

# Study Compatibility Conceptual Design of Modular House Wall Panel by Using Solidwork

Mohd Zuhdi Hidayat Zadeli<sup>1</sup>, Mohammad Sukri Mustafa<sup>1\*</sup>, Mohd Rasidi Ibrahim<sup>1</sup>

<sup>1</sup> Faculty of Mechanical and Manufacturing Engineering  
Universiti Tun Hussein Onn Malaysia, 86400, Johor, MALAYSIA

\*Corresponding Author: [sukri@uthm.edu.my](mailto:sukri@uthm.edu.my)

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## Abstract

This study dives into how well different designs for modular house wall panels fit together, using SolidWorks to create the designs and ANSYS to give them a thorough check-up. While modular construction is great for being efficient and eco-friendly, making sure all the parts work seamlessly can be tricky. With SolidWorks, a user-friendly CAD tool, we craft detailed designs for these wall panels, keeping an eye on things like strength, material use, and how easy they are to put together. Then, we turn to ANSYS to test the panels under different kinds of stress, seeing how they hold up and where they might need some tweaking. By combining these tools, we hope to make modular construction systems even better, helping to make buildings more sustainable and easier to build.

## 1. Introduction

The Wall panel modular homes are a revolutionary method of construction that is radically altering the conventional building enterprise. This creative technique makes use of prefabricated panels that are carefully designed and produced under regulated conditions. These panels promise unmatched accuracy, longevity, and consistency because of factory quality control, in contrast to conventional site-built construction [1]. Designed to interlock perfectly, the panels can be quickly and effectively assembled on site thanks to their varied selection of construction materials, which include sturdy steel, sustainable timber, and revolutionary composites. By using this simplified approach instead of traditional ones, building times can be shortened by up to 50% [2]. but also, reportedly saves 30% on labor expenses and material waste [3]. This means that both builders and homeowners may make an economical and sustainable decision. Moreover, the modular architecture of these houses promotes unmatched versatility and flexibility. In contrast to traditional structures, where changes may be expensive and time-consuming, wall panel houses make it simple to customize external aesthetics, interior layouts, and floor plans to meet the specific needs of each homeowner and their distinct vision. The versatility of this is not limited to home use. Wall panel modular construction's efficiency, accuracy, and environmental friendliness can also be advantageous in commercial and industrial environments. The innate benefits of this approach provide a

competitive advantage in many fields, enabling quicker project completion and less environmental impact. Wall panel modular homes embrace innovation, sustainability, and customized design, making them a shining example of efficiency, modernism, and environmental responsibility in the building and architectural industries. With its revolutionary approach to tackling pressing issues like pricing, construction speed, and environmental effect, the building industry might undergo a revolution.



Figure 1: Wall panel modular house

## 2. Literature Review

### 2.1 Wall panel modular house.

A major area of study and invention in recent years has been the construction of modular homes utilizing prefabricated wall panels. There are several benefits to using modular panel systems, which assemble building parts at the site after they are manufactured in a factory. These include less material waste and increased measurement accuracy as compared to conventional on-site building techniques [4]. Malaysia, for example, has achieved success with the modular panel system, where homes are built using a grid system based on multiples of 610 mm to improve material efficiency and allow for future additions [4]. Numerous scholarly investigations have emphasized the advantages of modular building, such as heightened efficiency and excellence, along with its capacity to tackle sustainability concerns within the housing sector. An exhaustive examination of prefabricated enclosure wall panel systems, for example, highlighted how crucial it is to comprehend the embedded transport energy consumption linked to prefabricated construction, especially when it comes to timber-based systems [5]. According to transportation patterns, there are notable differences in the embodied transport energy consumption of prefabricated timber wall panelling units in the UK, as per the findings of another study [6]. These results highlight the necessity of conducting in-depth studies on modular building systems' environmental performance to guarantee their long-term viability [6].

