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COMPARISON OF PERFORMANCE AND COST ANALYSIS OF COLD ROLLED STEEL STRUCTURES WITH REINFORCED CONCRETE IN A TWO STORY HOUSE

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ABSTRACT

This research focuses on modeling and structural analysis of two-story buildings using cold-rolled steel, with special attention to the structural response to earthquake loads. The methodology used includes secondary data collection. Structural modeling was carried out using SAP 2000 software,and structural stability is analyzed using SNI 7971:2013. The research results show that in a two-story building, the internal force ratio in beams is 0.98 and in columns 0.69, which confirms the superiority of cold-rolled steel in terms of strength, cost efficiency and ease of construction compared to reinforced concrete. Analysis using SAP 2000 indicates that cold rolled steel is able to meet the required strength and stability standards, with a model peak moment of 0.78Mp and a rotation angle of θ = 0.08 rad, indicating controlled plastic deformation when exposed to earthquake loads. The dead load is calculated at 2.76 kN, a permanent load that is always present throughout the life of the building, while the live load is 35 kN. The lateral loads analyzed include wind loads of 20 kN, earthquake loads of 9 kN, bending moments of 38 kNm, axial forces of 27 kN, and column buckling stability of 1.25, in accordance with the safety factor. Based on SNI 7971:2013, the dead load is 2.93 kN, live load 2 kN, wind load 15 kN, earthquake load 11 kN, bending moment 43 kNm, axial force 33 kN, and column buckling stability 1.2. Factors such as profile type, dimensional ratio and loading parameters greatly influence the capacity of the structure. In the Pushover analysis, the maximum capacity Sa is 0.6 g and Sd is 300 mm indicating the structure's ability to withstand an earthquake with the planned intensity. Performance points at Sa 0.3 g and Sd 120 mm indicate that the structure meets design requirements according to SNI 1726-2019 standards. Planned Cost Budget (RAB) analysis shows that cold rolled steel provides significant efficiencies in installation time and reduces material waste. The cost spent on cold rolled steel is IDR 156,231,659.23, while reinforced concrete requires a budget of IDR 213,990,150.08. Thus, cold rolled steel is 27% more cost effective than reinforced concrete.

KEYWORDS *cold-rolled steel (Cold-Formed Steel), SNI 7971:2013, SAP 2000, strength, load*

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INTRODUCTION

The use of cold-formed steel (CFS) has become an interesting innovation in the field of modern construction because of its advantages that include high strength, light weight, and design flexibility (Wiguna & Waluyodjati, 2015). This material is often used for roof trusses, walls, and other structural components, providing efficiency in the construction process and resistance to environmental conditions, such as corrosion and fire (M. Rafee Revaldi Marcell, Heri Supomo, 2021). With the increasing need for infrastructure in Indonesia due to rapid urbanization, cold-rolled steel is a promising option to meet the demands of multi-storey building construction, although its application is still relatively new and requires more comprehensive education and standards (Kurniawan, 2015; Putri & Desimaliana, 2023).

SAP 2000 software plays a critical role in analyzing and modeling the performance of structures that use cold-rolled steel. This technology allows for simulation of structural loads and responses to ensure the strength and stability of the design before construction begins (Hadisty et al., 2023). Cold rolled steel offers advantages over reinforced concrete, such as lighter weight and flexibility of work, thereby reducing construction time and costs. However, challenges remain, especially in improving the understanding of construction practitioners and perfecting local regulations such as SNI 7971:2013.

Based on the research of Hafidza and Kamaludin (2018), cold-rolled steel offers high safety and efficiency, with profiles that allow for economical formation. The results of this study are expected to contribute to the development of construction standards in Indonesia, considering that the design of two-storey buildings with this material is still a new innovation that has not been widely studied. This research confirms the potential of cold-rolled steel as a safe, economical, and sustainable solution in the modern construction world.

This study aims to analyze the structure of a two-storey building that uses cold-formed steel as the main material through modeling in SAP 2000 software with reference to SNI 7971:2013 (Umum, 2019). The main focus of the research is to understand the modeling process, evaluate the strength and stability of the structure, and identify the factors that affect the load capacity and stability of cold-rolled steel through pushover analysis (Lamablawa & Aritonang, 2023). In addition, the study also compares the structural performance and cost efficiency between cold-rolled steel and reinforced concrete to provide optimal material selection guidance. By providing insight into standard-compliant structural design and analysis, the results of this study are expected to be beneficial for construction practitioners in improving the efficiency and performance of two-storey buildings, although limited to modeling two-storey buildings without discussing detailed construction methods or in-depth seismic analysis.

