Measurement of Stresses and Strains by Strain Gauge using IoT Platform

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Abstract: Mechanical components are exposed to various loading conditions henceforth it is important to ascertain the qualities to stay away from disappointment in the design. A part falls flat on account of axial stress, twisting pressure, and torsional stress. The work introduced here targets fostering a test apparatus to gauge the twisting pressure created in a cantilever beam. The test rig utilizes strain measure in Wheatstone full extension arrangement to detect the deformity. Information Acquisition System is utilized to gauge the pressure because of point load. Experimental and theoretical outcomes are in close understanding and the Flexural formula was effectively approved.

Keywords: Bending stress, mobile application, Strain gauge, Wheatstone network.

1. INTRODUCTION

In the moment's world due to the increase in complexity of designs, there has been an increase in the need for dimension and analysis of stresses and strain developed in the factors, which also needs to cover from a remote position. In numerous artificial sectors for similar measures, strain needles have an important consideration. Systems with correct measures can define the strain position generating on colorful construction similar to civil to biomechanics engineering. Specific construction's lifetime and trouble can be measured grounded on strain dimension. Strain is nothing but the distortion caused due to stress. The most standard and dependable system to measure strain is using bonded electrical strain hand. Upon distortion, the conductive grid changes the electrical resistance of the strained hand the strained hand gives readings in terms of resistance, so the Wheatstone bridge is used to convert the change of resistance into electrical signals i.e., in terms of electrical voltage. But this difference voltage is veritably small so it needs to amplify to a certain position to understand by the regulator. The strain hand is mounted as one of the four legs of the Wheatstone ground circuit designing a full ground circuit that amplifies the microstrain values from each strain hand and gives the perceptivity about two times & four times more advanced than half ground and quarter ground configuration independently. The attendant affair value is the difference voltage between two affair terminals. In this composition, stress dimension and analysis have been done on a cantilever beam, a setup was designed and fabricated for the trial, readings were taken, and the attained experimental results were validated with theoretical and simulation results.

2. LITERATURE

Fortified electrical metal foil Strain Checks are considered the most acknowledged method for estimating strain by Dr. Sadhu Singh [1]. The Strain measure gives opposition values and this difference in obstruction values is changed over into differential voltage between two terminals of the Wheatstone span Electrical signs. The properties of material utilizing strain checks coordinated in the Wheatstone span alongside the Information Securing framework are determined by E. LABAŠOVÁ [2]. Strain measure sticking is dreary work, the System utilized for gluing of strain check relies upon the material to be utilized. Different strain measure application methodologies are chipped away by Thomas C. Moore [3]. Strain measure has numerous applications; Investigation of tension applied because of interior stresses created on a soft drink can by An Ibrahim et al. [4]. experiment with crack diagnosis done by L. Ramesh et al. [5]. They have performed vibration examination utilizing trial and limited component investigation. Strain measure has applications in the Clinical field too as Strain check rosettes in Dental Treatment by A. D. Vardimon et al. [6]. Structural designing purposes strain measures from building a little establishment section to working on a scaffold, by L. David et al. [7]. Stress-strain investigation of an RC Show off is finished by D. Simi et al. [8]. Analytical reproductions are additionally an optimal way of approving hypothetical outcomes. Recreated three kinds of pillars, for example, straight, quarter curve, and semi bend radiate keeping the same cross-segment and same kind of stacking and inferred that the semi bend bar is less stress than the other two shafts by M.D. Yaqoob Mehdi et al. [9]. Ansys recreations facilitated crafted by insightful confusions in calculations. Limited component investigation for the cross-section of direct and nonlinear circumstances by putting strain checks at the hubs characterizing components in FEM for example Limited component model, set strain measures as indicated by the hub characterizing the components in Limited component model and presumed that separation of strain checks brought about the mistake of up to 10%. Setup was developed for validation of bending stress and flexural formula by comparing Experimental results with theoretical and analytical results conveyed by Ahmet Erklig et al [10].

