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RESEARCH ARTICLE

Computing steel frame analysis of behavior semi-rigid connection

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Abstract

Semi-rigid connections are very economical compared to other connections because they can prevent the frame from breaking immediately due to brittleness without endangering the entire structure. Steel frame construction is one of the types of construction described in the building codes for simple seismic buildings. The research on the use of this semi-rigid connection uses one of the computer software that uses the finite element method, namely ANSYS ED.9, by taking validation models from experimental and manual calculation analysis and using 35 research models with different loads, positions and number of bolts and types of portal bracing. The ability to survive on the gantry due to side loads is dominated by the number and position of the bolts and the type of gantry stiffener used, this is evident from the different models, with the rise ratio in each model ranging from 0.7852 to 2.5900 and in ranges of softening compared to clamped stiffeners, which experience a decrease in stress, with the same ratio.

Keyword: ANSYS, Bolt, Drift, Steel, Semi-rigid

Introduction

Steel is a construction material with important properties, namely homogeneous, elastic, isotropic and highly ductile. Steel frame construction is one of the types outlined in simple seismic building codes, and using this type of construction has several advantages, such as practicality and speed of construction, as well as controlled quality of materials.

In general, when planning a steel construction, the main concern is the connection problem, both in the form of a portal and in the form of a frame. The connection must not experience permanent deformation and material fatigue must not occur, so more attention must be paid to the connection details so that the stress transmission occurring either in the structure or in the connection should not exceed the allowable stress. There are several types of connections that are commonly used, namely simple flexible connections, rigid connections and semi-rigid connections(Hoehler et al., 2017).

Investigations into the use of semi-rigid steel connections designed to be ductile to withstand lateral loads in earthquake events, these connections are designed as a connection between fasteners with high ductility capacity, so during an earthquake the connections can have very satisfactory ductility behavior and the connections are semi-rigid. It is very economical compared to other connections because it can prevent the frame from breaking immediately because it is brittle, without endangering the entire structure(Jacobsen, 2017).

In the case of constructions with joints, this results in a sufficiently large cross-section. The design with a clamp connection leads to very complicated connection details in order to provide a fairly rigid moment capacity. In the case of supports with a semi-rigid connection structure, an anti-rotation device is advantageous in order to save on the use of steel cross-sections(Gambhir, 2013).

The behavior of steel frames with semi-rigid connections under lateral loads and simulated seismic loads is discussed in this study, in which very few studies or tests have been conducted to investigate the behavior of steel structures. The performance of the lateral support frame system on the steel frame and knowledge of the capacity of the structural frame system. The load ratio to the occurring deformation (drift), the stress-strain ratio, von Mises counter, stress combination, softening of the portal frame and ductility are analyzed as parameters.

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Methods

A. Modeling Finite Element Method (Fem)

Portal with double-channel steel profile monotonically loaded in this study with a semi-rigid connection. Then the model is analyzed with the finite element method using ANSYS Ed.9.0 software. Model analysis was performed to identify and predict anomalies and visually observe crack patterns(Taufik et al., 2009).

The steel model uses Bricknode8 material SOLID45, SHELL143 and COMBINE39 is used for the connection. The first step is to model the double channel steel profile with the input data according to the results of previous experimental tests. Calculations are carried out before modeling in ANSYS Geometry made of double C profile steel 125 × 50 × 20 × 2.3 mm.

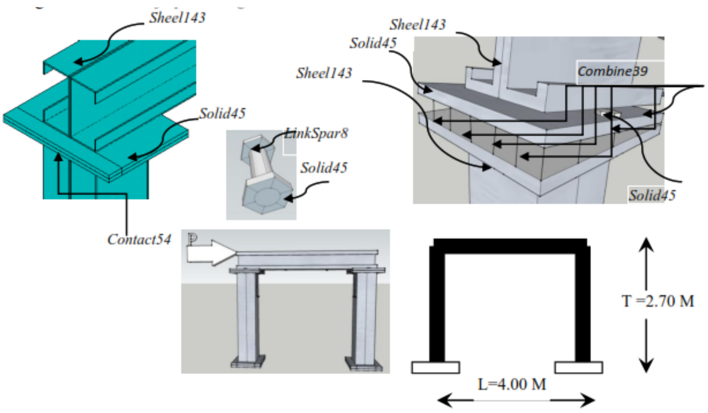

Figure 1. Test object model

The critical lateral load and the critical horizontal deflection were analyzed based on the yield stress value. The calculation of the FEM results of the critical lateral load and the critical horizontal deflection can be seen in Appendix D. The results of the FEM calculation of the critical side load and the critical horizontal deflection are shown in Figure 2, and Figure 3.