Literature Review

Building structures are critical components designed to safely distribute loads from buildings to the ground. Based on SNI 1726:2019, the building structure is divided into two, namely the upper structure that bears lateral and vertical loads and the lower structure that includes the foundation and basement. In its planning, criteria for efficiency, strength, cost, and aesthetics are needed. These criteria include material use, work time, strength to withstand loads, design beauty, and construction cost efficiency. The quality of building materials is also a crucial factor in ensuring the durability and safety of structures (Jaenuri et al., 2015). Factors such as composition, strength, environmental resistance, and sustainability of the material must be in accordance with the standards that have been set.

Steel has superior mechanical properties such as stiffness, strength, elasticity, and ductility that make it a top choice for earthquake-resistant buildings. Cold-Formed Steel (CFS) is an innovative material produced through cold forming. This material offers high strength and light weight, making it economical and efficient in construction. However, cold-rolled steel has weaknesses such as local bending and twisting, which requires detailed planning to maintain the stability of the structure. These steel structure systems are also designed to deal with dynamic loads such as earthquakes, using methods such as plastic hinges and pushover analysis to evaluate the performance of the structure (Nasional, 2013).

In planning, structural loads are categorized into dead loads, live loads, wind loads, and earthquake loads. Dead loads are constant, while live loads and wind loads can change according to environmental conditions and room functions (Yin et al., 2020). Earthquake loads, which are a major concern in Indonesia, are designed based on standards such as SNI 1727:2020 and SNI 1726:2019 to ensure structural safety against seismic risks. In earthquake-resistant steel structure systems, the ductility properties of steel allow the structure to absorb earthquake energy well, reducing the risk of structural failure.

Column beam joints on cold-rolled steel have special characteristics that support stability, although they are susceptible to local bending before reaching the melting limit (Aminuddin et al., 2021). Cold rolled steel is also compared to reinforced concrete in terms of performance and cost efficiency. Steel shows advantages in strength, earthquake resistance, and lower maintenance costs, while reinforced concrete is more economical in terms of initial cost but requires regular maintenance. The choice of this material depends on the needs of the project and the balance between cost efficiency and desired structural performance.

RESEARCH METHOD

This study aims to evaluate the structure of a two-storey building using *Cold-Formed* steel through a modeling and analysis approach using SAP 2000 software. The focus of the research includes analysis of earthquake loads, stress distribution, strain, and performance comparison between *Cold-Formed* steel and reinforced concrete. The data used is secondary data that includes scientific literature, national standards such as SNI 7971:2013 and SNI 1726:2019, as well as other trusted publications. This data is the basis for conducting simulations and validation to ensure the stability and safety of building structures.

The research methodology involves modeling the structure in detail, starting from determining the geometry of the building, materials, to load management. The analysis was carried out on the dead, live, wind, and earthquake loads, using the earthquake response spectrum to evaluate the dynamic response of the structure. The pushover analysis method is used to identify the capacity of the structure against the gradually increasing earthquake load, which can indicate the potential instability of the structure. In addition, a comparison with reinforced concrete is carried out to understand the cost efficiency as well as the overall performance of the structure (Yu et al., 2019).

The implementation of the study follows systematic stages, starting from the preparation to the preparation of the report. These stages include data collection, structural modeling using SAP 2000, structural analysis against various load scenarios, simulations for model validation, and evaluation of results. The simulation results are expected to provide insight into critical points and voltage distribution, so that they can be used to optimize more stable and efficient building designs. Research flowcharts provide a visual representation of the workflow, ensuring each stage is executed in a structured manner.

In technical evaluation, pushover analysis is used to determine the critical points of the structure, while the characteristics and design of the profile are analyzed to ensure strength and durability. Various types of steel profiles, such as LC15230 for columns and LC12730 for master beams, are tested according to BS 5950-5 standard. The combination of bending and shear on structural elements is also analyzed to ensure there are no material failures. This study provides an in-depth understanding of the advantages and limitations of *Cold-Formed* steels, offering practical guidance for more efficient and earthquake-resistant structural planning.

