EXPERIMENTAL AND IMAGE PROCESSING FRAMEWORK FOR EVALUATING DEFORMATION IN ELASTOMERIC BEARINGS UNDER STATIC COMPRESSION

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Keywords:

Elastomeric Bearing, Digital Image Processing, MATLAB, Deformation Analysis, Stress-Strain, Machine Learning

Introduction:

1. Elastomeric bearings are widely used in bridges and structural systems to transfer loads and allow controlled deformation. Their behaviour under compression is critical for ensuring structural safety and durability.
2. Traditional measurement methods such as dial gauges provide limited information about deformation behaviour. To overcome this, image processing using MATLAB is adopted as a non-contact method for analysing deformation.
3. In this project, elastomeric bearings are tested under static compression using a Universal Testing Machine (UTM). Deformation is evaluated using both experimental readings and MATLAB-based image analysis. In addition, machine learning techniques are introduced to develop predictive models for deformation behaviour.

Objectives:

1. To experimentally investigate the deformation behaviour of elastomeric bearings under static compression loading.
2. To establish the stress strain properties and energy absorbing property of elastomeric bearings of various sizes.
3. To analyse deformation using MATLAB-based image processing techniques.
4. To compare the results of the experiment with the results of image processing to ensure accuracy.
5. To create a machine learning-based deformation behaviour prediction method on elastomeric bearings

Methodology:

The project is carried out in four phases:

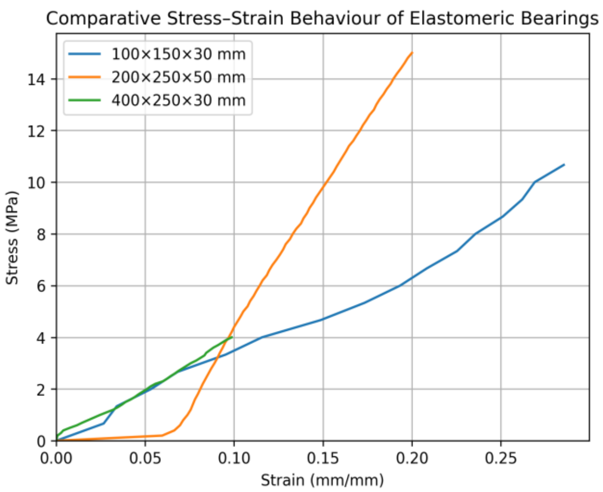
1. **Experimental Phase:** The elastomeric bearings of various sizes (100×150×30 mm, 200×250×41 mm, and 400×250×60 mm) are subjected to compression through a Universal Testing Machine. Values of load and deflection are measured and stress strain and energy absorption properties are taken.

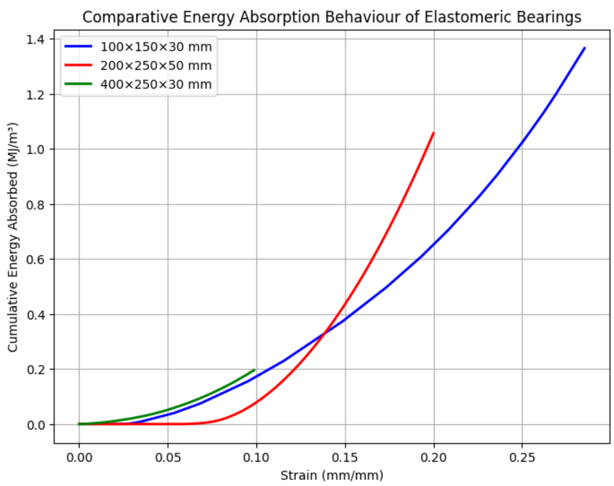
2. **Image Processing Phase:** MATLAB is used to analyse images taken before and after deformation to establish deformation through geometry changes.
3. **Machine Learning Phase:** Datasets are prepared with the help of experimental and MATLAB results and machine learning models including SVM, Random Forest, and Gradient Boosting are suggested to forecast deformation behaviour.
4. **Comparison Phase:** Comparison of experimental and MATLAB analysis results is done to assess accuracy and reliability.