3. EXPERIMENTATION

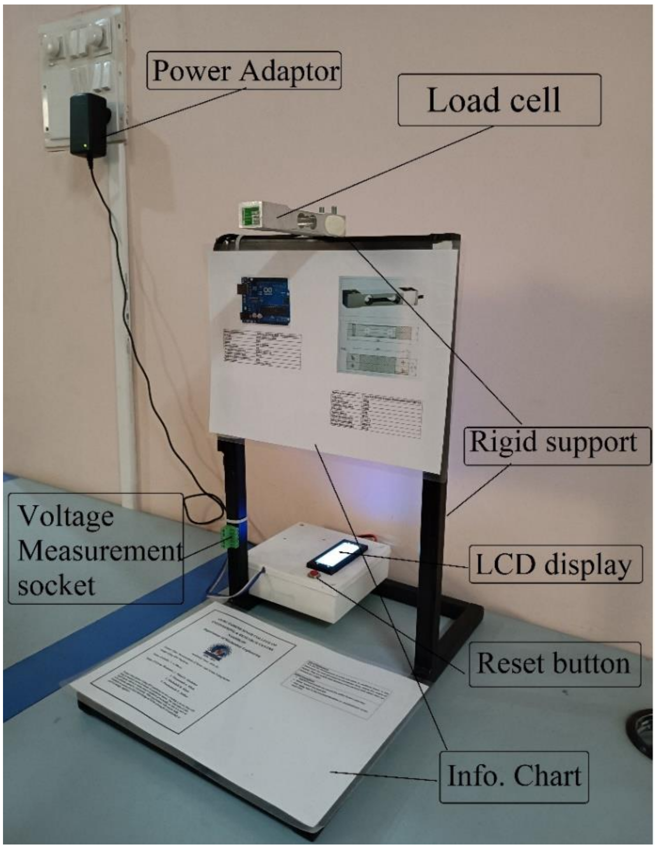

Fig.No.1 Experimental Setup

The instruments used to experiment are a steel beam, rigid support frame, dead weights, and frame structure. The assumptions made are as follows:

1. Beam is assumed to be isotropic and homogenous.
2. Residual stress is neglected in theoretical calculations and limited by calibration in experimentation.
3. Young's modulus, *E = 210GPa.*

The arrangement was created to quantify the bending stress and strain in the cantilever beam for various loading conditions.
The beam is fixed at one end by using a rigid support frame as shown in Fig.1. The strain gauges are mounted on the beam at a distance of 65mm from the fixed support. Strain gauges are mounted per Wheatstone bridge by using a full-bridge circuit. The strain gauges mounted on the upper part give us tensile stress and the strain gauges on the lower part weights. The deflection of the strain gauges is acquired by the system and displayed on the mobile application. From the experimental strain values, experimental stress is calculated. The experimental and theoretical stress values were validated using Fusion 360 software. The experiment was conducted for various loadings and the values of stresses are shown in Table.1 below. Results were compared with analytical (simulations) and theoretical values of stresses and the graph indicating deviation is shown in Fig.2(a & b).

Table 1:

Sr. no	Mass (kg)	Theoretical value $\frac{N}{mm^2}$	Experimental value $\frac{N}{mm^2}$	Analytical value $\frac{N}{mm^2}$	The error between theoretical & experimental (%)	The error between theoretical & analytical (%)
1	0.8	0.24323	0.24	0.2432	1.3279	0.0123
2	1.15	0.3497	0.34	0.3496	2.8567	0.0286
3	5.2	1.581	1.55	1.581	2.001	0

The above table shows the comparison of stress measured by experiment, analysis, and simulation. There is an almost negligible deviation between the theoretical and analytical values and their % of error is very small. Comparing the values of the experimental and simulation model there may seem to have a little bit of variation but is it due to the hollow section present in the actual load cell as can be seen in fig.no.1. the strain gauge can handle values up to 40,000GMS or 40Kg safely and can go up to 48Kg without facing failure.

