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Strength Analysis of Steel Construction and Swing Hanger using Theoretical Method and Simulation of Finite Element

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Abstract

The initial activity in this study was carried out by examining the results of testing of reinforcing steel through tensile testing and bending testing. The study focused on the stress analysis of the test material to determine and classify the test material with SNI reference which applies as a condition for the application of test material to a construction. The material tested was a type of Fin Reinforcing Steel (BjTS 40) with diameters of 10 mm, 13 mm, 16 mm, 19 mm and 22 mm respectively with each sample 2 specimens. In tensile and bending tests, the test results will be known the load of the test material when tested at the yield point and at the maximum point, according to the strain stress graph illustrated. The results of the scale of the test machine are then recorded to perform stress analysis. The test results data are then used to calculate the amount of stress that occurs in the test material. Stress analysis is carried out on the swing hanger as well as construction steel samples. Stress analysis uses theoretical stress analysis methods and finite element simulation methods using computer work program simulation CAD / CAE technology solidworks. From the results of theoretical calculations, it is known that the amount of stress that occurs, the yield strength limit of the material and also the safety factor of the test material, both on the swing hanger test material and also the construction steel test sample. Furthermore, the initial data of the swing hanger test material as well as steel construction were carried out modeling by using a solidworks computer work program application. While the results of solidwork modeling are then analyzed by finite element simulation and known the magnitude of stress, strain, loading buckling that occurs and also the visualization of the material characteristics of the load treatment.

***Keywords**: steel; swing hanger; stress; strength; simulation; finite element*

1. Introduction

Designing is the main function of an engineering in the development of products and processes, besides that an integral aspect of planning is the use of mechanical characteristics obtained through mechanical testing (1). Material mechanical testing is carried out by researchers as a periodic examination of the quality control of a product, product development through the results of testing data and to obtain measurement data for use in the field of science. Moreover, testing, engineering and technology evaluation of the strength of material structure (2) in transportation equipment and also industry is needed to know the properties and material characteristics of the workload when applied later.

The data of mechanical testing results briefly do not know the characteristic parameters of a material (3, 4, 5), but to find out first we can conduct an experimental stress analysis study to determine the characteristics of a material. Experimental stress analysis is an important practical tool, but the theoretical approach that usually uses computer techniques is increasingly prevalent. In addition, through a computer program (6, 7) can also reflect the differences in the results of researchers' data with experimental data.

Therefore from the results of some of the above explanations, the author in the study will discuss the stress analysis study of the differences in the results of theoretical stress analysis with the results of analysis using solidworks computer simulation to compare and find out the differences in the results of theoretical and simulation analysis (8, 9).

2. METHODS

In this study, stress analysis was carried out through static testing and case study calculations, in the calculation of the case study an analysis of calculations and analysis was carried out using a solidworks simulation process. The research mechanism flowchart is as follows:

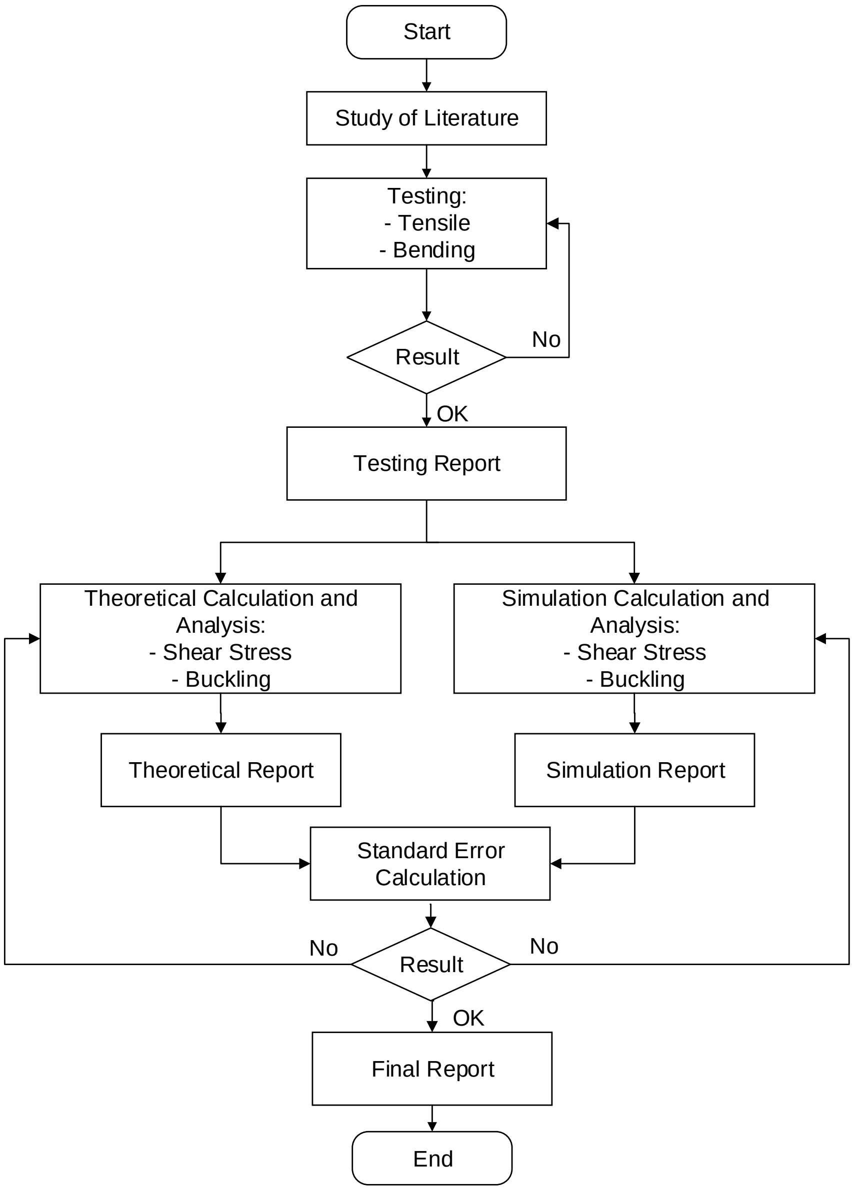

Figure 1. The Research Mechanism flowchart

In assembling multifunctional machines for making this animal feed first by designing machines, namely by using the Solidworks application. The following is the design of a multifunctional animal feed machine.

2.1 Tensile Testing Tools and Materials

Tensile testing is an activity to determine the material characteristics of the toughness and quality of a material that will be used in a construction (9). Where tensile testing activities are carried out by giving a tensile load to the material until it breaks, so that the material properties of the tensile testing activity are obtained. In tensile testing several parameters will be known, such as stress and strain. The purpose of the tensile test in this report is to find out the tensile strength of fin reinforcement (BjTS) by providing a tensile load to break (fracture), then the load is recorded when the material is yielded and also breaks.

The material used in this study is the tensile steel reinforcement test material for the Master Steel brand with a diameter of 10 mm, 13 mm, 16 mm, 19 mm, 22 mm.

The equipment used to carry out the tensile test is the UPM 1000 Test Machine found in the Static and Dynamic Test Laboratory with a maximum power of 1000 kN and visualized through XY Recorder.