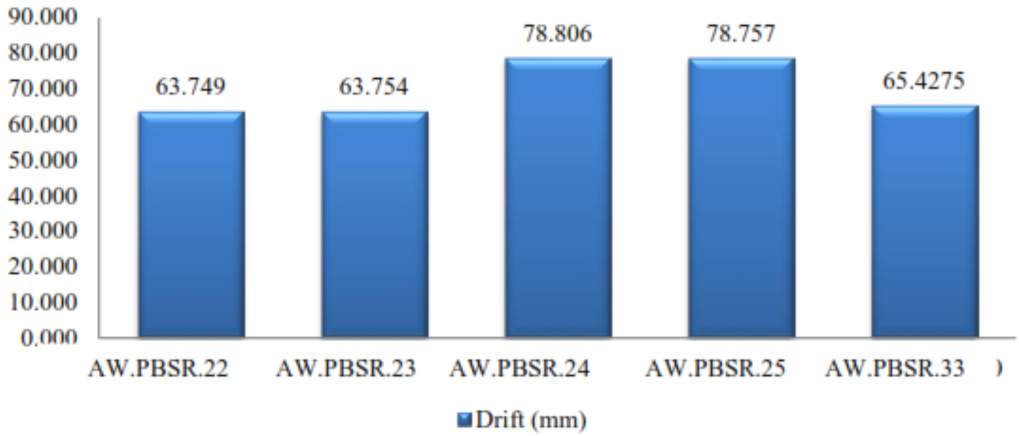

Figure 2 Bar chart of the drift comparison between models from DEM calculation results

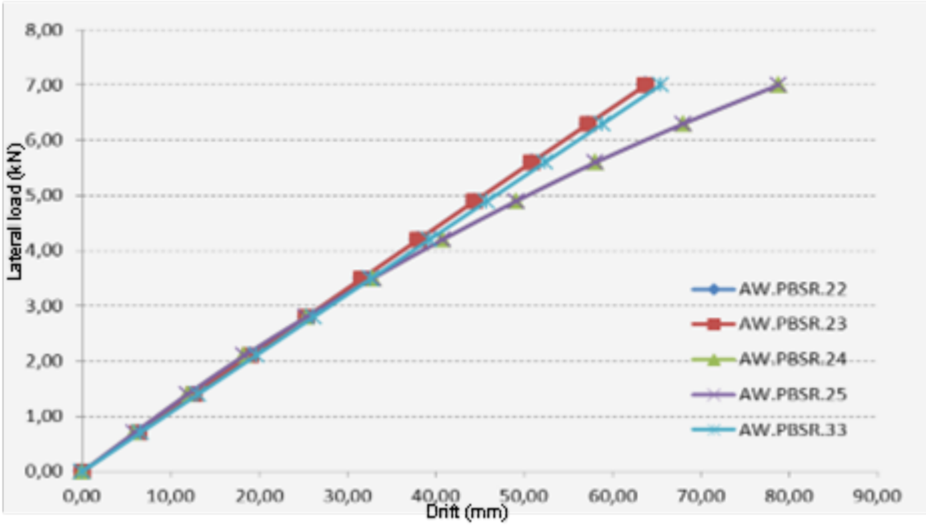

Figure 3 Comparison chart of deflection between models from FEM calculation results

With the portal model AW.PBSR.08, which is loaded with 7.00 kN, different deflections occur. From the results of the analysis, it was found that the increase in horizontal deflection on the AW.PBSR.23 portal was 0.0078 percent with a ratio of 1.0001, on the AW.PBSR.24 portal it was 23.6192 percent with an increase ratio of 1.2362 and on portal AW.PBSR..25 by 23.5423 percent with an increase ratio of 1.2354 and on portal model AW.PBSR.33 an increase in drift of 2.6330 percent with an increase ratio from 1.0614 compared to the portal AW.PBSR.22. As shown in Figure 3