### 2.2 Cost and time efficiency of wall panel modular house.

Prefabricated manufacturing technology used in the construction of modular panel homes can result in effective and affordable housing [7]. When compared to conventional building methods, the modular construction strategy minimizes construction time and schedule [8]. Project completion can be expedited by fabricating prefabricated wall panels and other modular components off-site and swiftly assembling them on-site [7],[10]. According to studies, modular panel homes can lower building costs by using more responsive manufacturing methods, more efficient production techniques, and less waste [7],[8]. Prefabricated concrete panels and other modular components are used in the construction process to reduce operational expenses and their negative effects on the environment [10],[11]. According to housing authorities and agencies, as compared to traditional on-site building,

prefabrication and modular construction processes result in improved efficiency, better quality control, and superior craftsmanship [10]. These time and money advantages are further enhanced by the factory-based, efficient manufacturing process and the orderly building site [10].

### **2.3 SolidWorks for conceptual design.**

SolidWorks is a CAD software that can support the conceptual design process for modular wall panels in a prefabricated house. The literature review indicates that SolidWorks provides features to facilitate conceptual design, such as topology optimization, simulation, and mechanism design and analysis [11],[12]. With the help of these tools, designers can produce and assess design concepts rapidly, optimize component shape, and verify mechanical operation all inside a versatile modelling environment [12]. Additionally, SolidWorks has collaboration features so that groups may exchange and get input on design suggestions [12]. Overall, it appears that SolidWorks may be a useful tool for conceptual design of modular wall panels, assisting designers in ideation, performance testing, and productive teamwork [11],[12],[13].

### **2.4 Sustainability and Environmental Impact.**

Wall panel sustainability and environmental effect Modular homes demonstrate how modular building may reduce environmental impact and increase cost. Research has demonstrated that, when compared to traditional building techniques, the use of sustainable waste materials in modular wall panels may lower greenhouse gas emissions and increase energy efficiency. For example, research discovered that, when compared to conventional materials, employing waste materials in wall panels can cut CO<sub>2</sub> emissions by up to 50% [15]. Modular building is a feasible option for meeting the need for cheap housing since it may also shorten the construction process and lower expenses [15]. Additionally, in line with the Net Zero challenge, integrating solar panels and energy-efficient insulation might assist in achieving net-zero energy use [14]. All things considered, modular wall panels that use energy-efficient designs and sustainable waste materials may help create a more economical and ecologically responsible building method.

### **2.5 Summary.**

Prefabricated wall panels in modular building have become a breakthrough in the construction business, providing advantages including lower material waste, increased precision, cost-effectiveness, and efficiency. Research has demonstrated effective implementations, such as those in Malaysia, where modular systems increase future expandability and material efficiency. Prefabrication reduces costs and construction time while guaranteeing excellent quality control by enabling off-site manufacture and quick on-site assembly. Furthermore, by providing collaborative features, optimization, and simulation capabilities, design productivity is increased by tools like as SolidWorks that help with the conceptual design process. Utilizing waste materials may drastically reduce greenhouse gas emissions and increase energy efficiency, supporting net-zero energy targets and encouraging ecologically friendly building practices. This is another way that modular construction tackles sustainability problems.

