

## Implementation of Light Steel Roof Design in Gili Iyang Ubhara Sumenep

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| Article Information                                                                                                                                                                                                                                         | ABSTRACT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
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| <b>Article History</b><br><br><b>Received</b> : November 09, 2025<br><b>Revised</b> : November 22, 2025<br><b>Published</b> : January 02, 2026<br><br><br><b>Keywords:</b><br><i>Design;</i><br><i>Lightweight steel;</i><br><i>Roof;</i><br><i>Sumenep</i> | The increasing demand for housing in Indonesia requires innovative and efficient construction systems to ensure sustainable development. This study presents the design and analysis of a lightweight steel roof structure, titled “Gili Iyang Ubhara,” inspired by the ecological values of Gili Iyang Island in Sumenep, known for its exceptional air quality. The design integrates the concept of a green and solar roof to optimize energy use and environmental performance. The structural analysis methodology used in this research is standards of SNI 7971:2013 and SNI 1727:2020. The roof structure was then analyzed with SAP2000 software to evaluate strength, load distribution, and material efficiency. The results show that all members of the structure have strength ratios below 1.0, indicating safe performance under dead, live, and wind loads. The combination of solar panels and green roof elements contributes to reduced heat absorption and increased energy efficiency. For the record, future research is recommended to incorporate dynamic thermal-energy simulations to quantify the long-term performance of hybrid eco-roof systems under varying climatic conditions, thereby enhancing predictive accuracy for large-scale implementation. |

## INTRODUCTION

The Republic of Indonesia's Ministry of Public Works and Public Housing (PUPR) reports that 800,000 new dwellings are needed annually (Dinas Pekerjaan Umum dan Tata Ruang, 2016). To address this need, the Ministry of PUPR has designed the One Million Houses Program. 805,000 homes were constructed in 2016 thanks to this scheme, of which 570,000 were for low-income areas (MBR) and 240,000 were not (Gofur & Jumiati, 2021).

To avoid delays in the execution of construction projects, the large target number of dwellings to be produced must be accompanied by an effective construction procedure (Hassan et al., 2016). A project's durability, upkeep, customer satisfaction, manufacturing methods, life cycle, usage, environment, and cost are all significantly impacted by the choice of building materials (Cabral & Blanchet, 2023). One of the advances in building projects over the past ten years is the use of lightweight steel roofing. Compared to traditional hardwood roofing, light steel roofs are of higher quality (Zulfiar & Kusumawardana, 2024). Light steel roof installation is less expensive and time-consuming (Oktarina & Darmawan, 2015).

High-quality light steel is thin and light, but it is just as strong as regular steel. Nowadays, the most popular option for constructing truss frames for roof construction in homes and other buildings is cold-formed steel (CFS), also known as light steel or BCD (Wuryanti, 2019). This facilitates engineers' ability to develop, specifically with regard to calculation and analytical

programs. According to (Purwanto, 2017), many tall structures must be constructed appropriately, which calls for structural strength depending on the loads and forces they support.

Another difficulty for planners is the large range of roof frame shapes. Economic factors, aesthetics, field implementation simplicity, and structural strength against working loads must all be taken into account when choosing a roof frame shape (Purwanto, 2017). As a result, a lightweight steel roof frame design that is both effective and able to sustain the building's functional requirements as well as its visual appeal is required.

The objectives of this research are to create a lightweight steel roof truss structure that can support heavy loads, generate an economical and material-efficient design, and incorporate solar panels as a substitute for electricity. Therefore, it is anticipated that the *Gili Iyang Ubhara* building's lightweight steel roof design would be one of the design options available to civil engineers for producing a strong, affordable, and ecologically friendly structure. Additionally, it is anticipated that this research will contribute to the advancement of knowledge in the field of construction engineering, specifically with regard to contemporary roof truss design.