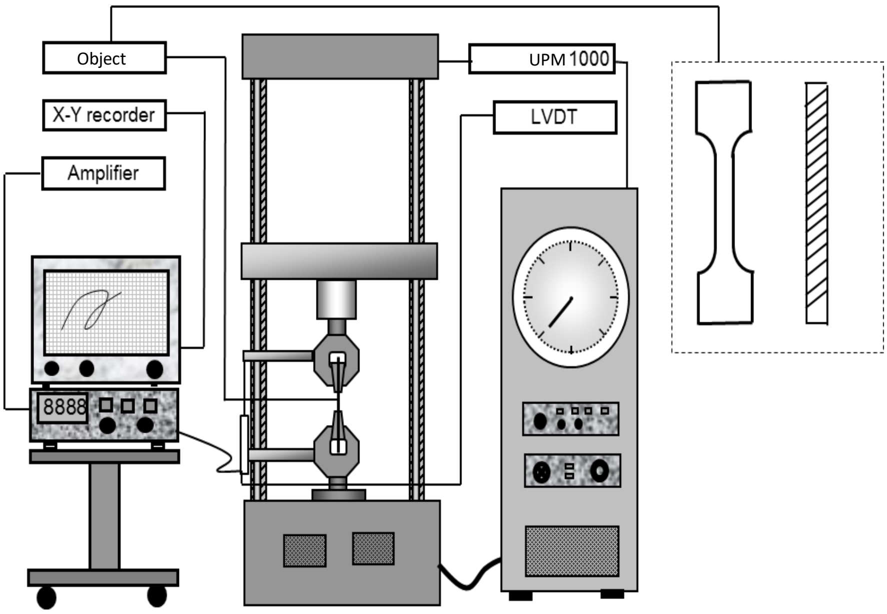

Figure 2. UPM 1000 Tensile Testing Machine Series

2.2 Bending Testing Tools and Materials

Bending testing is intended to determine the plasticity or flexural strength (flexural strength) of a material (9). In conducting bending tests on materials, it can refer to several standards that require a bending test process. The wrong standard in Indonesia which requires a bending test for reinforcing steel material is SNI 07-0410-1989. In the SNI it is stated that bending testing is carried out to determine the curvature of the material according to the material requirements tested (10). The bending test is carried out by forming a curved angle to reach 180 ° to check the visible and surface properties of the test rod which has tensile stress (not cracking) (11).

The equipment used to carry out bending tests is the UPM 200 Test Machine found in Static and Dynamic Test Laboratories with a maximum power of 200 kN. Draw a series of test machines such as Figure 2.

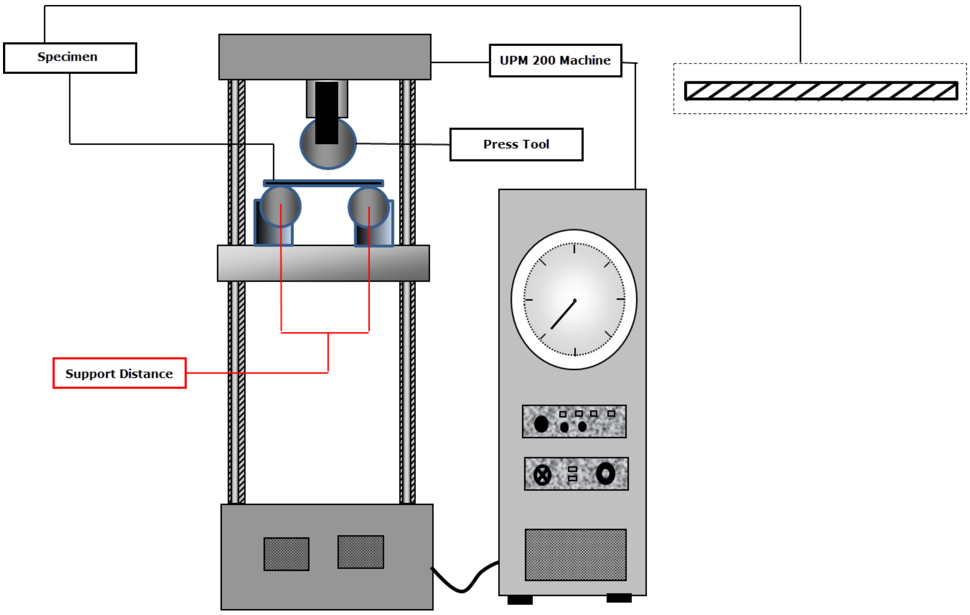

Figure 3. UPM 200 Bending Testing Machine Series

Determining the distance of the test sample and the pressure diameter according to the diameter of the test sample is attached to Table 1.

Table 1. Support Distance and Diameter Press Tool

No.	Diameter Specimen (mm)	Support Distance (mm)	Diameter Press Tool (mm)
1.	10	130	50.6
2.	13	146	64.7
3.	16	178	70.4
4.	19	202	95.1
5.	22	226	111.7

3. RESULTS AND DISCUSSION

3.1 Tensile Testing

After tensile testing using the UPM 1000 Tensile Testing Machine to break up, after that it will get a load when the material yields (12, 13), the maximum load and when the material breaks through the tensile test graph. The preliminary data on the test results are attached to Table 2.

