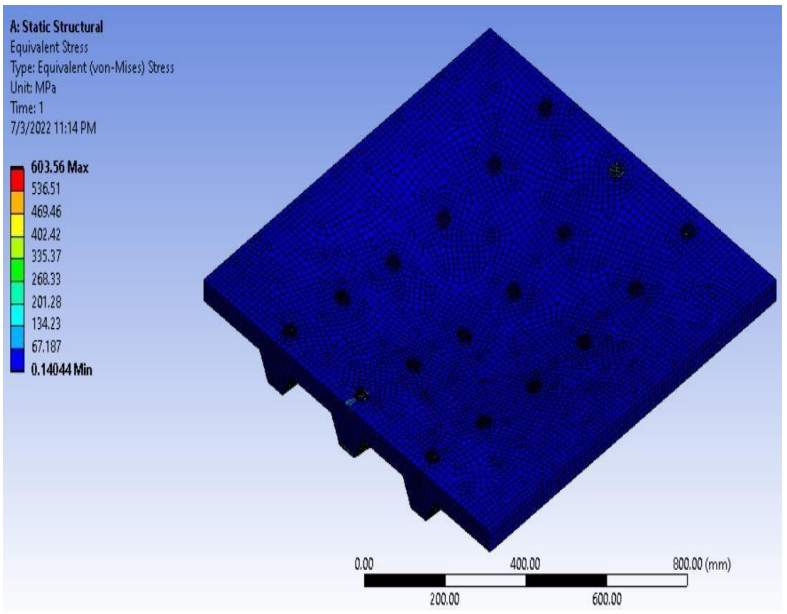
1. Total Deformation of Composite Floor Deck with Shear Studs