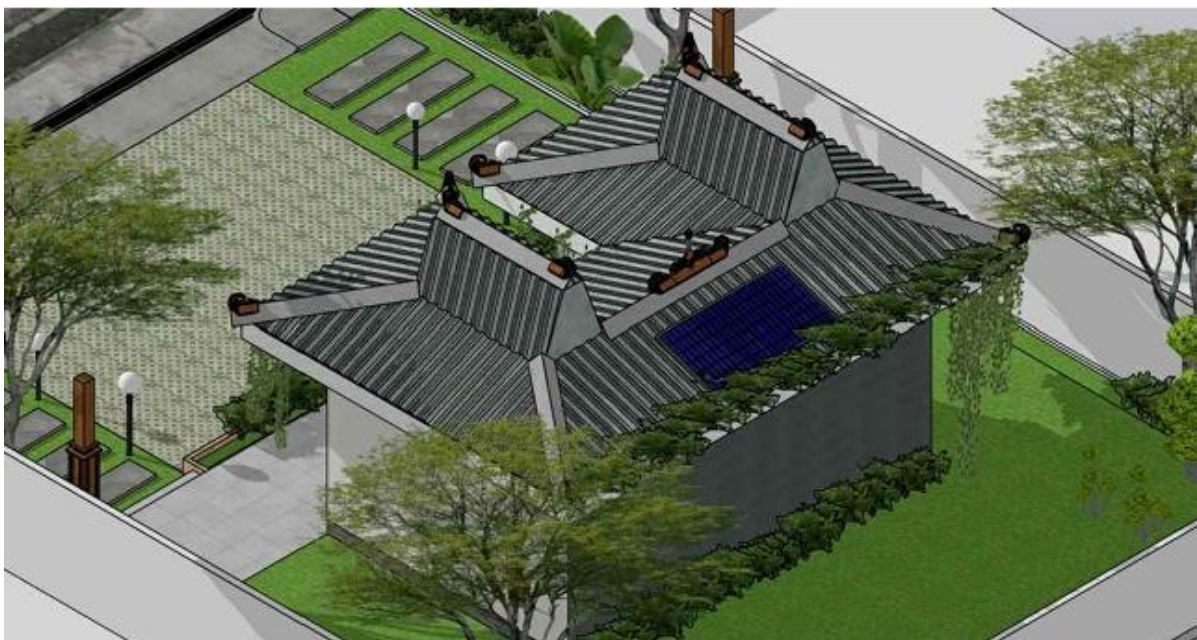


**Figure 1.** Building Roof Design

However, any existing studies on lightweight steel roof structures in Indonesia still focus primarily on static loading behaviour and conventional roof configurations, with limited attention to the integration of renewable-energy components such as photovoltaic panels, solar load, or thermal effects, as well as how modified geometric configurations influence the safety and efficiency of lightweight steel trusses designed for mass-housing applications. Furthermore, the application of national standards SNI 7971:2013 and SNI 1727:2020 in the context of hybrid eco-roof systems remains scarcely explored, particularly for regions with unique environmental characteristics such as *Gili Iyang Ubhara*. These gaps indicate a need for a comprehensive structural evaluation that incorporates modern roof functionalities while ensuring material efficiency and compliance with Indonesian standards.

## RESEARCH METHODS

The lightweight steel roof structure known as "Gili Iyang Ubhara" was designed and analyzed using a numerical modeling approach and a review of the literature. The goal of the project was to develop a roof system that combines solar panels and green roof ideas in a way that is both ecologically friendly and energy-efficient.

Gathering geometric and material data from manufacturer datasheets, existing literature, and earlier research on lightweight steel construction comprised the first phase of the study. In order to achieve the best possible load distribution and aesthetic balance, the roof geometry was created using the classic limas (pyramid) configuration. The primary structural components used Reng 30/20/0.45 profiles for the secondary components and C75/35/0.65 cold-formed lightweight steel sections for the truss members. These materials were chosen due of their excellent tensile strength, lightweight nature, and construction efficiency.

SNI 7971:2013 for cold-formed steel structures and SNI 1727:2020 for building load combinations were followed in the structural analysis and design process (Desimaliana, 2023). Dead loads (DL), living loads (L), wind loads (W), and additional dead loads that represented solar panels and roofing materials were all included in the applied load instances. In particular, the live load was set at 960 N/m<sup>2</sup> according to SNI 1727:2020, while the extra loads included solar panels at 200 N/m<sup>2</sup> and Spandek roofing at 52 N/m<sup>2</sup> (Badan Standardisasi Nasional, 2020). In order to model actual load scenarios on the roof system, load combinations such as 1.4D, 1.2D + 1.6L, and 1.2D + 1.0W + L were determined in accordance with the SNI regulations.