Table 2. Test Results Pull Fin Reinforcement Steel

No.	*D* (mm)	*Ao* (mm^2)	*Lo* (mm)	*Py* (N)	*Pm* (N)	*Δl* (mm)	Class
1.	10	78.5	300	38000	48000	63	BjTS 40
2.	10	78.5	300	37000	48000	63	BjTS 40
3.	13	132.7	350	60000	83000	80.5	BjTS 40
4.	13	132.7	350	60000	83000	80.5	BjTS 40
5.	16	201.0	400	90000	120000	88	BjTS 40
6.	16	201.0	400	87000	119000	88	BjTS 40
7.	19	283.5	430	135000	177500	86	BjTS 40
8.	19	283.5	430	132500	175000	86	BjTS 40
9.	22	380.1	450	177500	232500	90	BjTS 40
10.	22	380.1	450	180000	232500	90	BjTS 40

Information:
D : Diameter of steel (mm)
Ao : Initial cross-sectional area (mm^2)
Py : Yield (N)
Pm : Maximum force (N/mm^2)

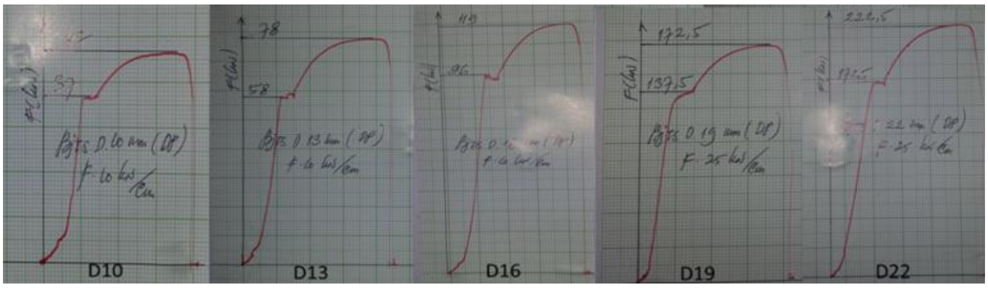

Figure 4. Tensile Test Chart Photo

Figure 5. Pull Fin Reinforcement Steel Tensile Test Results

From the results of the tensile testing of fin reinforcing steel, the calculations are then performa (14). The calculation includes the calculation of stress when experiencing a yield load, when experiencing a maximum load and calculating the strain that occurs in the test material.

The yield stress for each diameter can be calculated according to the SNI Standard, so that the stress at yield.

Table 3. Theoretical Stress and Strain Calculation Results

No.	*D* (mm)	*Ao* (mm^2)	*Lo* (mm)	*Fy* (kN)	*Fm* (kN)	σ_y (N/mm^2)	σ_u (N/mm^2)	ε (%)	*Δl* (mm)
1.	10	78.5	300	38.0	48.0	484	611	21	63
2.	10	78.5	300	37.0	48.0	471	611	21	63
3.	13	132.7	350	60.0	83.0	452	626	23	80.5
4.	13	132.7	350	60.0	83.0	452	626	23	80.5
5.	16	201.0	400	90.0	120.0	448	597	22	88
6.	16	201.0	400	87.0	119.0	433	592	22	88
7.	19	283.5	430	135.0	177.5	476	626	20	86
8.	19	283.5	430	132.5	175.0	468	618	20	86
9.	22	380.1	450	177.5	232.5	467	612	20	90
10.	22	380.1	450	180.0	232.5	474	612	20	90

3.2 Bending Testing

Bending test materials are reinforced steel Master Steel brand, specifications of bending test samples such as Table 4.