### 3. Methodology

#### 3.1 Methodology Flowchart

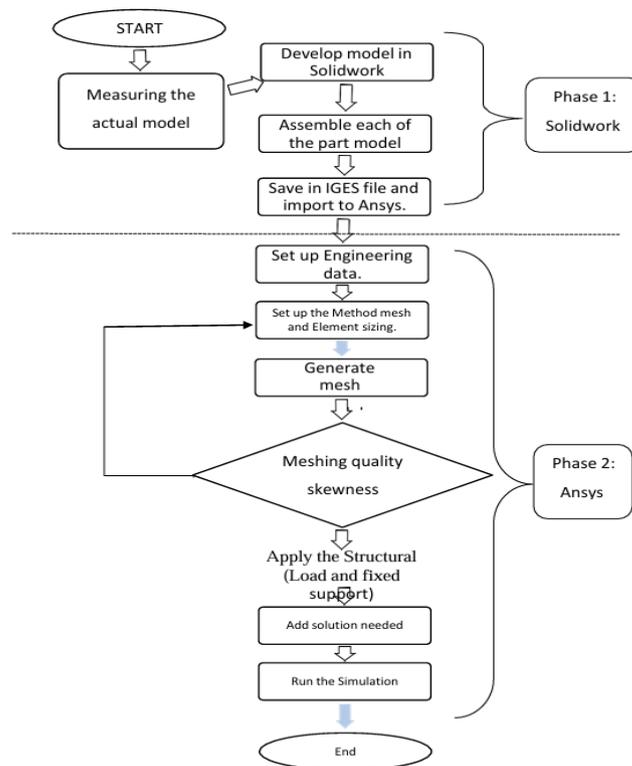


Figure 2: Flowchart of research

#### 3.2 3 Design wall panel using solid work.

##### 1. Slot - in joint

- First part and second part

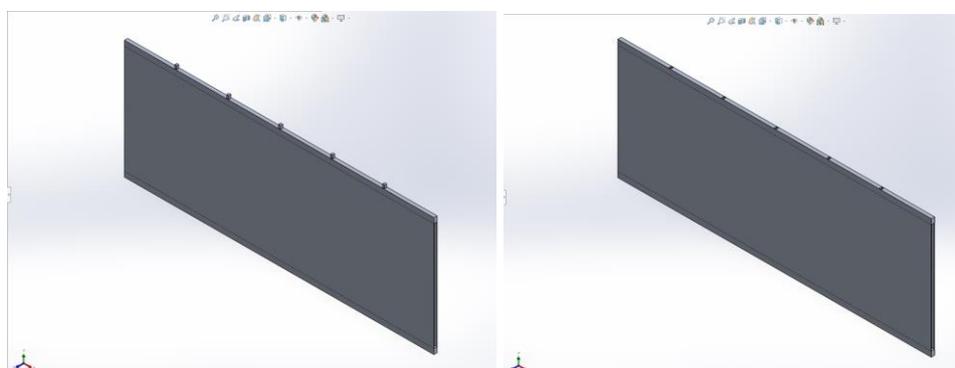
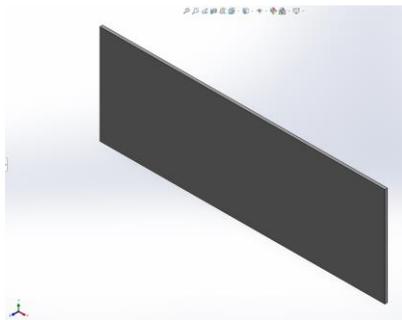


Figure3: Material: Aluminum Alloys [6061 - T6 (ss)]

Function: Frame of wall panel

- **Middle part of wall panel**



Material: Natural fiber (Wood)

Function: to support frame of wall panel.

## 2. Tongue and groove joint

- **First part and second part**

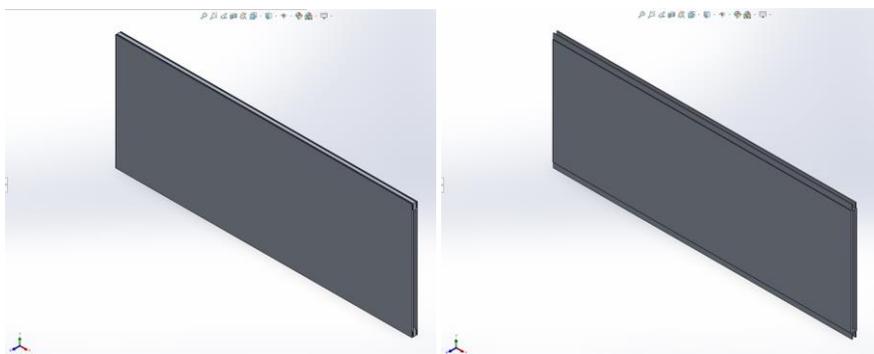
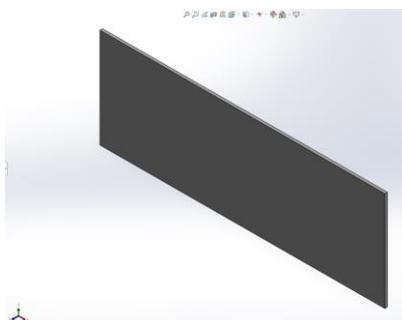