2. Maximum Shear Stress of Composite Floor Deck with Shear Studs.

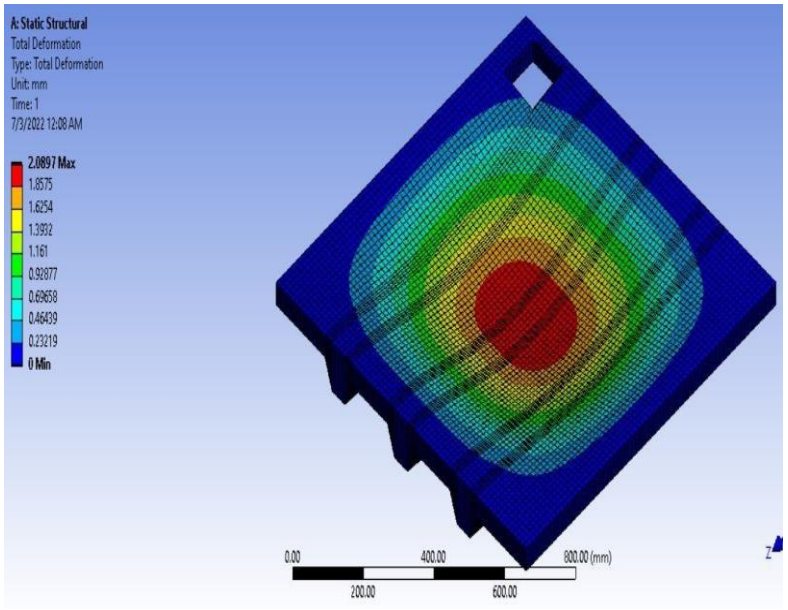


3. Equivalent Stress of Composite Floor Deck with Shear Studs.

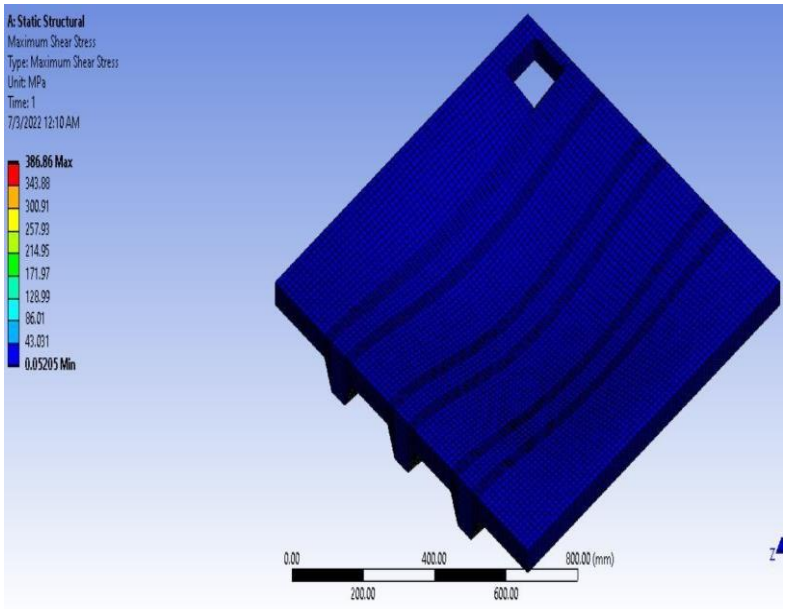


Composite Floor Deck with Openings

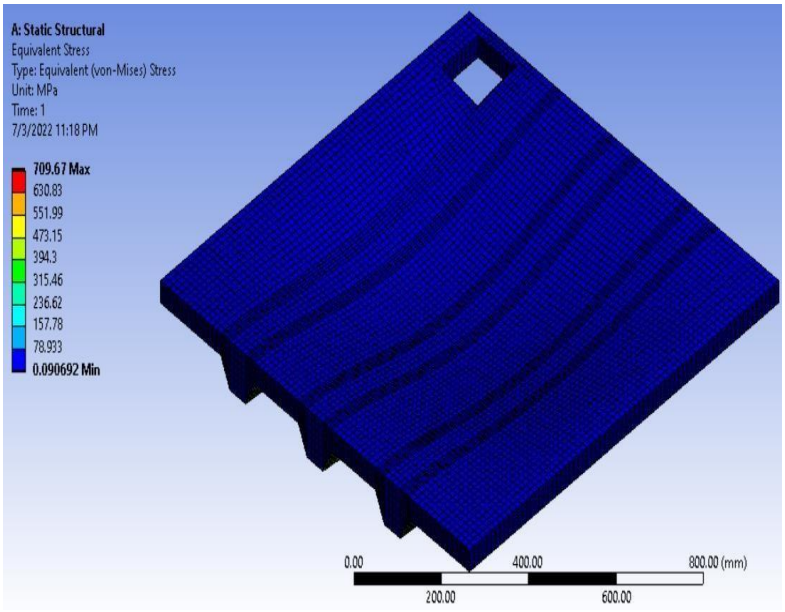
1. Total Deformation of Composite Floor Deck with Opening.