4.FUSION360 SIMULATION

4.1 Fusion360 simulation for 6800GMS:

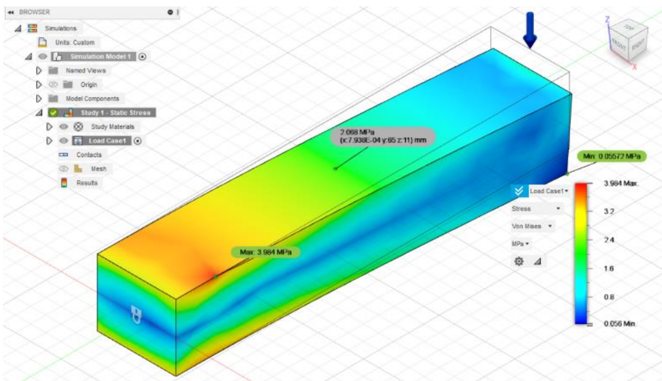

Fig. 2(a). Fusion360 stress simulation (6800 grams).

The above figure shows the stress simulation designed in Fusion360 software. here a random value of the load is taken i.e 6800GMS. The load is applied as a point load at the free end while the other end is kept fixed. The color variation along its length from fixed end to free end shows the stress concentration, the red area being the most stress concentrated area while the blue color has the least stress concentration.

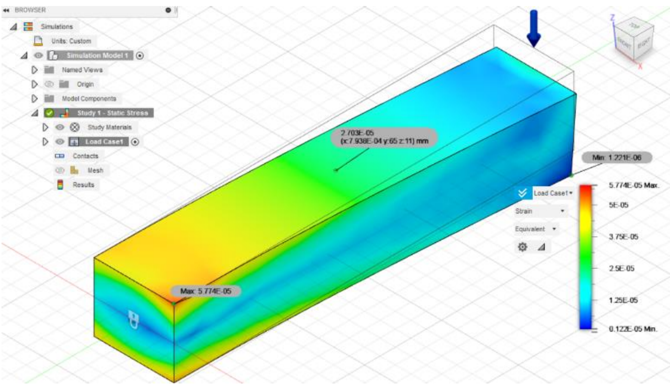

Fig. 2(b). Fusion360 strain simulation (6800grams).

The above figure shows the strain simulation designed in Fusion360 software. here a random value of the load is taken i.e. 6800GMS. As mentioned earlier the load is applied as a point load at the free end while the other end is kept fixed. The color shows the strain variation from fixed end to free end, being high to low respectively.

5. RESULTS AND DISCUSSION

Based on the numerous trials and readings from experiments, simulations, and theoretical calculations, data was collected. With the help of this data, graphs were plotted of stress and strain variations.

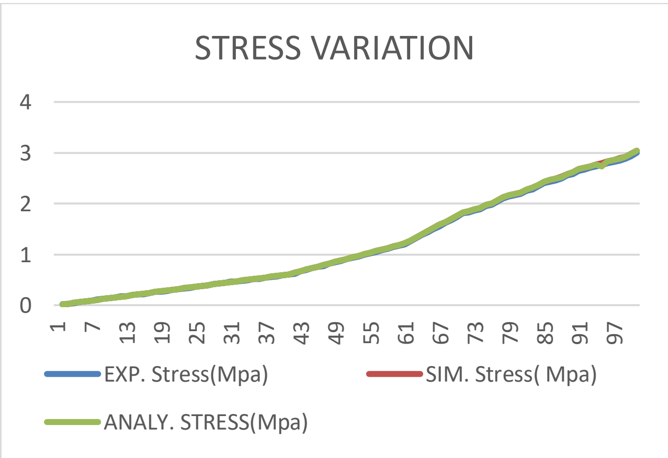

Fig. 3(a) stress variation.

The above graph is plotted between experimental stress, simulation stress, and analytical stress. The above graph shows us the variation of stress along the x-axis, and along the y-axis, it shows the variation of weights in Kg. the graph represents the stress variation as we increase the weight on the cantilever beam. As already known that stress is directly proportional to weight, here we can see and validate the same by observation of the graph.