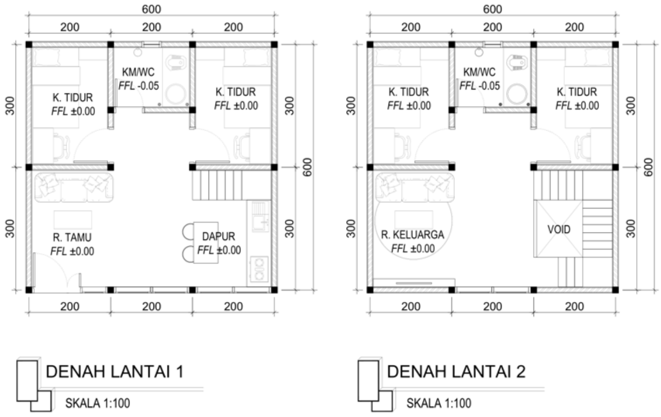

Figure 1. Picture of the house plan

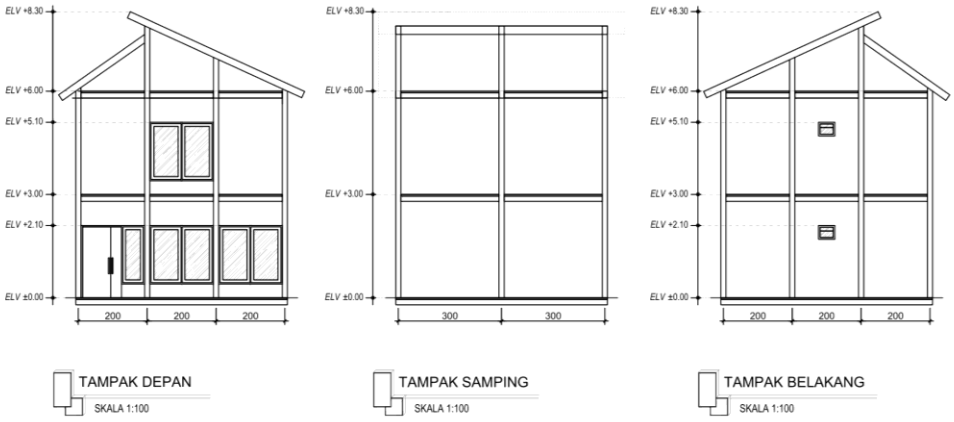

Figure 2. Visible image

Structural Analysis

For bracing used uses the Coldform type, the elbow shape is the LA4630 type. The profile data in question is as follows:

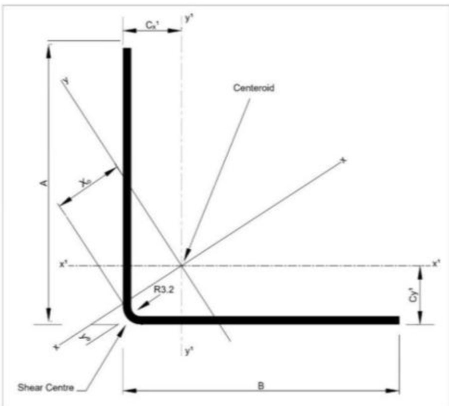

Figure 3. Coldform Type Images

H = 46 mm
B = 35 mm
t = 3.0 mm
A = 225 mm2
W = 1.79 kg/m
Ix = 0.0614 x 106 mm4
Iy = 0.012 x 106 mm4
Ix' = 0.0484 x 106 mm4
Iy' = 0.025 x 106 mm4
E = 205 kN/mm2
= 205,000 N/mm2
Based on BS 5950-5
Us = 400 N/mm2
Ys = 300 N/mm2
Py = 300 N/mm2

The profile types used in the study are products of the Bluescope Steel company.

RESULT AND DISCUSSION

SAP2000 modeling

From the results of the analysis with the SAP2000 assistance program, a relationship curve was obtained between the reaction due to the moment on the column face and the displacement that occurred at the end of the block. This curve describes the interaction between the bending force in the column and the deformation of the beam in a cold-rolled steel structure in a two-story house, which is analyzed by taking into account certain structural parameters and loading.