2. Maximum Shear Stress of Composite Floor Deck with Opening.

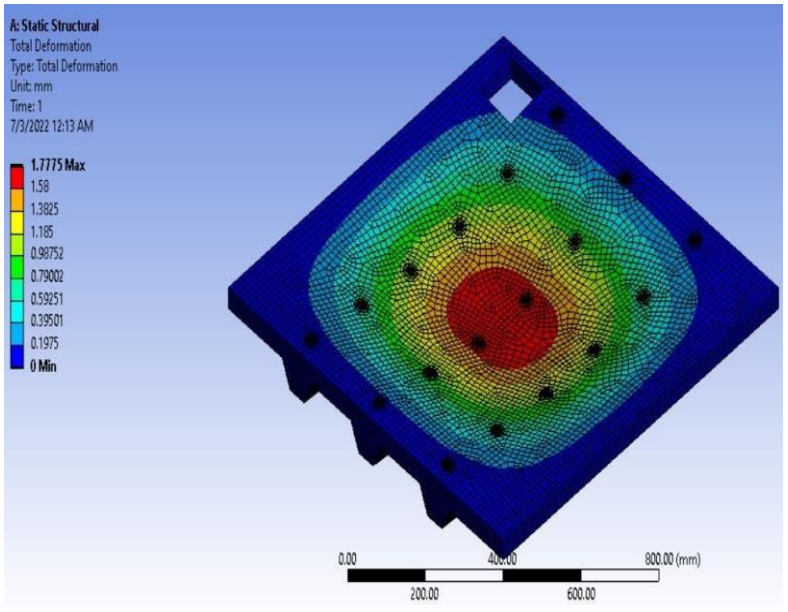


3. Equivalent Stress of Composite Floor Deck with Opening.

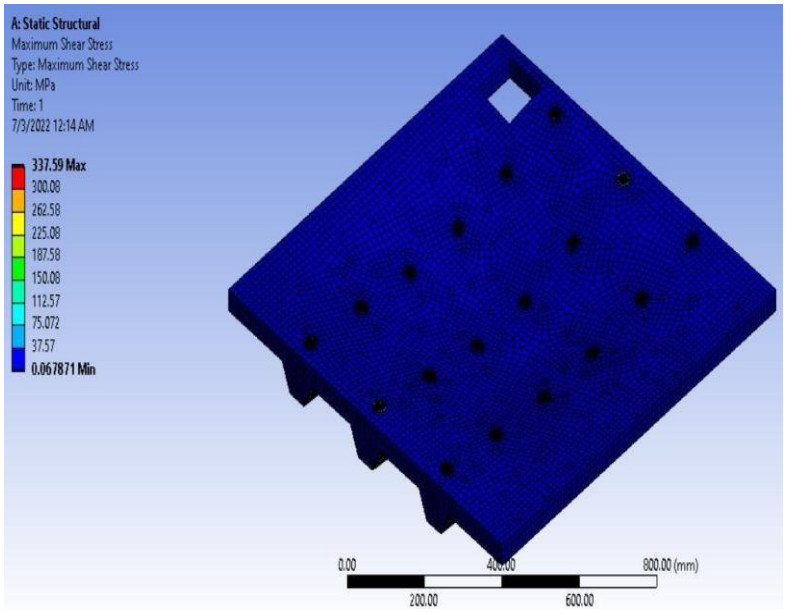


Composite Floor Deck with Shear Studs and Opening

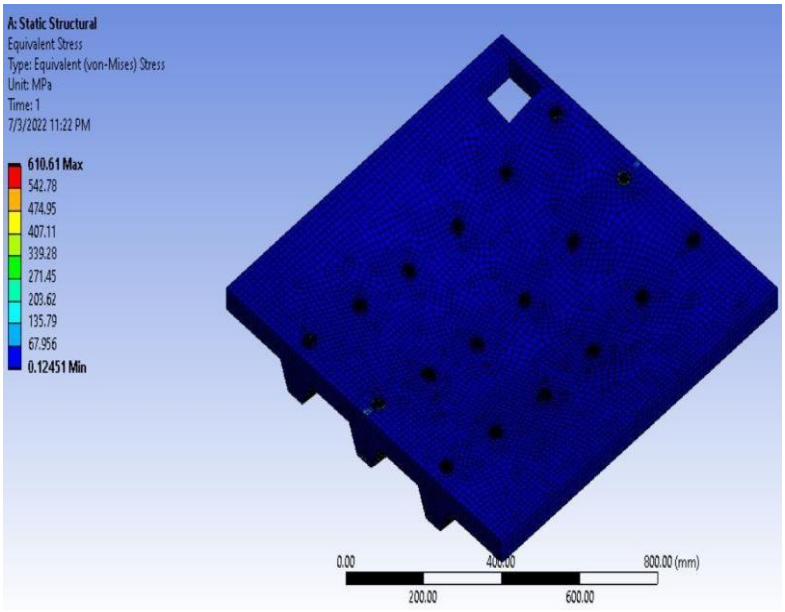
1. Total Deformation of Composite Floor Deck with Shear Studs and Opening.