Table 4. Bending Test Sample Specifications

No.	*D* (mm)	*Lo* (mm)	Support Distance (mm)	$D_{presstool}$ (mm)
1.	10	190	130	50.6
2.	10	190	130	50.6
3.	13	220	146	64.7
4.	13	220	146	64.7
5.	16	260	178	70.4
6.	16	260	178	70.4
7.	19	290	202	95.1
8.	19	290	202	95.1
9.	22	380	226	111.7
10.	22	380	226	111.7

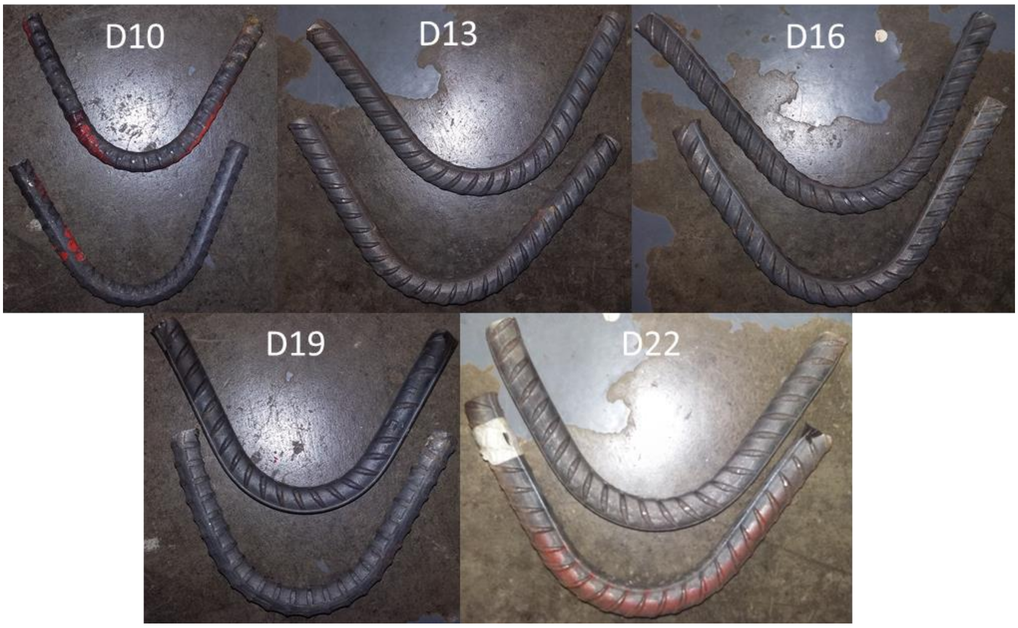

Figure 6. Pull Fin Reinforcement Steel Ben Test Results

3.3 Swing Hanger Analysis Using Solidworks Simulation

Analysis using solidworks simulation will be known in areas where the greatest shear stress works. Referring to the similarity of dimensions of the swing hanger size clearly can be seen in Figure 7:

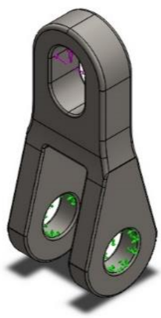

Figure 7. Swing Hanger Modeling by Using Solidworks

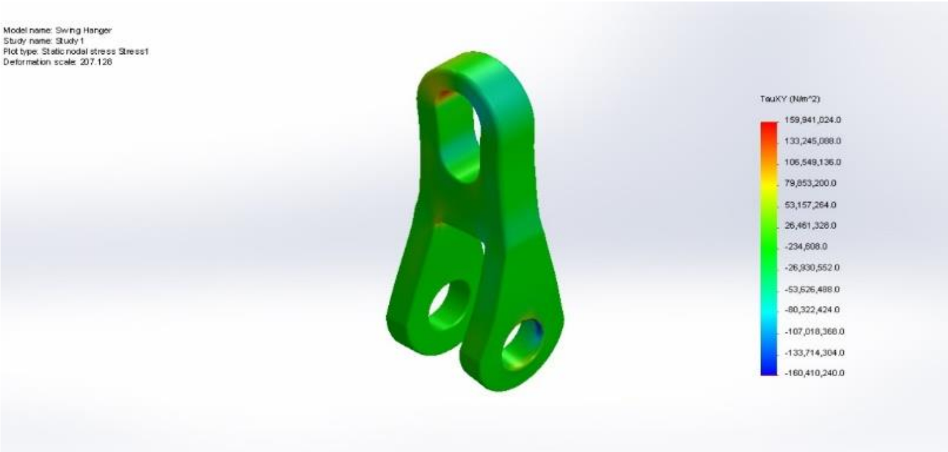

Figure 8. Shear Stress Simulation Result by Using Solidworks

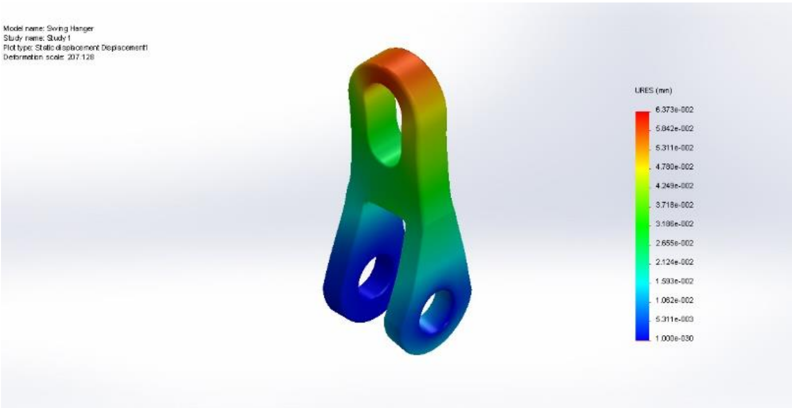

Figure 9. Strain Simulation Result by Using Solidworks

3.4 Buckling Analysis Using Solidworks Simulation

In the von Mises stress analysis using solidworks simulation, loading was obtained through buckling loading obtained from the Euler equation of 88842.32 N for S40C specification steel construction material.