Figure 4: Material: Aluminum Alloys [6061 – T6 (ss)]

Function: Frame of wall panel

- **Middle part of wall panel**



Material: Natural fiber (Wood)

Function: to support frame of wall panel

### 3. Sandwich joint

- **First part and second part**

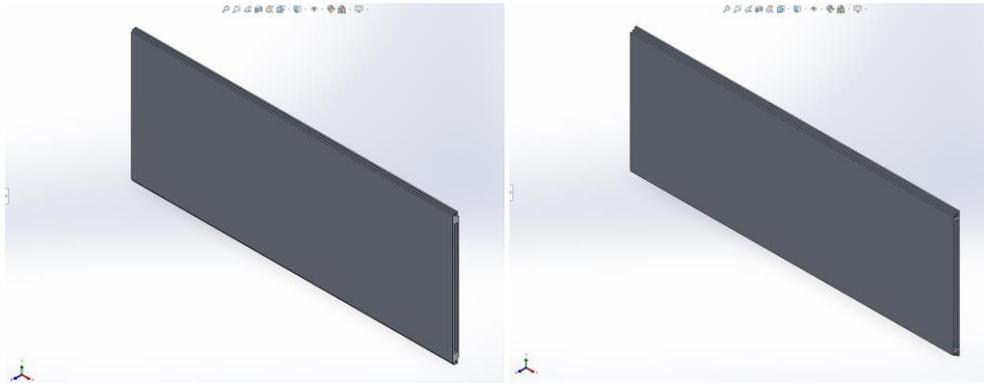


Figure 5: Material: Aluminum Alloys [6061 – T6 (ss)]

Function: Frame of wall panel

- **Middle part of wall panel**

The middle part of wall panel modular house fall all three design was same.

### 3.3 Simulation using Ansys

To assess the wall panel's performance under various load scenarios, ANSYS was used to run a static structural simulation for this investigation. The wall panel's stress distribution, deformation, and overall structural integrity were all revealed by the simulation, which made it possible to optimize the design and guarantee longevity and safety in applications involving modular construction.

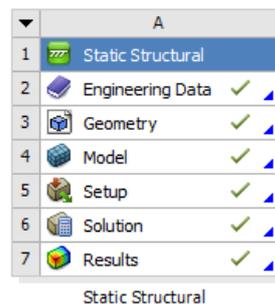


Figure 6: Static Structure Parameter

### 3.4 Determine Load of wall panel.

The allowed load on the aluminum alloy 6061-T6 wall panel can be increased by lowering the factor of safety (Fos) from 2 to 1.5. 184 MPa is the permissible stress, which is determined by dividing the yield strength by the new Fos. We calculate the maximum evenly distributed load that the panel may safely support using this updated allowed stress. According to the calculation, a uniformly distributed load can have an acceptable range of 37.9 kPa, which allows for a more efficient design with a respectable safety margin. As the stress of 37.9 kPa is for a single part, it will increase to 75.8 kPa for the assembly part.

## 4. Result and Discussion

### 4.1 Static structure Analysis using Ansys.

#### 1) Design 1 (Slot-in joint)

##### (a) Equivalent Stress (Von - Mises)

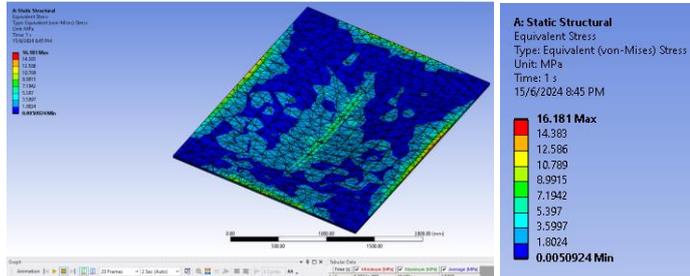


Figure 7: Result of Von – Mises Stress

The photos that are presented depict a stress study that was conducted using ANSYS software on the Design 1 (slot-in joint) wall panel for a modular home. 16.181 MPa is the greatest equivalent (von-Mises) stress, while 0.005924 MPa is the lowest. Critical high-stress locations (red and orange areas) are indicated by the stress distribution and may need to be reinforced or redesigned to maintain structural integrity. The blue and green low-stress sections indicate that they are less stressed. Stress-relief elements should be considered, high-stress locations should be evaluated for possible enhancements, and alternate materials or configurations may need to be investigated to improve the design.