2. Maximum Shear Stress of Composite Floor Deck with Shear Studs and Opening.

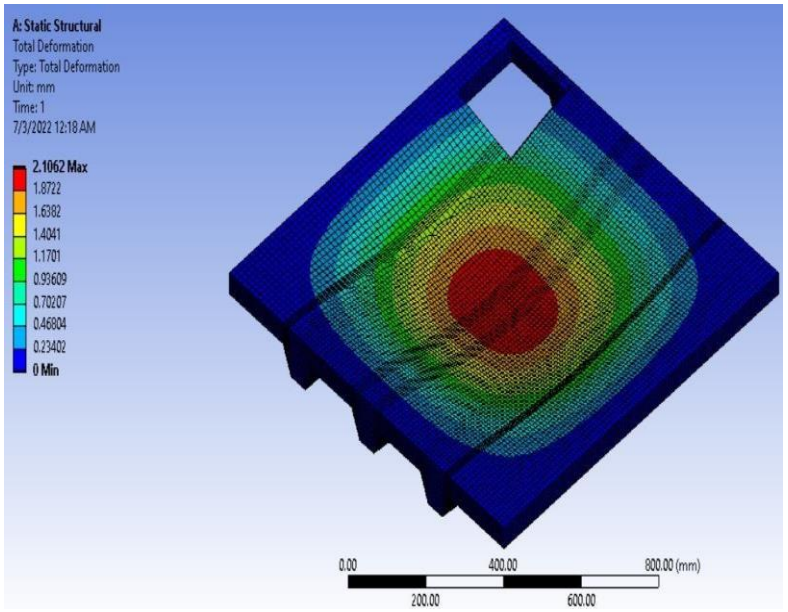


3. Equivalent Stress of Composite Floor Deck with Shear Studs and Opening.