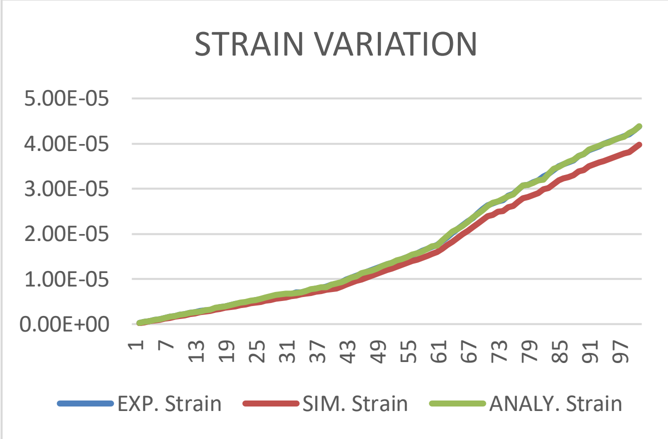

Fig. 3(b) strain variation.

The above graph is plotted between experimental strain, simulation strain, and analytical strain. The above graph shows us no. of values along the x-axis, and along the y-axis, it shows the variation of strain. the graph represents the stress variation as we increase the weight on the cantilever beam. As already known that strain is directly proportional to weight, here we can see and validate the same by observation of the graph.

6. CONCLUSION

The theoretical, analytical, and experimental values are in close agreement with each other. For a load of 0.8kg, the theoretical stress value was 0.24323 $\frac{N}{mm^2}$and experimental value measured was 0.24 $\frac{N}{mm^2}$and the error calculated was 1.23 %. For a load of 1.15kg, the theoretical stress value was 0.3497 $\frac{N}{mm^2}$and experimental value measured was 0.34 $\frac{N}{mm^2}$and the error calculated was 2.86 %. For a load of 5.2kg, the theoretical stress value was 1.581 $\frac{N}{mm^2}$and experimental value measured was 1.55 $\frac{N}{mm^2}$and the error calculated was 3.1 %.

The variations in the values were due to assumptions. The beam was assumed to be isotropic and homogenous. The average % error was calculated up to 2.9%. The residual stress in the beam was nullified by the calibration process. The temperature compensation was attained by Wheatstone full-bridge configuration.

7. ACKNOWLEDGMENT

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8. CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

9. REFERENCE

[1]. Dr. Sadhu Singh, *experimental stress analysis* (Khanna Publishers, Fourth Edition, 2015, 103-110).

[2]. Eva LABAŠOVÁ *determination of modulus of elasticity and shear modulus by the measurement of relative strains,* faculty of materials science and technology in Trnava Slovak university of technology in Bratislava, *24(39)*, 2016.

[3]. Thomas C. Moore, Sr., *Recommended Strain Gage Application Procedures for Various Langley Research Centre Balances and Test Articles*, NASA Technical Memorandum *110327*, 1997.

[4]. Ahmed Ibrahim, Yeong Ryu, Mir Saidpour, Stress Analysis of Thin-Walled Pressure Vessels, Modern Mechanical Engineering, 2015, *1-9.*

[5]. Lanka Ramesh, P. Srinivasa Rao, K. Ch. Kishore Kumar, D. Kiran Prasad, Experimental and Finite Element Model Analysis of uncracked and cracked Cantilever beam, *International Journal of Advanced Research In Science, Engineering and Technology, 3(1)*, 2016.

[6]. Alexander D. Vardimon, Daniel Robbins and Tamar Brosh, In-vivo von mises strains during Invisalign treatment, *American Association of Orthodontists*, 2008, 399-409.

[7]. Litvan David, Mateckova Pavlina, and Smirakova Martina, Analysis of model foundation slab focused on strain gauge measurement, *International Journal of Theoretical and Applied Mechanics*, 1, 2016, 292-296.

[8]. Diana Simic and Marina Francic, analysis of stress and strain in the reinforced concrete structure of a sports hall grandstand, Broj 6, Godina, 2013, 81-95.

[9]. M. D. Yaqoob Mehdi, A. Purushotham, Simulations Study on a Mixed Beams Structure, *IOSR Journal of Mechanical and Civil Engineering, 12(6)*, 2015, pp-66-72.

[10]. Ahmet Erklig and, M. Akif Kütük, Experimental Finite Element Approach for Stress Analysis, Hindawi Publishing Corporation Journal *of Engineering Volume* 2014, Article ID 643051.