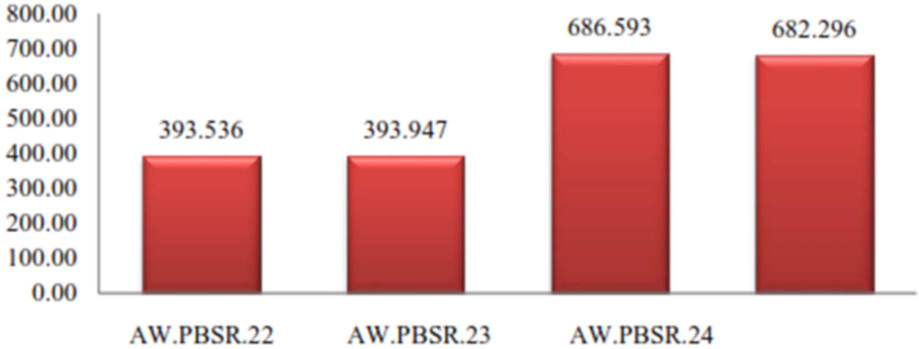

Figure 4 Bar chart of stress comparison between models from results FEM calculation

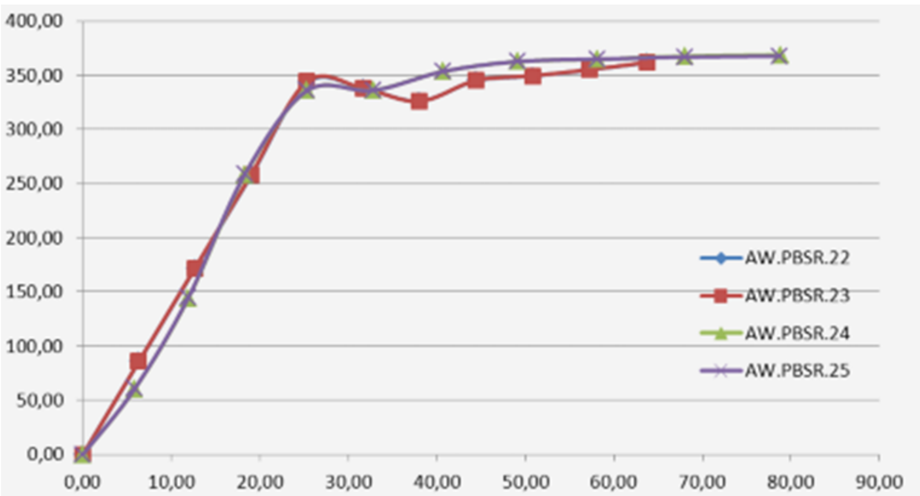

Figure 5 Diagram comparing drift and stresses between models from FEM calculation results

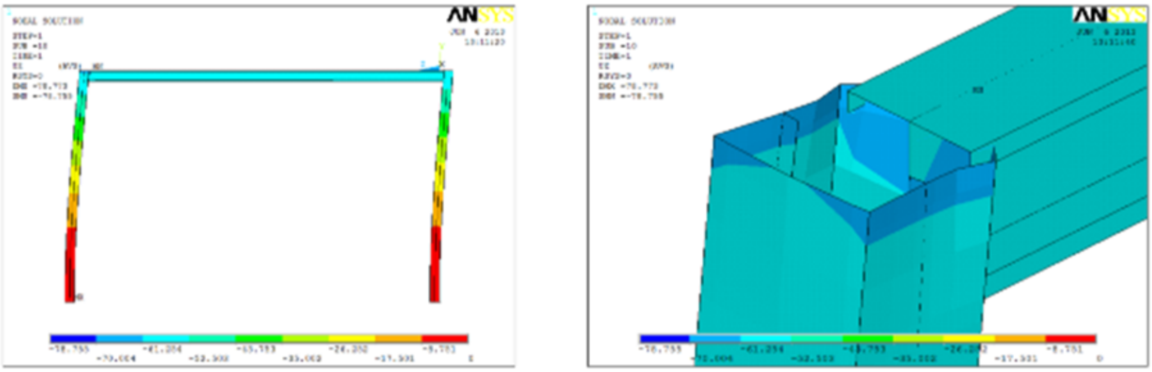

Figure 5 Connection behavior of beams and columns in portal FEM modeling results

Results and Discussion

A. Strain Softening Effect

The strain softening model is used to determine the maximum service limit of the analyzed steel gantry, from which model it can accommodate the maximum stress and stress encountered until the steel gantry drifts to destruction.