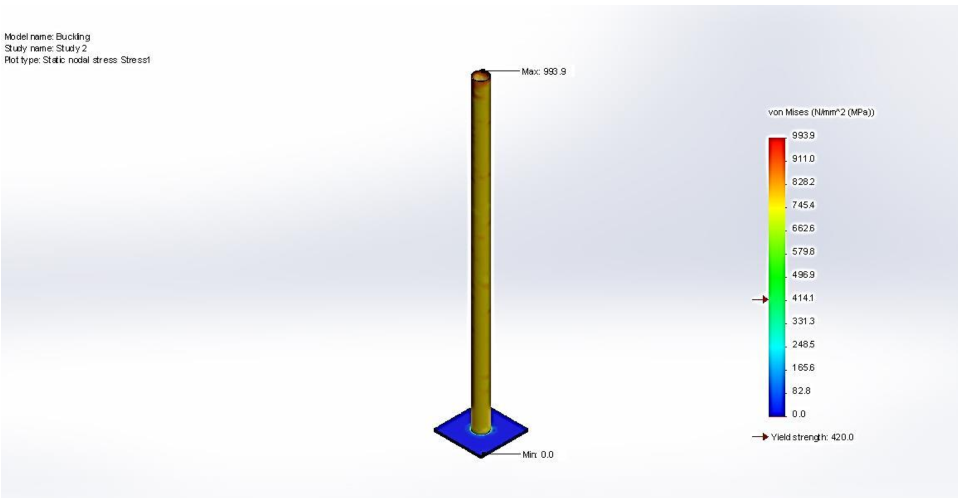

Figure 10. Stress Simulation Result of Construction Steel by Using Solidworks

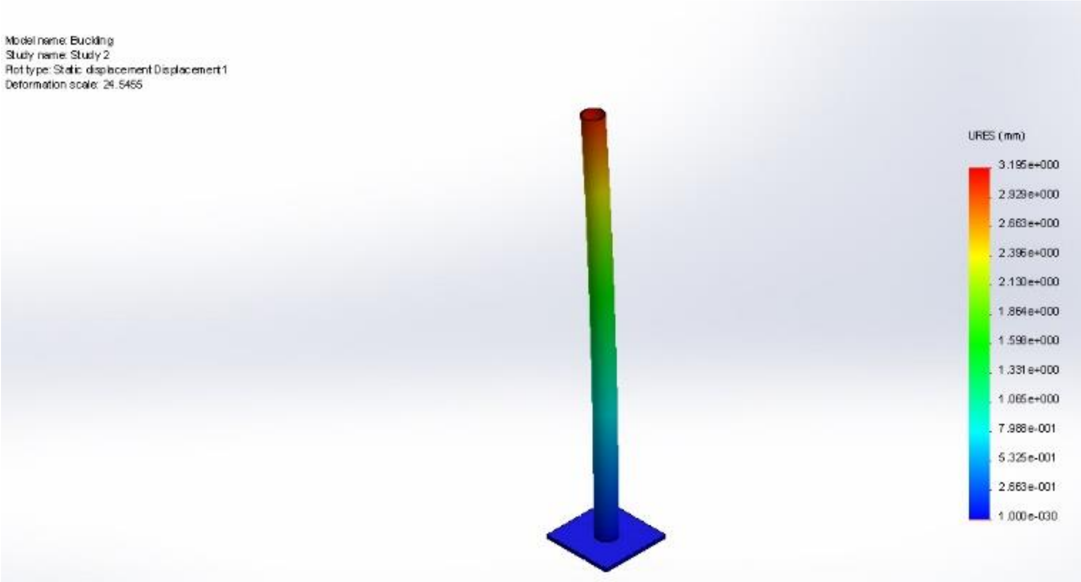

Figure 11. Strain Simulation Result of Construction Steel by Using Solidworks

3.5 Error Calculation

In calculating this error is done to determine the error of the results of theoretical analysis with simulation analysis using solidworks. Data from calculations and simulations are shown in Table 5:

Table 5. Data from Theoretical and Simulation Calculation Results

Case	Shear Stress of Swing Hanger	Buckling Stress of Construction Steel	Buckling Load Maimum
A (mm^2)	323	93.85	93.85
P (N)	40000	88842.32	-
Theoretical (N/mm^2)	123.84	946.64	88842.32
Simulation (N/mm^2)	106.5	993.87	103325
Error (%)	14	4.98	16.3

So the standard error for shear stress calculations by using theoretical calculation simulation is 14%, for simulation of buckling stress with theoretical calculations of 4.98% and for loading buckling SE at 16.3%.

4. Conclusion

Conclusions from the results of the research reports that have been carried out are as follows:

- Tensile test results for BjTS 40 Fin Steel for diameter 10 mm to 22 mm diameter lowest price of 597 N / mm^2 for test sample No. 2 diameter 16 mm, this shows the tensile strength exceeding the minimum limit of mechanical properties of reinforcing steel according to requirements SNI 07-2052-2002 and also for all tensile test samples from a diameter of 10 mm to 22 mm exceed the minimum strain limit required by SNI by 17%.

- The bending test results show that the average strength of the bending test sample for a diameter of 10 mm is 1820 N/mm^2, a diameter of 13 mm is 1774.5 N/mm^2, a diameter of 16 mm is 1660 N/mm^2, a diameter of 19 mm is 1875 N / mm^2 and a 22 mm diameter of 1919 N / mm^2.
- For case studies the results of theoretical shear loads for pins 1a and 2a are 63.66 N/mm^2. This result is still below the yield shear strength of 197 N/mm^2. For eye swing hanger 1a shear stress of 110.8 N/mm^2. For eye swing hanger 2a shear strength of 123.83 N / mm^2. Based on the calculation results of the specifications of the swing hanger material able to withstand loads up to 129200 N.
- Solidworks simulation results for shear stress at eye swing hanger 2a of 106.5 N/mm^2.
- The theoretical calculation for buckling load that can be accepted by the buckling test sample using Euler equation is 63458.8 N, for Rankine equation obtained 24314.32 N. Theoretical buckling stress with load through the Euler equation is 676.17 N/mm^2 and for the Tetmejer equation is 294.96 N/mm^2.
- The calculation results using buckling stress solidworks simulation obtained the distribution of von Mises stress of 650.75 N/mm^2.
- Calculation of standard error for shear stress and load simulation of 13.99%, and theoretical calculation of buckling stress with simulation of buckling stress of 3.76%.

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