In addition to capture axial and flexural behaviors under combined loads, the roof structure was modeled using SAP2000 v22.0.0 Ultimate, with each member represented as a frame element. To ascertain internal forces, deflections, and stress distributions throughout the truss elements, a linear static analysis was carried out (Levinson & Akbari, 2010). The impact of purlin spacing, profile choice, and solar panel integration on the overall structural performance and material efficiency was then assessed by sensitivity analysis.

Finally, model validation was carried out by comparing numerical outputs to manual calculations on important elements to ensure agreement with engineering theory and SNI design specifications (Akbari et al., 2011). The analytical results showed that all truss parts had strength ratios less than 1.0, indicating that the Gili Iyang Ubhara roof structure met safety and serviceability requirements. Finally, the design evaluation focused strength adequacy, deflection control, and material efficiency, as well as the environmental benefits of solar panel integration and green design principles, which resulted in reduced heat absorption and enhanced energy consumption.

## RESULTS AND DISCUSSION

### Load and Load Combination

For roof truss construction calculations, we utilize the following load combinations:

1. Load combination 1 → 1.4D
2. Load combination 2 → 1.2D + 1.6L
3. Load combination 3 → 1.2D + 1.0W + L

### Main Truss Loading

In this study, the primary struts are separated by 865 mm.

### Dead Load

SAP2000 software is used to automatically calculate dead load (DL). The following additional dead loads were applied to the model:

**Table 1.** Additional Dead Load (ADL)

| Additional Dead Load (ADL) |     | Weight           |
|----------------------------|-----|------------------|
| Spandex                    | 52  | N/m <sup>2</sup> |
| Solar Panel                | 200 | N/m              |