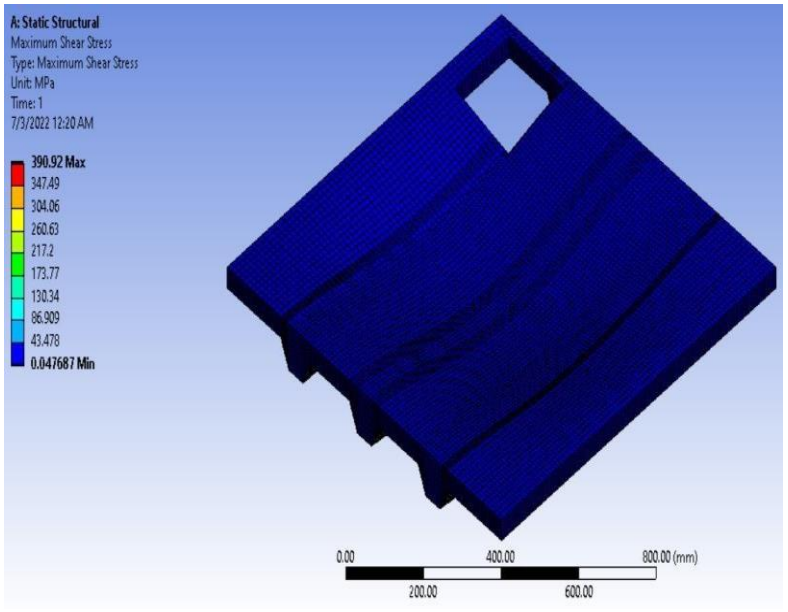


Composite Floor Deck with 200mm x 200mm Opening

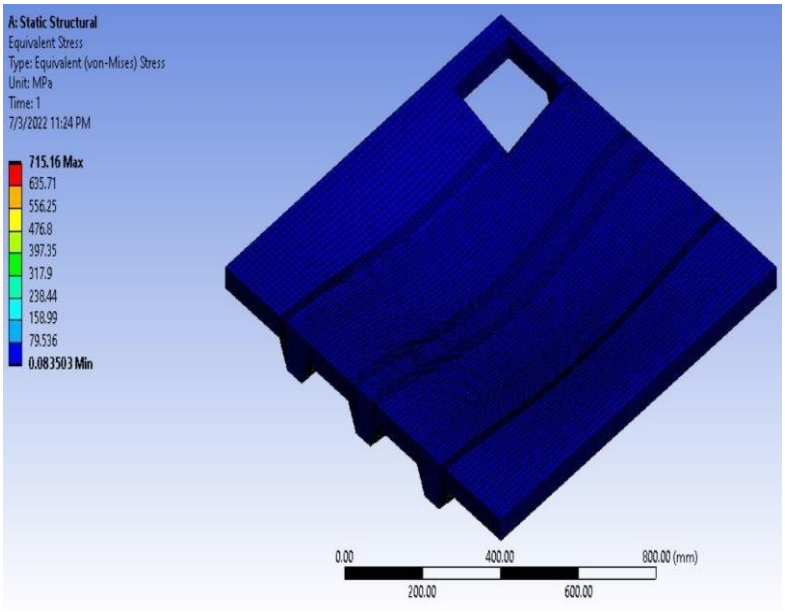
1. Total Deformation of Composite Floor Deck with 200mm x 200mm Opening.