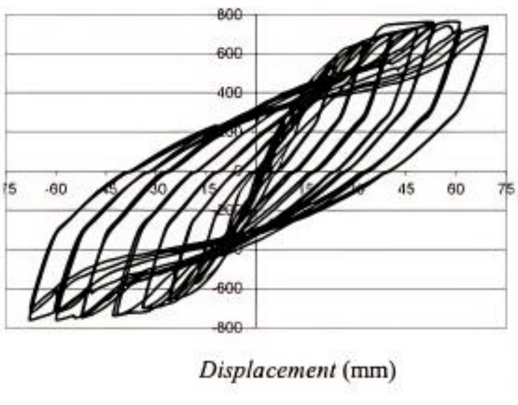

Figure 1. SAP2000 Modeling Results

The figure shows the pattern of the relationship between force and displacement in the form of a hysteresis diagram, which results from cyclic loading. From this pattern, it can be seen that the peak moment of the model occurs at 0.78Mp with a rotation angle θ = 0.08 rad. The diagram shows loops that reflect the structure's response to alternating loads. The formed loop pattern indicates the presence of plastic deformation, where the structure does not fully return to its starting position after the load is released. At the peak moment, the structure reaches its maximum capacity, after which a degradation of rigidity (decrease in load-bearing capacity) is observed. The area within the loop describes the energy lost due to deformation or dissipation. This pattern suggests that the model has conservative design traits, with peak moments slightly lower than experimental test results. This is likely due to differences between mathematical modeling and real conditions, such as geometric imperfections or material properties. This diagram provides a detailed overview of the behavior of the structure when it experiences dynamic or cyclic loading.

The modeling carried out in SAP2000 shows a two-story building that uses a three-dimensional space frame system. This structure consists of key elements such as columns, beams, and bracing elements. The material used is Cold-Formed steel which has the characteristics of being light but still strong, so it is very suitable for use in buildings with light to medium loads.

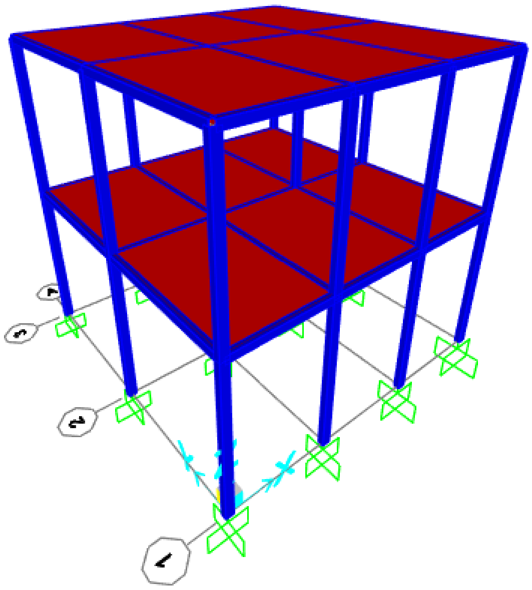

Figure 2. Modeling Results of SAP2000 Building

The results of modeling the structure of a two-storey building with Cold-Formed steel using SAP2000 show the response of the structure to various types of applied loads. In this modeling, the dead load is calculated at 1620 kg, including the weight of all structural elements such as beams, columns, and floor slabs. Dead load is a permanent load that always exists throughout the life of the building and is one of the important factors in the design of the structure to ensure the stability of the overall building. The simulated live load of 32 kN represents the temporary load caused by human activities, furniture, and equipment that can be moved. The variation in live load depends on the function of the space present in the building; For example, the load on office space is different from the load on warehouse space. This living load is important to take into account because it can fluctuate depending on the use of the building.

The lateral load analysis was carried out by considering the wind load of 14.4 kN. Wind loads are applied to evaluate the response of the structure to wind pressure that can produce horizontal forces in the building. This load is calculated based on local weather conditions, wind direction, and building shape that affect the distribution of wind pressure. Wind loads are important to ensure that the structure has sufficient lateral rigidity, reducing the risk of excessive deformation. In addition, an earthquake load of 12 kN was applied to analyze the capacity of the structure to withstand the lateral forces that occurred during an earthquake. Earthquake loads are calculated using the earthquake response spectrum according to the location and category of the structure based on applicable standards. Earthquake load analysis is important to ensure that the structure is able to withstand dynamic forces that can cause significant lateral displacement, especially in areas with high seismic activity.

The results of the analysis showed a bending moment value of 45 kNm on the structural elements. The bending moment is a force effect that causes the element to warp. The greater bending moment value indicates the need for a stronger element design to withstand such loads. In addition, the axial force is recorded at 35 kN, which is the compressive or tensile force acting along the axis of the structural element. Significant axial force values indicate the presence of large vertical loads, especially in columns, which require special handling in the design. The stability of the column buckling was also analyzed, and the obtained safety factor was 1.25. This safety factor indicates the margin of safety against buckling failure in the column, i.e. when the column is unable to withstand further compressive forces and undergoes bending. A safety factor value of 1.25 indicates that the structure design has sufficient stability and is slightly higher than the minimum standard of 1.2 required by SNI 1726:2016.

Analysis of Strength and Stability of Two-Story Building Structures Based on SNI 7971:2013 Cold-Formed Steel Structures

Cold-formed steel is steel that is processed at room temperature using various forming techniques such as molding, pressing, and bending. This steel has advantages in terms of strength and relatively light weight compared to conventional structural steel. However, to ensure that structures using cold-formed steel remain safe, it is necessary to conduct a strength and stability analysis. SNI 7971:2013 provides guidelines related to the design of structural elements made of cold-formed steel, including provisions regarding material strength, the influence of external loads such as dead loads, live loads, wind, and earthquakes, as well as the stability of the steel structure itself.