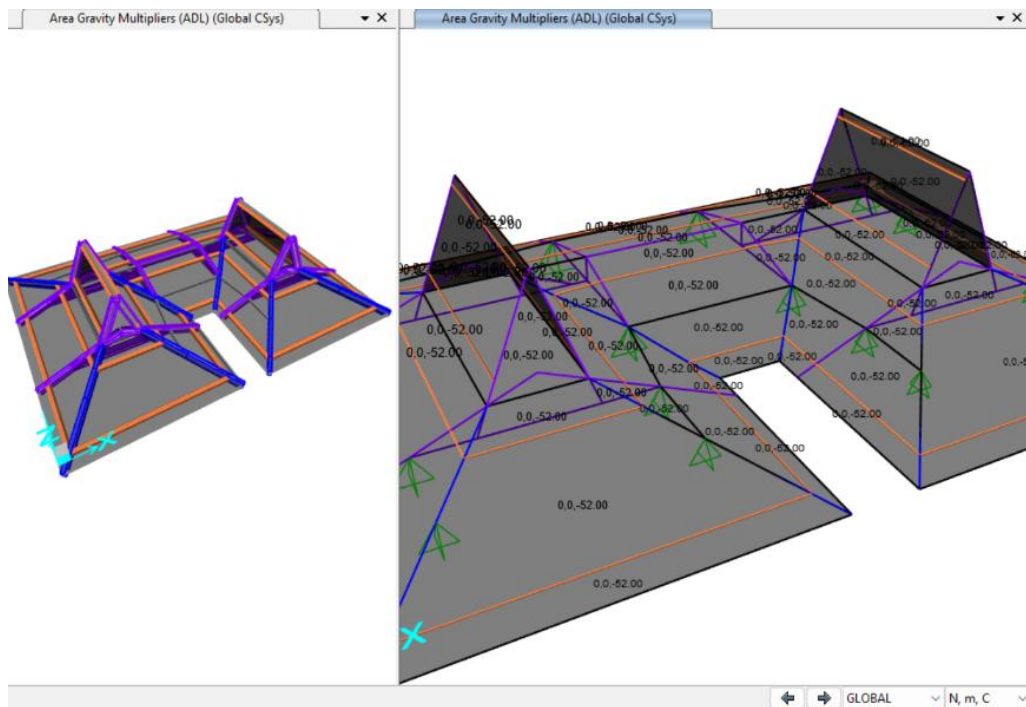


**Figure 2.** Dead Load Bearing

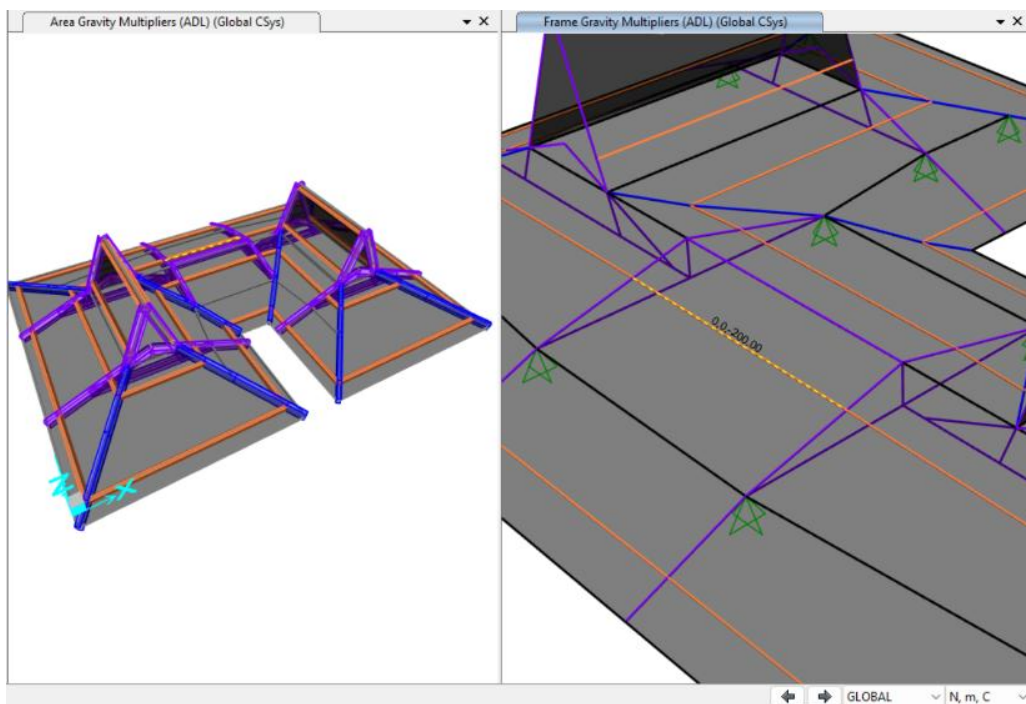


**Figure 3.** Solar Panel Loading

### Live Load

SNI 1727-2020 (Yulistiyantri & Setyobudi, 2025) states that the minimum live load for roofs = 0.96 kN/m<sup>2</sup>