2. Maximum Shear Stress of Composite Floor Deck with 200mm x 200mm Opening.

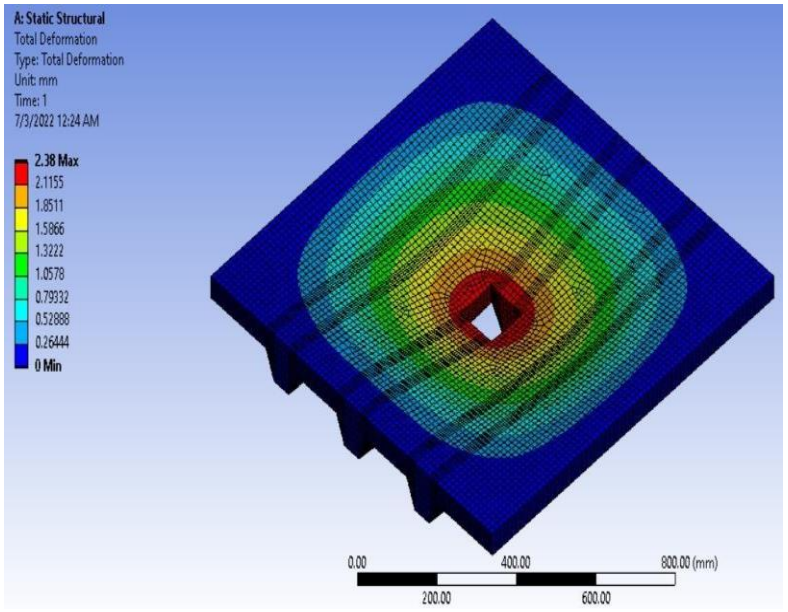


3. Equivalent Stress of Composite Floor Deck with 200mm x 200mm Opening.

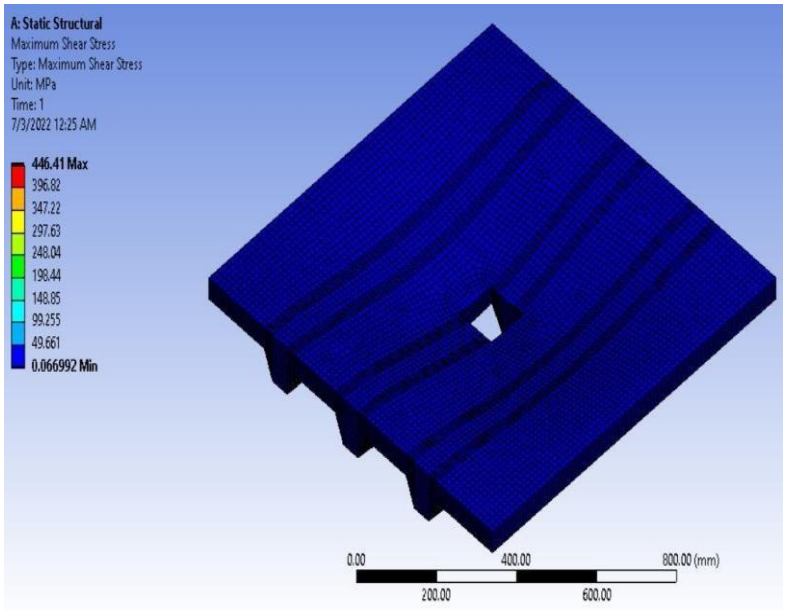


Composite Floor Deck with Opening at Centre

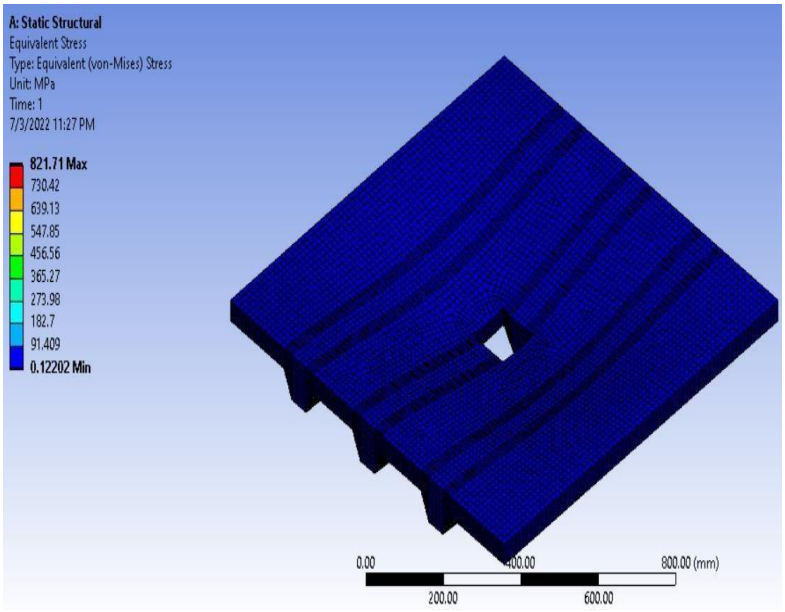
1. Total Deformation of Composite Floor Deck with Opening at Centre.