##### (b) Equivalent Elastic Strain

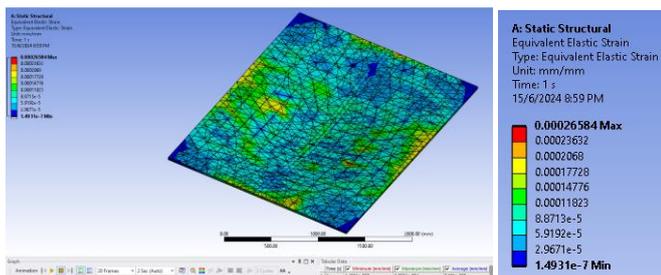


Figure 8: Result of Elastic Strain

The equivalent elastic strain study using ANSYS software of Design 1 (slot-in joint) wall panel for a modular home. The comparable elastic strain has a maximum of 0.00026584 mm/mm and a minimum of 1.4931e-7 mm/mm. Areas of greater strain (orange and red regions) are clustered around zones in the strain distribution, indicating that these areas undergo more deformation under load. On the other hand, the green and blue spots represent locations with reduced strain, which suggests less deformation. The significance of concentrating on the high-strain regions to guarantee their ability to tolerate operating loads without experiencing undue deformation is underscored by these findings.

### (c) Total Deformation

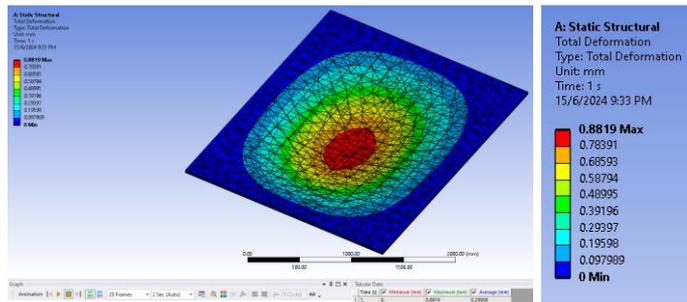


Figure 9: Result of Total Deformation

With ANSYS software, a total deformation study of the Design 1 (slot-in joint) wall panel for a modular home was carried out. With a minimum deformation of 0 mm, the greatest total deformation measured is 0.8819 mm. The panel's middle portion (red area) exhibits the most distortion, progressively decreasing towards the panel's margins (blue areas), according to the deformation distribution. The pattern indicates that although the borders are generally stable, the core area is more flexible and prone to bending or displacement under applied stresses.

### (d) FOS using SolidWorks

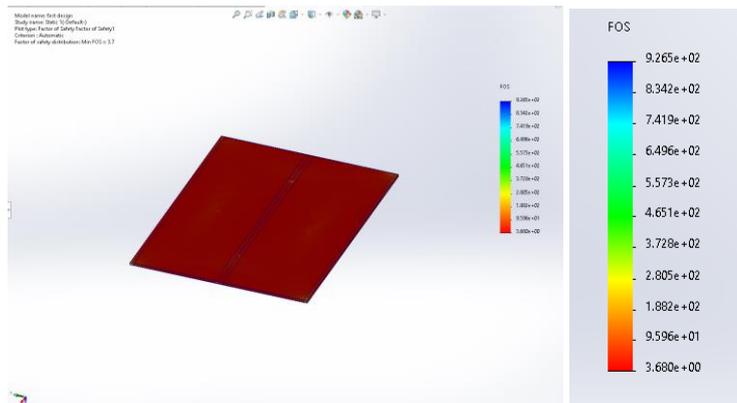


Figure 10: Result of Factor of Safety (FOS)

Based on a SolidWorks analysis, the Factor of Safety (FOS) values for the Design 1 (slot-in joint) wall panel of a modular home vary from 3.690 to 926.5. The panel is much over the acceptable safety threshold in most of its high FOS values (blue regions), but certain important parts (orange and red regions) have lower FOS values and may be weaker.