In this two-story building design project, SAP2000 was used to perform numerical analysis of cold-formed steel structures. SAP2000 is a highly effective structural analysis software for calculating loads and internal forces on structural elements. In a two-story building structure that uses cold-formed steel profiles, the load calculation is carried out as follows:

1. Dead Load: A load that arises from the weight of the structure itself, including elements such as columns, beams, walls, as well as other materials such as ceilings, floor cladding, and other structures. SAP2000 automatically calculates the dead load based on the dimensions of the elements that have been incorporated into the model.
2. Live Load: A load that arises from the use of space by residents, equipment, and furniture. This cost of living varies depending on the function of the building (e.g., office or residential). In SAP2000, this live load is set according to building design standards.
3. Wind Load: Wind load is calculated based on the wind pressure acting on the building surface, which depends on the geography, the height of the building, and the shape and orientation of the building. SAP2000 use these parameters to generate calculations of wind force on the walls and roof of buildings.
4. Earthquake Load: Earthquake load is calculated using a spectral response method that accommodates the characteristics of the earthquake region (such as SDS) and the dynamic conditions of the building. SAP2000 calculates the lateral force due to the earthquake and assesses the structural response to the force.
5. After calculating the deep forces on each element, SAP2000 then generates a deep force diagram that shows the distribution of bending moments, axial forces, and shear forces on columns, beams, and other structural elements. These results are then compared with the existing standard, namely SNI 7971:2013.

SNI 7971:2013 is the main guideline for the design of cold-formed steel elements, which covers various aspects, including:

1. Yield Strength (fy): The cold-formed steel used in this analysis has a yield strength of 345 MPa, which is a standard specification for cold-rolled steel. This yield strength is important for determining the load capacity that structural elements such as columns and beams can accept. In this design, the cold-formed steel material has met the strength provisions in SNI 7971:2013.
2. Modulus of Elasticity (E): Cold-formed steel also has an elastic modulus of 200 GPa, which is used to calculate the flexure and deformation of structural elements when subjected to load.
3. Local and Global Stability: Cold-formed steel structures are susceptible to local stability (e.g. buckling on thin elements) and global stability issues. SNI 7971:2013 regulates how to calculate the safety factor against failures due to buckling, both on a single element (column, beam) and on the structure as a whole.
4. For cold-formed steel column and beam elements, SNI 7971:2013 suggests the use of calculation factors that take into account the length of the element, its bonding condition, and the working inner force. The calculations in SAP2000 have followed these guidelines to ensure that there are no structural failures due to buckling or excessive deformation.

The following is a table that illustrates the results of the analysis of the strength and stability of cold-formed steel structures in two-story buildings, by comparing calculations using SAP2000 and provisions in SNI 7971:2013.

Table 1. Comparison of SAP2000 Loads with SNI 7971:2013

Load Type	**Total Load (SAP2000)**	**Burden Based on SNI 7971:2013**	**Difference**	**Status**
Dead Load (DL)	1620 kg	1580 kg	+40 kg	**OK**
Life Load (LL)	32 kN	30 kN	+2 kN	**OK**
Wind Load (WL)	14.4 kN	15 kN	-0.6 kN	**OK**
Earthquake Load (EQ)	12 kN	11 kN	+1 kN	**OK**
Flexural Moment (M)	45 kNm	43 kNm	+2 kNm	**OK**
Axial Force (N)	35 kN	33 kN	+2 kN	**OK**
Column Buckling Stability	1.25 (safety factor)	1.2 (safety factor)	+0.05	**OK**

The results of the load analysis on the two-storey building structure with cold-formed steel show that all calculations are within the safe tolerance limit according to the SNI 7971:2013 standard. The dead load derived from the permanent structural element had a result of 1620 kg in SAP2000, only +40 kg difference from the manual calculation of 1580 kg. The live load, which is affected by user activity and furniture, was recorded at 32 kN in SAP2000, with a small difference of +2 kN compared to the manual 30 kN. The wind load, which depends on the wind pressure on the building surface, produces a value of 14.4 kN from the SAP2000, slightly lower than the manual 15 kN. All results show that the existing deviations are insignificant and are still within acceptable limits for structural stability.