$$= 960 \text{ N/m}^2$$

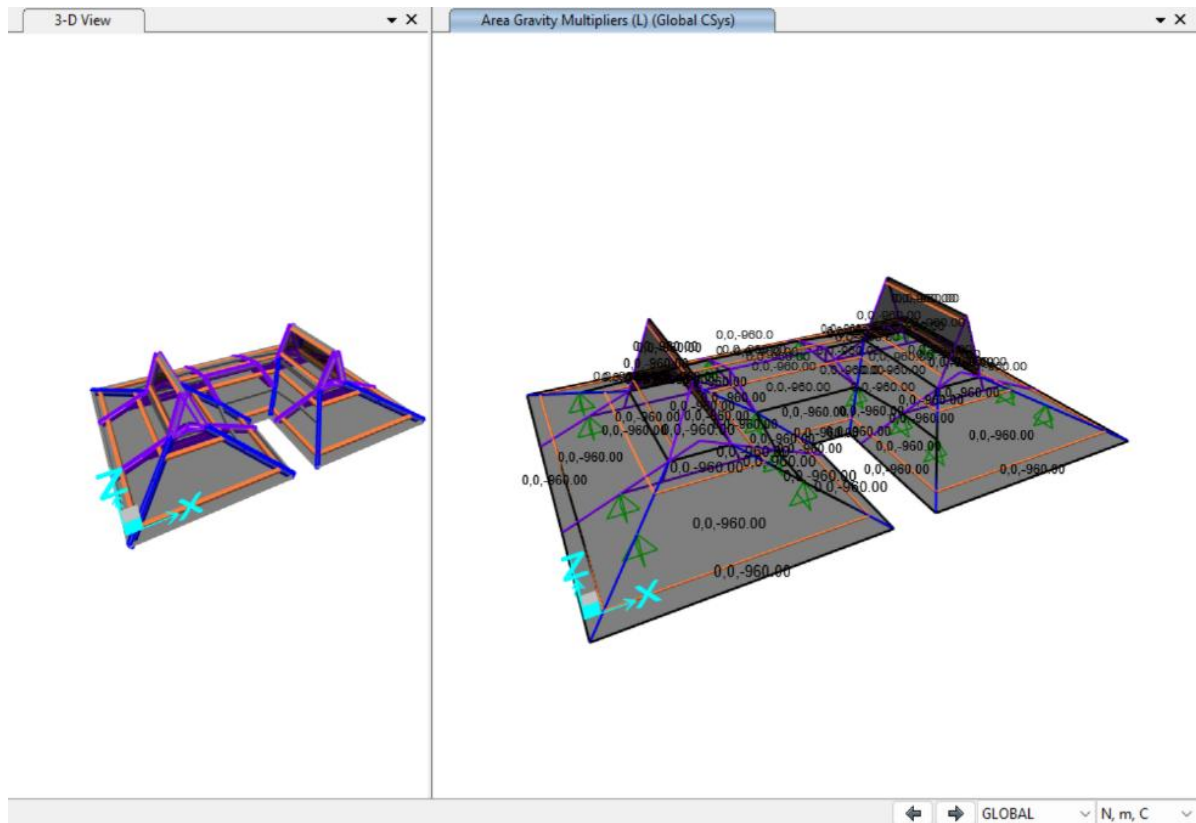


Figure 4. Live Load Bearing

### Wind Load

The following mechanical data is automatically entered into SAP2000 software together with wind loads:

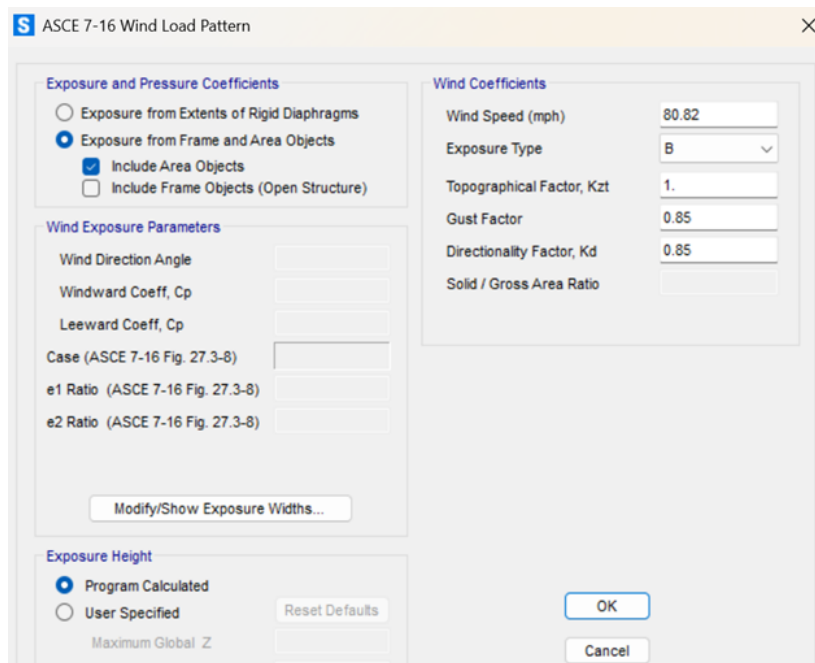


Figure 5. Wind Load Bearing

The following wind suction and wind pressure coefficients are then used in the model:

Wind Pressure Coefficient = 20

$$\alpha = 20 \rightarrow = 0.02 \cdot 20.4 - 0.4 = 0.01$$

$$\alpha = 60 \rightarrow = 0.02 \cdot 60.4 - 0.4 = 0.8$$

$$\alpha = 90 \rightarrow = 0.02 \cdot 90.4 - 0.4 = 1.4$$

Wind suction coefficient = -0.4

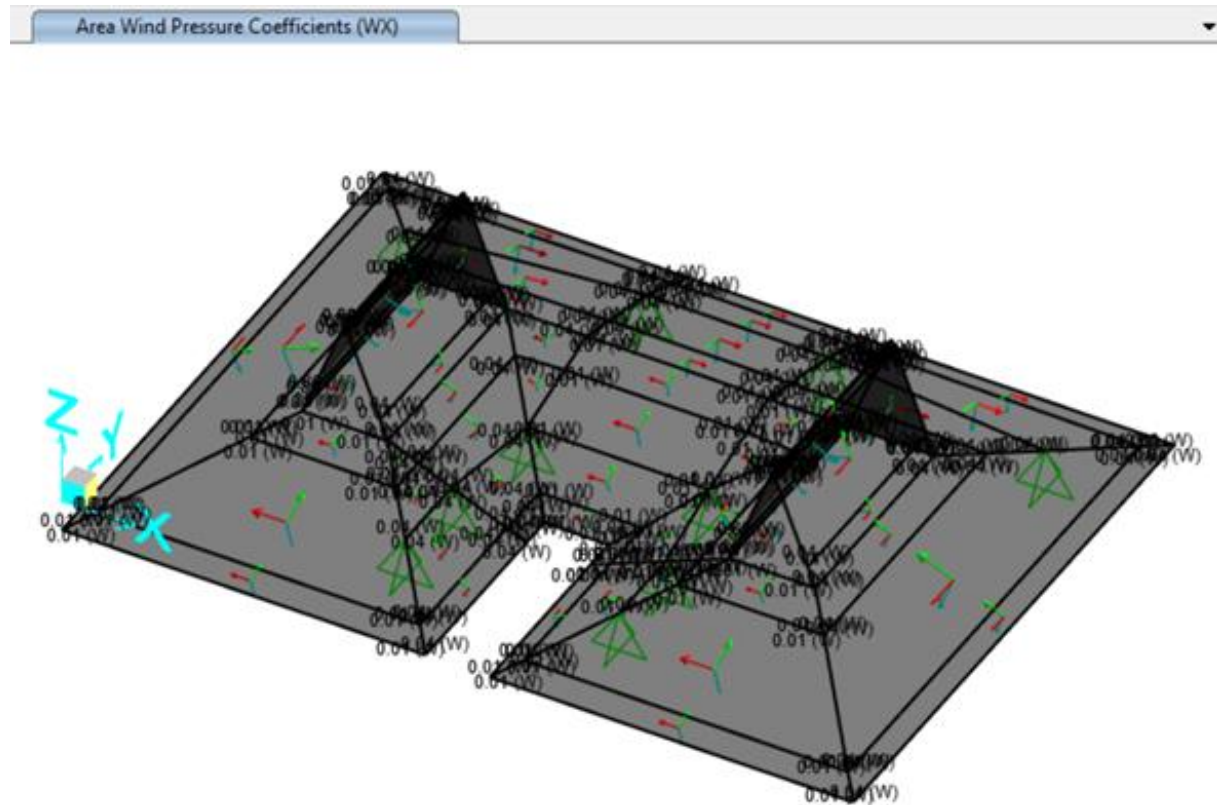


**Figure 6.** Wind load  
Source: Author Analysis Using SAP 2000

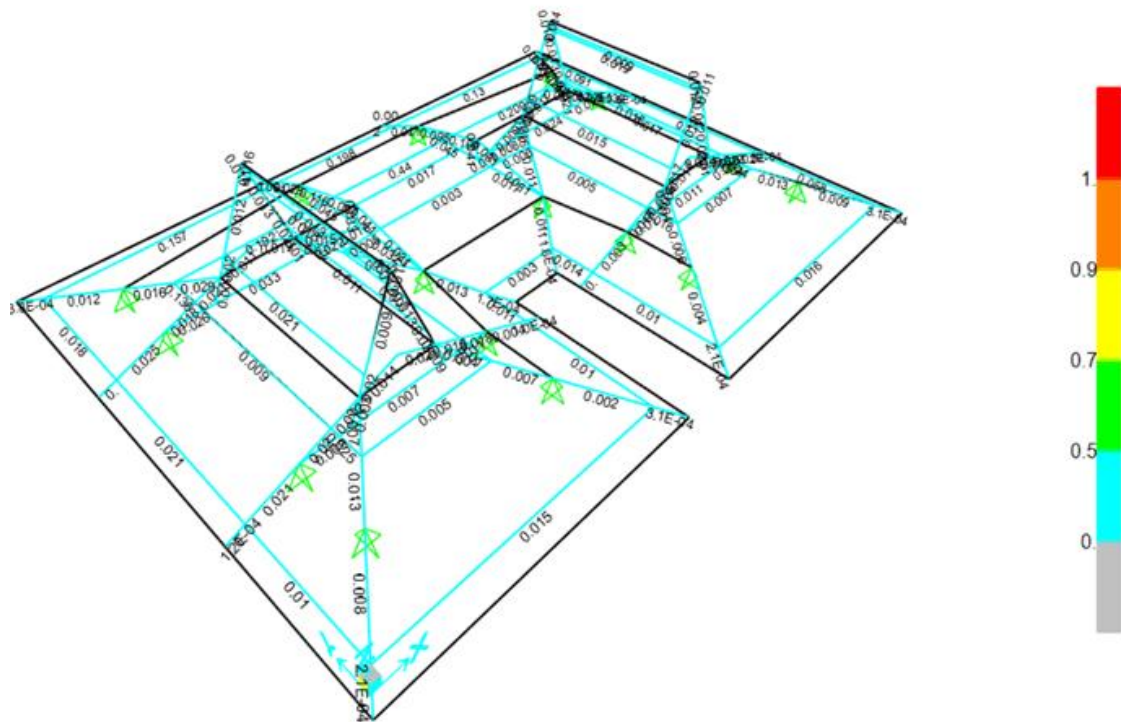
### Load Combination

In this study the author utilizes the following load combinations for calculating roof truss structures (Nawar et al., 2025):

1. Load combination 1  $\rightarrow 1.4D$
2. Load combination 2  $\rightarrow 1.2D+1.6L$
3. Load combination 3  $\rightarrow 1.2D+1.0W+L$

### Structural Analysis Results Using SAP2000

The construction Analysis Program (SAP) 2000 is used in the planning of this truss construction to assess its strength in bearing the load on the steel trusses using the nodal equilibrium approach.



### Figure 7. Strength Ratio

The frame can be deemed safe because, according to the SAP200 analysis results, each beam's strength ratio is still less than 1.

## Material Requirements

For the truss and rafter structures in this study, cold-rolled C-shaped steel constructed from alloy steel plate with a 0.75 mm thickness was utilized. (La Ola et al., 2025) The mechanical data for C75 material are as follows.