2) Design 2 (Tongue and Groove joint)

(a) Equivalent Stress (Von - Mises)

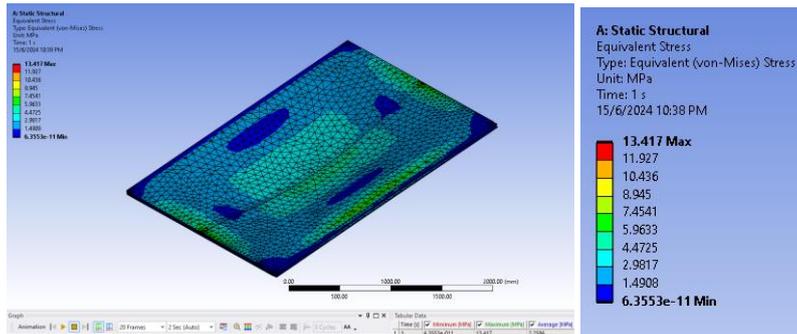


Figure 11: Result of Von – Mises Stress

The pictures depict the equivalent stress analysis, performed with ANSYS software, for Design 2 (Tongue and Groove joint) wall panel for a modular home. 13.417 MPa is the greatest equivalent (von-Mises) stress, while 6.3553e-11 MPa is the lowest. As can be seen from the stress distribution, there may be possible locations of failure under load as the strongest stress areas (red regions) are clustered panel zones, most likely close to the joints. The blue and green patches denoting lower stress levels indicate that most of the panel suffers much lower levels of stress.

(b) Equivalent Elastic Strain

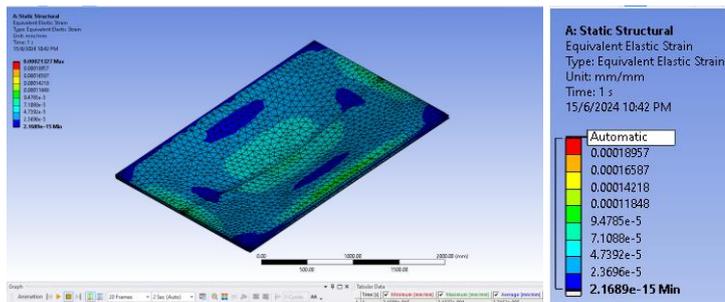


Figure 12: Result of Elastic Strain

The pictures display the corresponding elastic strain analysis performed by ANSYS software on a wall panel of a modular home with a tongue and groove joint in Design 2. 2.1689e-15 mm/mm is the least equivalent elastic strain, while 0.00018957 mm/mm is the highest. According to the strain distribution, the greatest strain regions represented by red areas are confined, most likely close to joints or sites of stress concentration. The bulk of the panel shows parts that are green and blue, which indicate places with much lower strain levels and less deformation.

### (C) Total Deformation

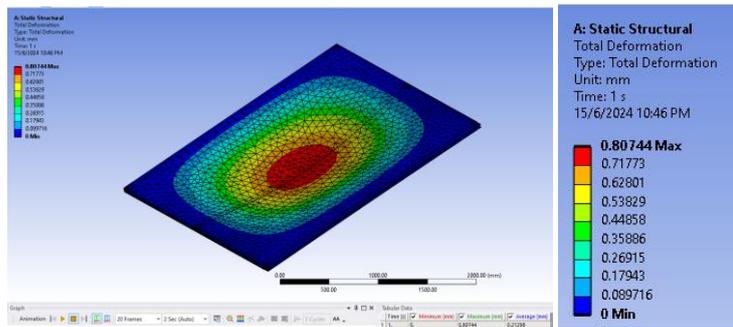


Figure 13: Result of Total Deformation

ANSYS software was used to complete the deformation analysis for the wall panel in Design 2 (the tongue and groove junction) of a modular home. With a minimum deformation of 0 mm, the greatest total deformation measured is 0.80744 mm. According to the deformation distribution pattern, the panel's center (red region) has the most distortion, which progressively decreases toward the panel's margins (blue areas). This implies that although the margins are comparatively stable, the core region is more flexible and prone to bending or displacement under applied stresses.