2. Maximum Shear Stress of Composite Floor Deck with Opening at Centre.

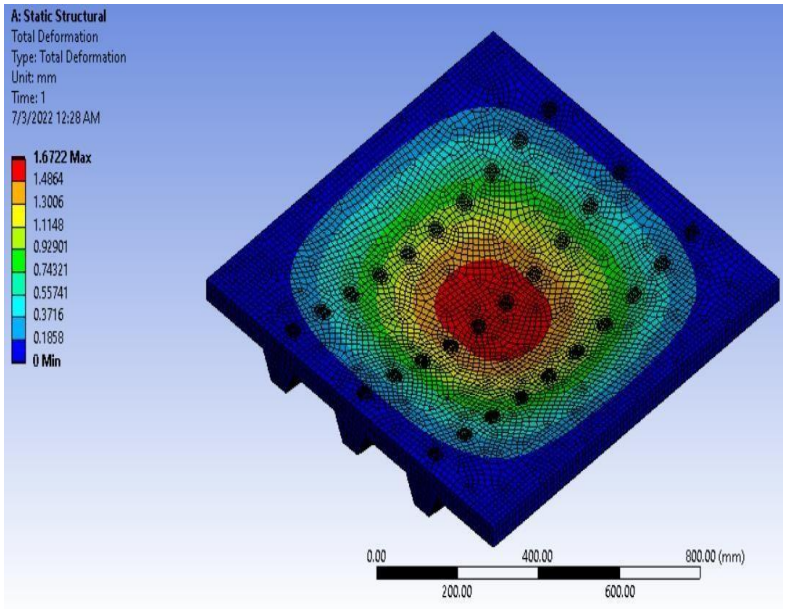


3. Equivalent Stress of Composite Floor Deck with Opening at Centre.

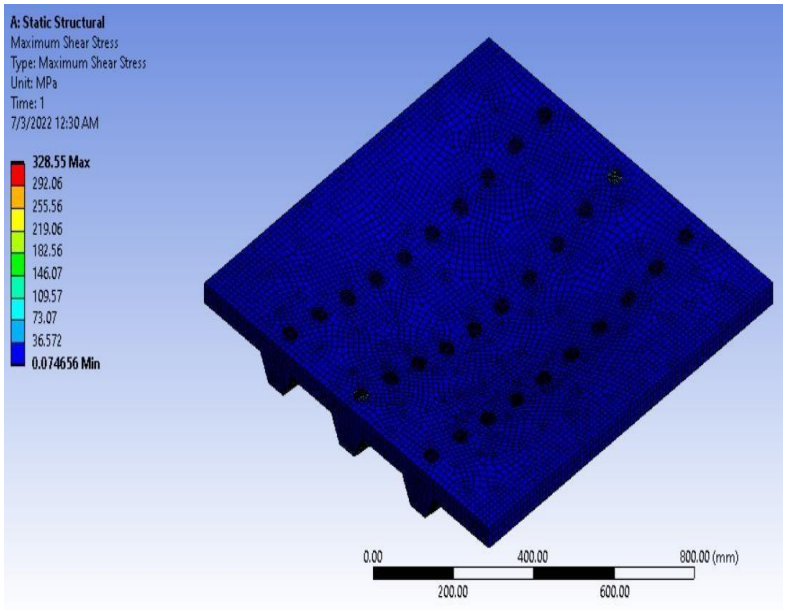


Composite Floor Deck with 10 Shear Studs

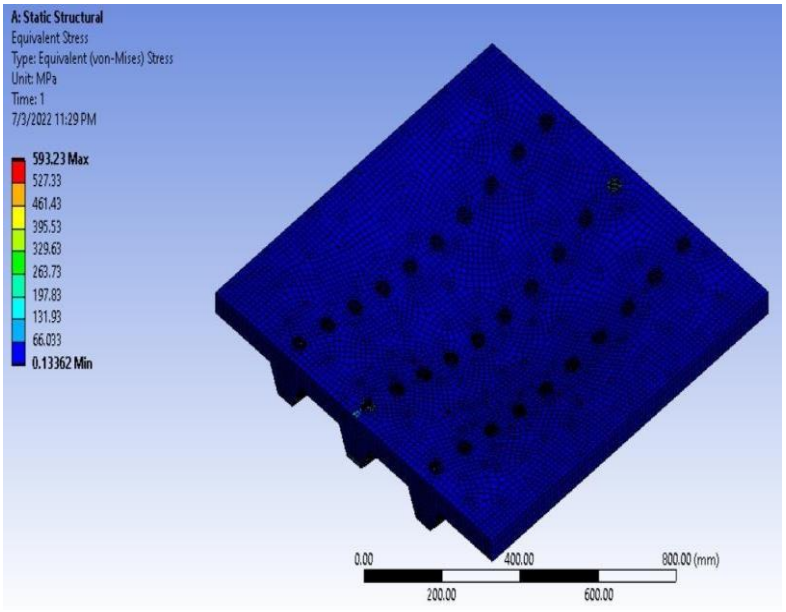
1. Total Deformation of Composite Floor Deck with 10 Shear Studs.