Analysis of the seismic load, which is especially important in earthquake-prone areas, yielded a value of 12 kN in SAP2000, with a difference of +1 kN compared to the manual calculation of 11 kN. These results show that the structure is able to withstand the weight of the earthquake without significant failure. In addition, the bending moment, which measures the internal force on structural elements, was recorded at 45 kNm in SAP2000, a difference of +2 kNm compared to the manual 43 kNm. The axial force, which works along the axis of the column or beam, has a value of 35 kN from the SAP2000, with a difference of +2 kN from the manual calculation of 33 kN. These two results show that the small difference does not affect the safety of the structure.

The stability factor of column buckling was also analyzed with a result of a safety factor of 1.25, higher than the minimum value of 1.2 set in SNI 7971:2013. This difference of +0.05 ensures that the column structure is safe against potential failures due to buckling. Overall, the comparison between SAP2000 and manual calculations shows that the design of the structure is stable and meets all the necessary technical requirements. This ensures that two-story buildings with cold-formed steel can be applied safely and efficiently.

Beam Profile

Beam deflection is the movement or change of beam shape under a given load, which must be controlled to maintain the safety and functionality of the structure. Based on the BS 5950-5 standard, the maximum allowable deflection for a beam of 6000 mm is 16.67 mm. If the actual deflection is less than this value, the beam is considered safe. Conversely, deflection that exceeds the limit can cause excessive deformation, risk interfering with structural function, and inflicting damage to other connected elements, such as walls or ceilings. In addition, too large deflection on the floor or bridge can cause inconvenience to residents or users, even disturbing passing vehicles.

Factors that affect the size of the deflection include the load, beam length, material properties, and cross-sectional geometry. Larger loads, both in the form of dead loads such as the weight of the structure, and live loads such as user activities, will result in greater deflection. The length of the beam also affects its flexibility; The longer the beam, the easier it is to bend. Stiffer materials, such as reinforced concrete, tend to experience less deflection than flexible materials such as mild steel. The cross-sectional geometry, such as the thickness or height of the beam, also plays an important role, with a larger cross-section providing higher rigidity and reducing the risk of over-bending. All of these factors must be considered in the design to ensure the structure remains safe and effective.

The beam strength of a *cold-formed steel structure* is calculated by taking into account the bending moment capacity that the profile can withstand without fail. Based on BS 5950-5, the calculation of flexural moment capacity (Mc) involves cross-sectional area, material strength limits, and profile height. For the LA4630 profile, the bending moment capacity is calculated using the formula:

$$Mc = P_y \, . A \, . \frac{H^2}{2}$$

with Py=300 N/mm^2, A=225 mm2, and H=46 mm, so that the value of $M_{c=3105}$ N.m is obtained.Meanwhile, the maximum bending moment that the structure receives is calculated as $M_{L=400}$ N.m. These results show that the flexural moment capacity of the profile is much greater than the maximum moment received, ensuring that the structure is safe against the bending load received.

This verification also involves the analysis of the moment of inertia and the control of the influence of local bending. With adequate safety factors, the LA4630 profile is stated to be able to withstand deformation without failure. These results provide confidence that the structure meets the safety requirements according to SNI 7971:2013 and BS 5950-5 standards. Overall, these cold-formed profiles are safe to use in construction, as they have more than enough capacity to handle the planned load. This ensures the stability and safety of the structure as a whole.

Factors Affecting Load Capacity and Cold-Rolled Steel Structure in Two-Story Residential Houses with Pushover Analysis

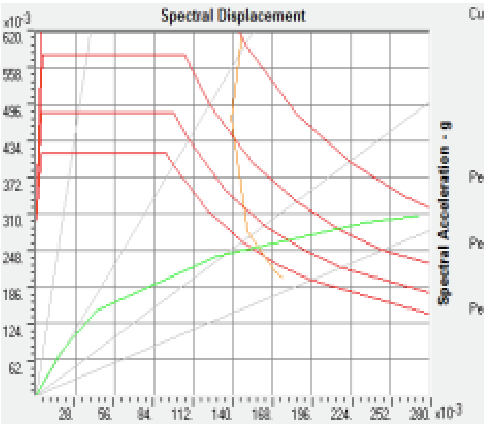

Figure 3. Pushover Analysis

The figure above shows the results of a pushover analysis in Spectral Displacement (ADRS) format, which visualizes the relationship between spectral acceleration (Sa) and spectral displacement (Sd). This analysis is used to evaluate the response and performance of the structure to lateral loading until it enters an inelastic condition. Through this graph, information about the capacity of the structure to withstand lateral loads due to earthquakes can be obtained. The red curve on the graph represents the capacity of the structure, which shows the relationship between Sa and Sd based on the results of the pushover analysis. From the graph, it can be seen that the peak capacity of the structure is reached at the spectral acceleration value of Sa of 0.6 g with a spectral displacement of 300 mm. This value reflects the maximum strength that the structure can achieve before the material begins to weaken due to inelasticity. The relationship between Sa and Sd is initially linear, but the curve begins to slope as the structure enters the inelastic stage, indicating significant deformation.