### (d) FOS using SolidWorks

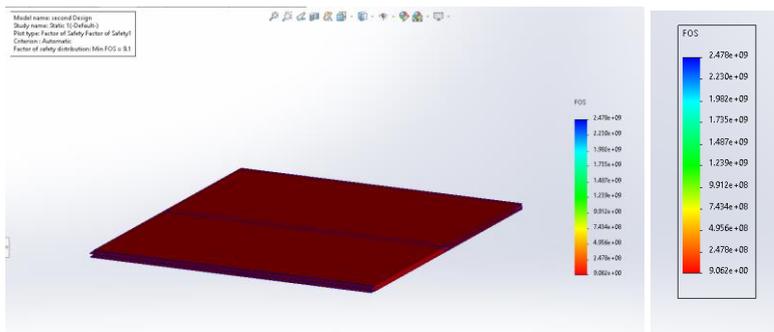


Figure 14: Result Factor of safety (FOS)

SolidWorks was used to do a Factor of Safety (FOS) study for the wall panel of Design 2 (the tongue and groove junction) of a modular home. The FOS values vary from 9.062 at the least to 2.47e+09 at the greatest. The distribution shows that the majority of the panel's regions (blue regions) have exceptionally high FOS values, indicating a severe overdesign and a region that is well beyond the necessary safety threshold. Lower FOS values are seen in some places (red zones), though, and these might be cause for alarm. In order to provide a more balanced and effective design, the large range of FOS values indicates a chance to optimize material utilization by removing extra material in the over-designed parts and reinforcing the lower FOS regions.

**(3) Design 3 (Sandwich joint)**

**(a) Equivalent Stress (Von - Mises)**

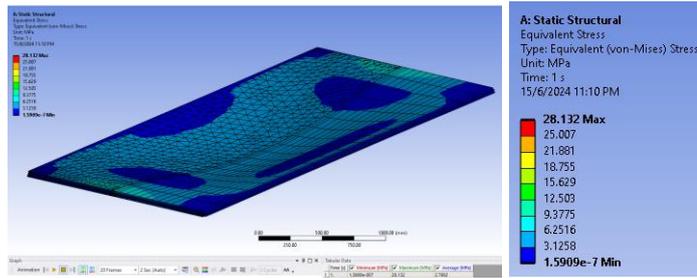


Figure 15: Result of Von – Mises Stress

the equivalent stress study for the modular home's Design 3 (Sandwich joint) wall panel using ANSYS software. There is a minimum stress of 1.5909e-7 MPa and a maximum equivalent (von-Mises) stress of 28.132 MPa. The stress distribution indicates possible failure spots under load by highlighting high-stress regions (red areas), which are mostly concentrated in particular zones of the panel, maybe close to the joints or load application places. On the other hand, the lower stress regions (the blue and green patches) indicate that a large portion of the panel is under much less stress.

**(b) Equivalent Elastic Strain**

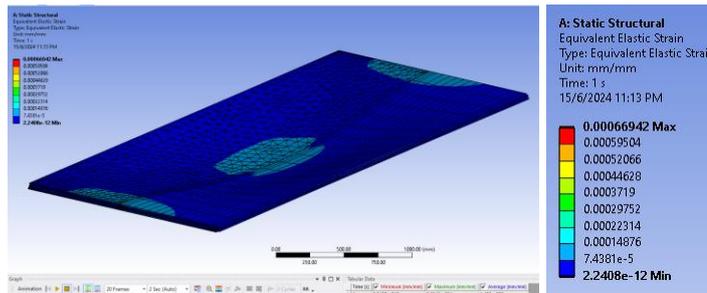


Figure 16: Result of Elastic Strain

the comparable elastic strain study using ANSYS software for a modular home's Design 3 (Sandwich joint) wall panel. 2.2408e-12 mm/mm is the least equivalent elastic strain while 0.00066942 mm/mm is the highest. The strain distribution shows that localized spots with the highest strain (red areas) are probably the joints or stress-concentration sites. Most of the panel (the blue and green portions) show noticeably lower strain values, suggesting that there hasn't been any deformation there. These findings imply that although the panel is still stable in most places, the high-strain regions need to be attended to to avoid excessive deformation and possible collapse.