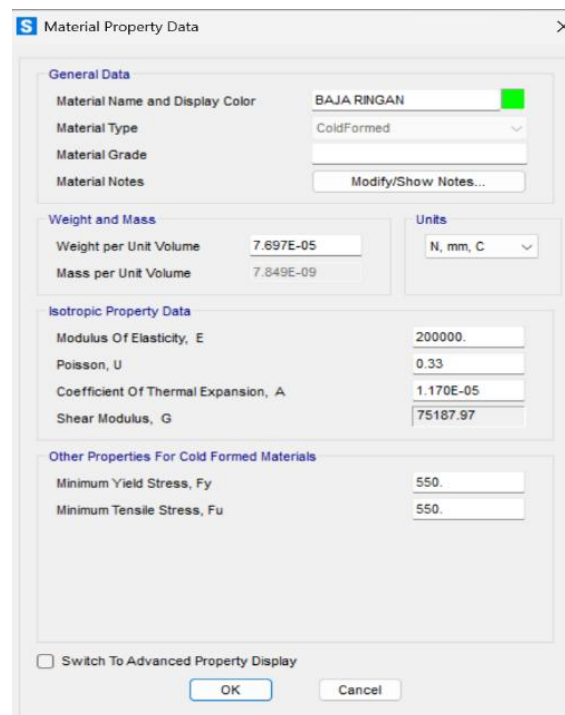


**Figure 8.** The Appearance of the Materials' Quality

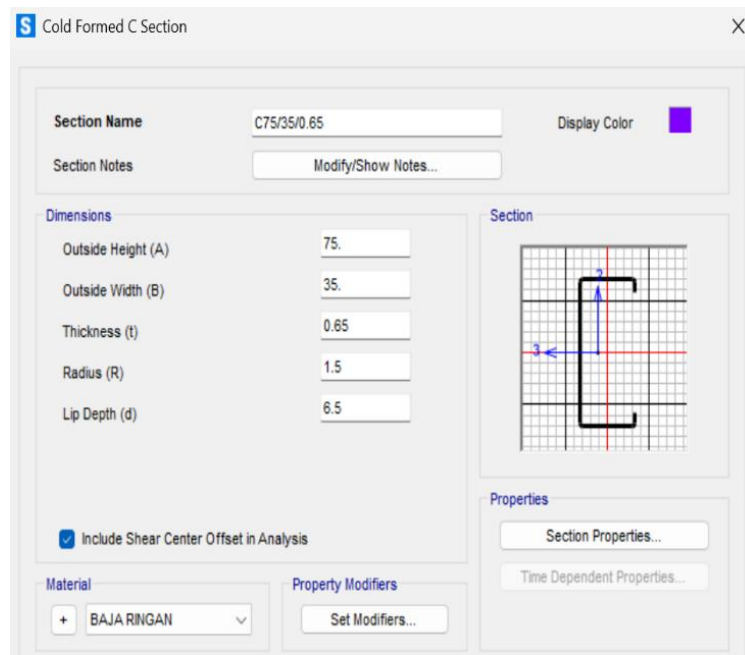


**Figure 9.** Display of the Material Profile's Dimensions

The following table illustrates how the total volume weight of the necessary materials can be computed using the findings of the aforementioned analysis.

**Table 2.** Total Volume of Necessary Materials

| Items                     | Length | Unit  |
|---------------------------|--------|-------|
| Main Truss                | 3,95   | Stem  |
| Reng                      | 5,38   | Stem  |
| L Breaced Bracing         | 0,43   | Stem  |
| Hip                       | 1,47   | Stem  |
| 10 x 16 x 16 C-type Screw | 258    | Pcs   |
| 12 x 14 x 20 C-type Screw | 244    | Pcs   |
| Spandex                   | 8,00   | Sheet |
| Ridge                     | 8,80   | Item  |

## CONCLUSION

The following conclusions can be made in light of the research findings and the previous discussion:

1. By modifying the building's solar system and surrounding vegetation, the lightweight steel roof frame with the name "Gili Iyang Ubhara" embraces eco-friendly concepts, striking a balance between construction and environmental preservation.
2. SAP 2000 V22.0.0 Ultimate structural design calculations for the "Gili Iyang Ubhara" lightweight steel roof frame are safe, and each beam's strength ratio is still below 1.
3. The following are the total materials needed for lightweight steel roofing:
  - a. Main Truss = 3,95 Stems
  - b. Reng = 5,38 Stems
  - c. L Breaced Bracing = 0,43 Stems
  - d. Hip = 1,47 Stems
  - e. 10 x 16 x 16 C-type Screw = 258 Pcs
  - f. 12 x 14 x 20 C-type Screw = 244 Pcs
  - g. Spandex = 8,00 Sheets
  - h. Ridge = 8,80 Items

4. Future studies are encouraged to conduct dynamic thermal–energy performance analyses on lightweight steel eco-roof systems, particularly those integrating solar panels and green-roof components. This approach will allow researchers to quantify long-term behavior under varying climatic conditions, thereby strengthening the empirical basis for large-scale implementation in Indonesia's mass-housing sector

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