2. Maximum Shear Stress of Composite Floor Deck with 10 Shear Studs.

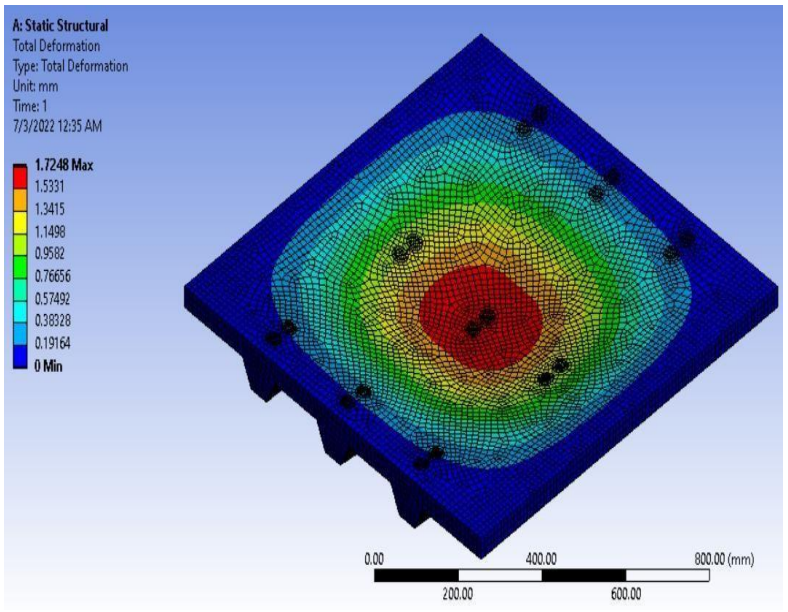


3. Equivalent Stress of Composite Floor Deck with 10 Shear Studs.

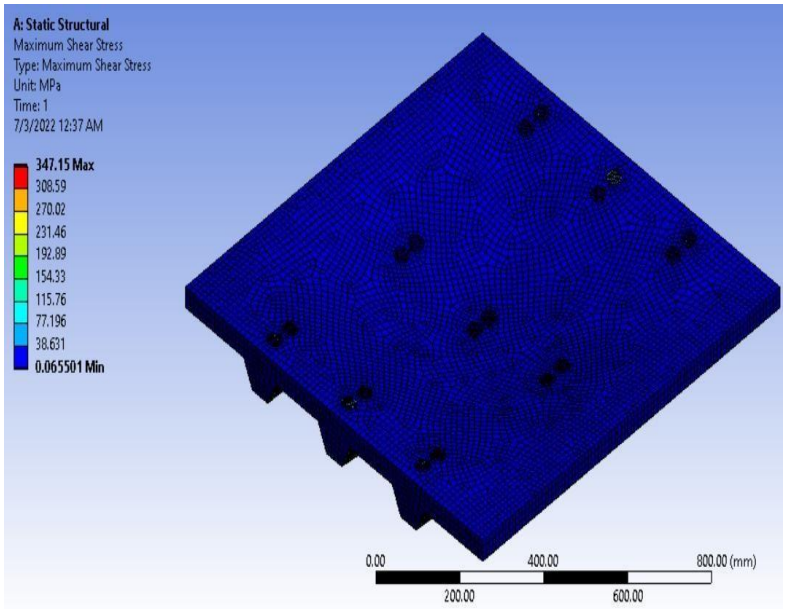


Composite Floor Deck with Different Shear Studs Arrangement

1. Total Deformation of Composite Floor Deck with Different Shear Studs Arrangement.



2. Maximum Shear Stress Composite Floor Deck with Different Shear Studs Arrangement.



3. Equivalent Stress Composite Floor Deck with Different Shear Studs Arrangement.