### (C) Total Deformation

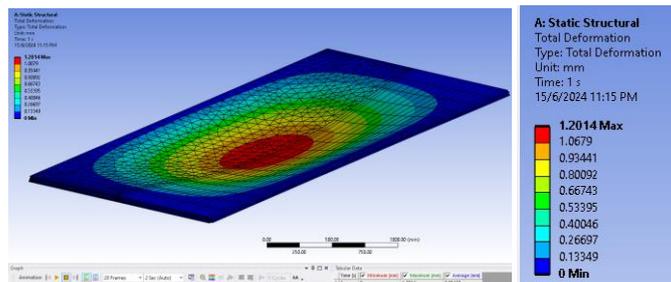


Figure 17: Result of Total Deformation

ANSYS software was used to complete the deformation analysis for the Design 3 (Sandwich joint) wall panel for a modular home. With a minimum deformation of 0 mm, the maximum total deformation measured is 1.2014 mm. According to the deformation distribution pattern, the panel's center (red region) has the most distortion, which progressively decreases toward the panel's margins (blue areas). This implies that although the margins are comparatively stable, the core region is more flexible and prone to bending or displacement under applied stresses.

### (d) FOS using SolidWorks

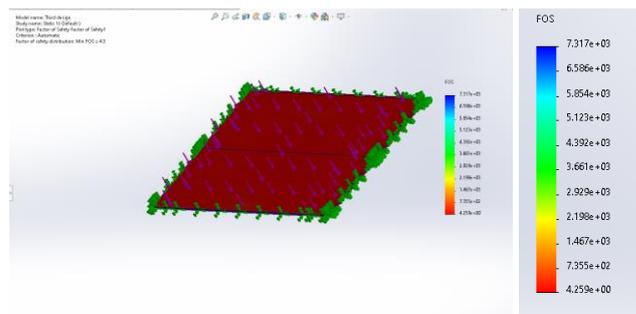


Figure 18: Result Factor of safety (FOS)

Utilizing SolidWorks, the Factor of Safety (FOS) study for the Design 3 (Sandwich joint) wall panel of a modular home yields FOS values between 4.259 to 7317. Very high FOS values (blue zones) are present throughout much of the panel, showing considerable overdesign and guaranteeing safety well over the necessary threshold. Lower FOS values, however, are seen in some places (red zones), which may be cause for concern when there is a heavy load.

## 4.2 Choose the best Design based on total deformation.

Design 2 (Tongue and Groove Joint) shows the lowest maximum total deformation at 0.80744 mm, compared to 0.8819 mm for Design 1 (Slot-in Joint) and 1.2014 mm for Design 3 (Sandwich Joint), according to the total deformation study of the three designs for wall panels of a modular home. The Tongue and Groove Joint design is the best option among the three designs in terms of minimizing deformation and guaranteeing durability because it shows the least amount of bending or displacement under load, indicating that it maintains better structural integrity and is more resistant to deformation.

## 5.0 Conclusion

Design 2 (Tongue and Groove Joint), out of the three wall panel designs for a modular home—Slot-in Joint, Tongue and Groove Joint, and Sandwich Joint—is the best option after a thorough examination. With a maximum total deformation of just 0.80744 mm, this design exhibits the lowest, suggesting better resistance to displacement and bending under load. Furthermore, it exhibits good distributions of stress and strain with a high range of the Factor of Safety (FOS), guaranteeing strong safety margins in most locations. In contrast, Design 3 (Sandwich Joint) and Design 1 (Slot-in Joint) show less advantageous stress distributions and larger deformations of 1.2014 mm and 0.8819 mm, respectively. As a result, they are less trustworthy. Therefore, the Tongue and Groove Joint design maintains better structural integrity and durability, making it the most efficient and reliable option among the three designs. Further optimization and physical validation are recommended to ensure it meets all performance and safety standards.

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