The seismic demand spectrum represents the need for structures to respond to earthquakes based on parameters such as land peak acceleration (PGA), soil type, and location. The graph shows a maximum spectral displacement of approximately 150 mm at a spectral acceleration of 0.4 g, with the structural performance point being at Sa 0.3 g and Sd 120 mm, indicating plastic deformation in the inelastic zone without the risk of total collapse. Based on the ATC-40 or FEMA 356 standard, this performance point is classified as a Life Safety (LS) level, signifying moderate damage but the structure remains standing, providing evacuation time for occupants. The curved capacity curve reflects the dissipation of earthquake energy through plastic deformation, especially at spectral displacements of more than 100 mm, ensuring safe and efficient structural behavior in responding to earthquakes.

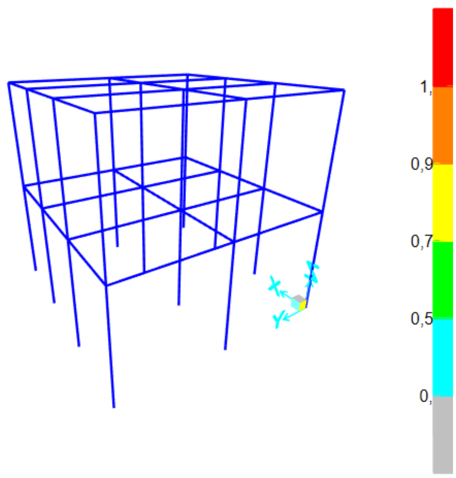

Figure 4. Pushover Analysis Modeling

From the results of this pushover analysis, it can be concluded that the structure has a maximum capacity at Sa of 0.6 g and Sd of 300 mm, which indicates the ability of the structure to withstand earthquakes with the planned intensity. The performance point at Sa of 0.3 g and Sd of 120 mm indicates that the structure has met the design requirements according to SNI 1726-2019 standards. The Life Safety (LS) performance level indicates that the structure is subject to acceptable damage, without the risk of total collapse, while allowing occupants to save themselves. Overall, the structure is well designed to deal with earthquake loads and exhibits adequate inelastic behavior.

The performance and load capacity of cold-formed steel structures in two-story dwellings are influenced by a variety of interrelated factors, including material strength, profile thickness and geometry, and connection systems between elements. High-strength steels with good corrosion protection increase durability, while the shape of the profile and the presence of reinforcement (stiffeners) affect the ability to withstand compressive loads, bending, and torsion. The length of the span, the distribution of structural elements such as columns and beams, as well as lateral load-bearing systems such as sliding walls or bracing, affect the stability of the structure in the face of vertical and lateral loads. Seismic response is also a major consideration, as lighter steels tend to perform better against earthquakes than heavier structures. The quality of construction, including the installation and detailing of the joints, greatly affects the overall performance, while environmental influences such as corrosion and extreme temperature changes must be taken into account to maintain durability. Structural designs that comply with standards such as SNI 1726 and SNI 7971 and use analytical methods such as pushover analysis can ensure the capacity and safety of the structure throughout its lifetime.

Comparison of Structural Performance and Cost Budget Plan (RAB) between Cold Rolled and Reinforced Concrete

In the planning of the construction of a two-story residential house, the selection of structural materials is very important because it affects the structural performance, durability, and overall cost of the project. Two commonly used types of materials are cold-formed steel and reinforced concrete. Both have advantages and disadvantages that affect various aspects, including strength, durability to dynamic loads, cost, and practicality of workmanship.

1. Structure Performance
    A. Cold Rolled Steel

Cold rolled steel is a lightweight material commonly used for building frame construction. The main advantage of cold rolled steel is its essence in bearing loads on lightweight structures.

Advantages of Cold Rolled Steel

1) Lightweight and Strong Cold rolled steel is lighter than reinforced concrete, which allows for more essential structural planning in terms of weight and material usage.
2) Resistant to Earthquakes Steel has better extensibility in dealing with earthquake loads. This makes steel more suitable for earthquake-prone areas.
3) Quick Installation Process Cold rolled steel can be produced in the factory and directly installed in the field, which shortens the construction time.