Table 2 Results of FEM calculation of side load and drift/difference

		Drift	Load	Stress
1	AW.PBSR.26	127.84	12.1845	459.683
2	AW.PBSR.27	135	12.9672	481.138
3	AW.PBSR.28	70	26.006	241.466
4	AW.PBSR.29	70	26,056	241,466

With the Softening portal model, which has a horizontal deflection of 127.84 mm and 135 mm, so the maximum load is 12.1845 kN and 12.9672 kN. And the portal receives a vertical deflection of 70 mm, so it receives a maximum vertical load of 26,006 kN and 26,056 kN. The analysis results show that the increase in the maximum horizontal load and strain of the AW.PBSR.27 portal compared to the AW.PBSR.08N-SFH model is 6.4237 percent. On the AW.PBSR.28 and AW.PBSR.29 portals, utilization increased by 0.1923 percent. As shown in Figure 6

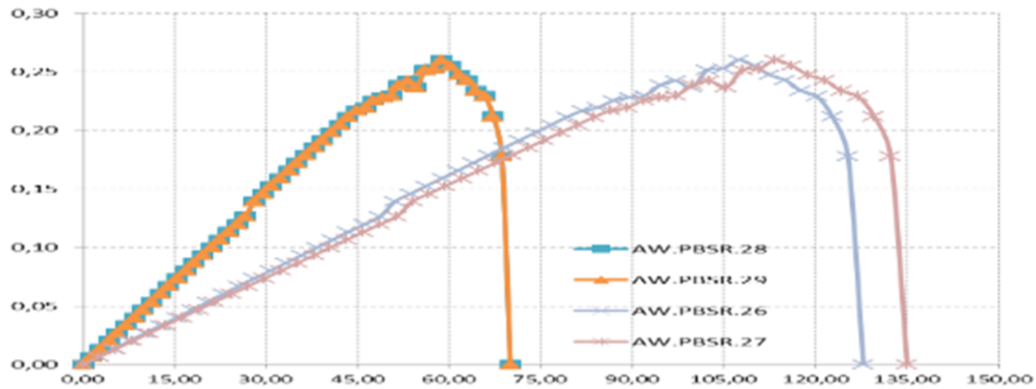

Figure 6 Diagram comparing drift and stresses between models from FEM calculation results

With the Softening portal model, which has a horizontal deflection of 127.84 mm and 135 mm there is a different tension. From the results of the analysis, it was found that the maximum stress increase on the AW.PBSR.27 portal was 4.6674 percent compared to the AW.PBSR.26 model. On the portal, AW.PBSR.28 and AW.PBSR.29 experience the same excitement. As shown in Figure 7

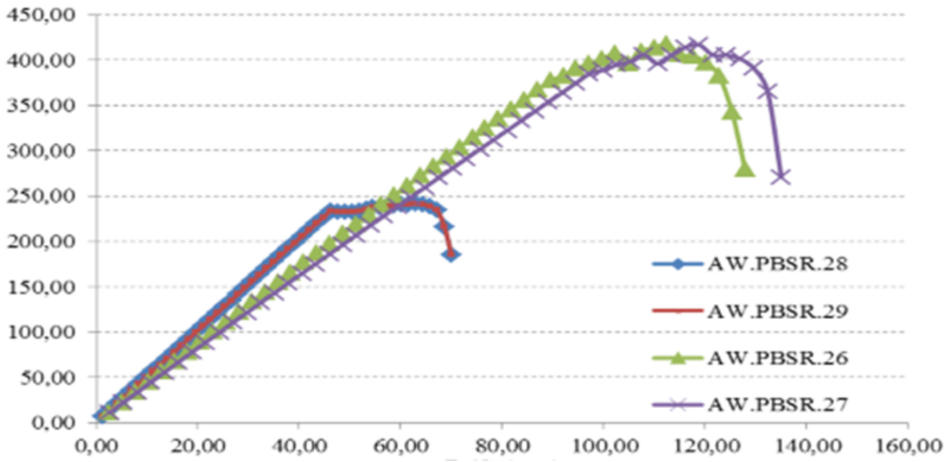

Figure 7 Diagram comparing drift and stresses between models from FEM calculation results