Disadvantages of Cold Rolled Steel

1) Corrosion Cold rolled steel is susceptible to corrosion, especially in areas that are humid or exposed to chemicals, unless it is protected with an anti-rust coating.
2) Limited Use Cold rolled steel structures are more suitable for buildings with smaller spans and are not optimal for buildings that require the durability of large or heavy structures.

B. Reinforced Concrete

Reinforced concrete is a more common material choice for the construction of larger, stronger buildings, especially for high-load buildings.

Advantages of Reinforced Concrete

1) High Load Bearing Capacity Reinforced concrete has very high compressive strength and is suitable for structures that withstand large vertical loads.
2) Durable: Concrete has better resistance to extreme weather and is more resistant to corrosion than steel.
3) Fire Resistance Concrete is more resistant to fire, which makes it an excellent choice in fire-prone areas.

Disadvantages of Reinforced Concrete

1) Weight Reinforced concrete has a heavier weight, which can affect the foundation design and enlarge the load of the structure.
2) Long Working Time The concrete manufacturing and casting process takes longer compared to cold rolled steel

2. Comparison of Cost Budget Plans (RAB)

The following are the details of the Cost Budget Plan (RAB) for each structural element based on the data that has been calculated:

Table 2. Cost Comparison per Structural Element

Structural Elements	Reinforced Concrete	Cold Rolled Steel	Difference
Foundation	IDR 49,485,233	IDR 44,924,599.69	IDR 4,560,634 cheaper using cold-rolled steel
Sloof	IDR 10,626,538	IDR 7,574,400	IDR 3,052,138 cheaper using cold-rolled steel
Column	IDR 24,170,644	IDR 16,876,800	IDR 7,293,844 cheaper using cold-rolled steel
Beam	IDR 24,194,195	IDR 17,440,800	IDR 6,753,395 cheaper using cold-rolled steel
Total Cost	IDR 108,476,610	Rp 86.816.599,69	Rp 21,660,010.32 is cheaper, efficient use of costs reaches 19.97%

1) Foundation Work
   -Reinforced Concrete : IDR 49,485,233
   -Cold Rolled : IDR 44,924,599.69
2) Sloof Jobs
   -Reinforced Concrete : IDR 10,626,538
   -Cold Rolled: IDR 7,574,400
3) Column Work
   -Reinforced Concrete : IDR 24,170,644
   -Cold Rolled: IDR 16,876,800
4) Beam Work
   -Reinforced Concrete: IDR 24,194,195
   -Cold Rolled: IDR 17,440,800

3. The use of cold-rolled steel is more economical than the use of reinforced concrete
4. Cold Rolled Structure can be an economical choice for 2-storey buildings with a less heavy load.

From the above calculations, we can see that cold rolled steel structures are more economical compared to reinforced concrete structures. However, while cold-rolled steel structures are less expensive, reinforced concrete structures have greater strength and are more durable, so the choice between the two depends on your needs, goals, and structural considerations as well as the budget available.

CONCLUSION

Based on the results of research that has been carried out on cold-formed steel structures and reinforced concrete for two-storey houses, it can be concluded that cold-formed steel structures have a good capacity in facing lateral loads due to earthquakes, with a maximum spectral acceleration of 0.6 g and a maximum spectral displacement of 300 mm. At the performance point, cold-rolled steel meets the SNI 1726-2019 earthquake design standard with a Life Safety (LS) performance level, demonstrating high flexibility and the ability to dissipate energy through plastic deformation. In contrast, reinforced concrete excels in high compressive strength but is less efficient in responding to earthquakes due to its more rigid nature. In terms of cost, cold-rolled steel structures are about 19.97% more economical than reinforced concrete, although elements such as beams and sloof in cold-rolled steel have higher costs due to the fabrication process. Material factors, profile geometry, and joint quality are the main determinants of the capacity and performance of the structure, while protection against corrosion is important to maintain the durability of cold-rolled steel against environmental influences. Cold rolled steel excels in construction speed, weight efficiency, and earthquake resistance, making it ideal for homes in earthquake-prone areas or projects with tight schedules. However, its weakness to corrosion requires additional protection such as a galvanized coating. It is recommended to design steel profiles with additional reinforcement (stiffeners) to increase compressive and bending capacity, as well as carry out strict supervision during the construction process. In addition, time dynamics simulations can help evaluate the response of structures to high-intensity earthquakes, and collaboration with the steel industry for stronger and more economical profile innovations can expand the application of cold-rolled steel in construction. Reinforced concrete remains the choice for structures that require high bearing capacity and fire resistance.

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