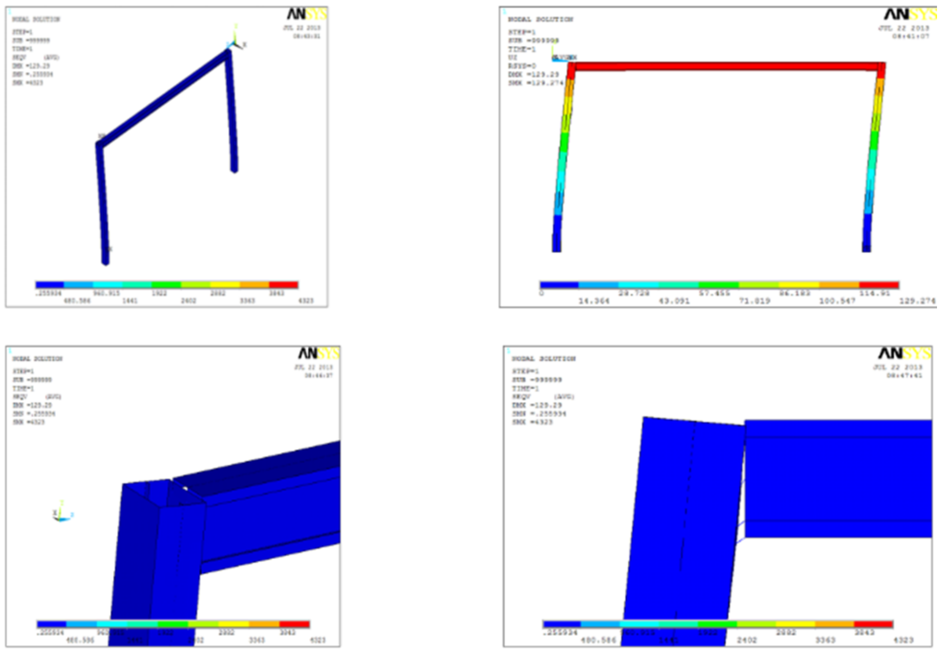

Figure 8 The behavior occurs due to the maximum lateral load drift

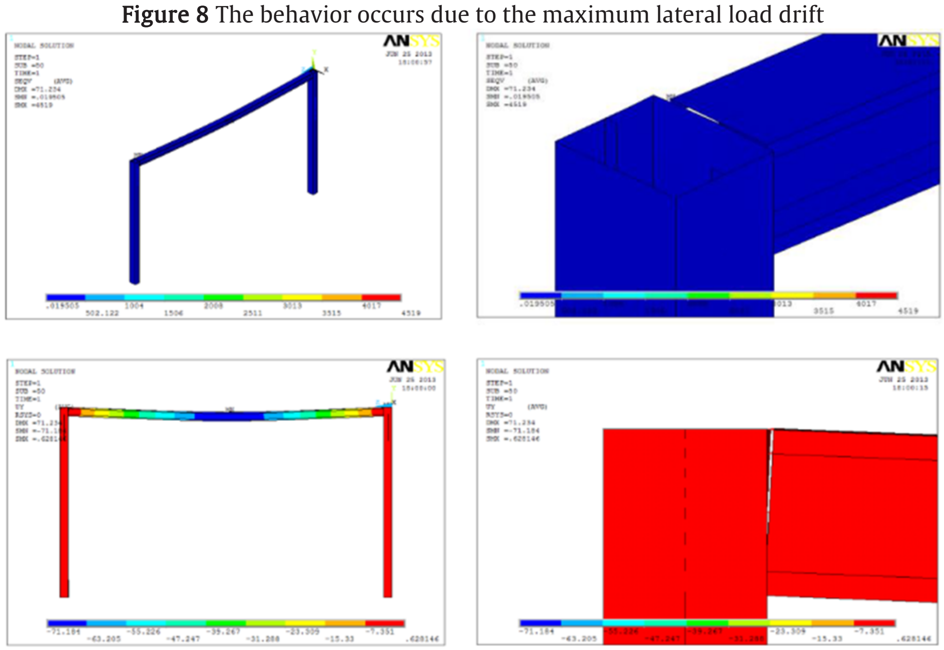

Figure 9 Behavior due to maximum lateral load deformation

CONCLUSION

Based on model analysis with manual calculations and FEM model analysis with ANSYS Ed. 9.0 in double rail section steel beams, the greatest stress occurring in the portal is the area where the bolts meet the beam and column connections, especially on the load-bearing side of the bolts on the column, which is subject to a sufficiently large load on the peak load caused by lateral-horizontal loads and the stress decreases at mid-span. With the difference in the portal stiffeners, it is also noted that there is a significant stress difference in the hinge stiffeners, sufficient to withstand greater stresses than the clamped stiffeners. The use of this semi-rigid connection can improve the handling of lateral loads because it takes large loads up to the maximum horizontal deformation that occurs in the softening area.

SUGGESTIONS

The focus of these investigations is limited to the drift behavior of the portal with the difference in the setting model of the semi-rigid pin stiffener connection and performed with rigid or flexible conditions. Since this research shows the effect of angular stiffness, it is recommended to increase the stiffness of the portal joints in the future by the effect of the estimated distance and number of bolts

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