Result and Conclusion:

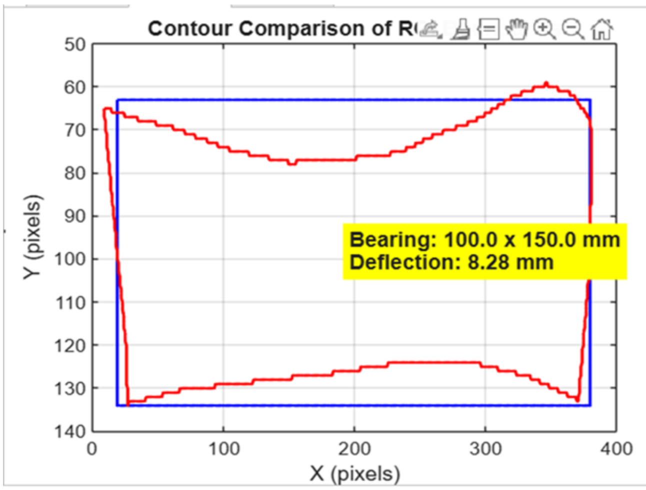
The experimental outcomes suggest that the deformation behaviour of the elastomeric bearings comprises significant variation with the size and the applied load. The bearing with the dimensions of 200 x 250 x 50 mm was more rigid and had more load bearing capability, but the bearing with the dimensions of 100 x 150 x 30 mm had more deformation and higher energy absorption. The bearing that was 400 × 250 × 30 mm exhibited relatively lower stress values in compression.

The stress strain curve and the energy taking curve of the experimental analysis are a clear indication of the nonlinear behaviour of the elastomeric materials.

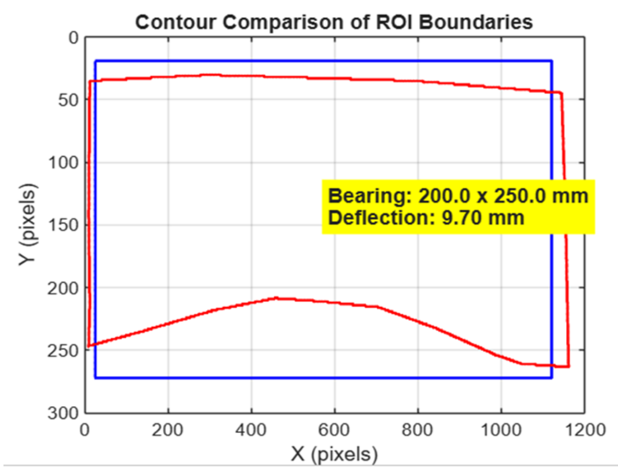




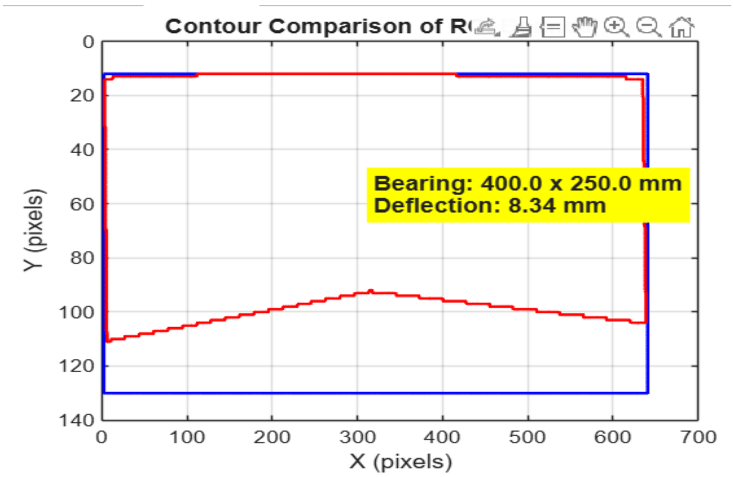
The image processing outcomes obtained using MATLAB are comparable to the experiment results with slight deviation, which proves the usefulness of the non-contact technique in deformation analysis.



(a)



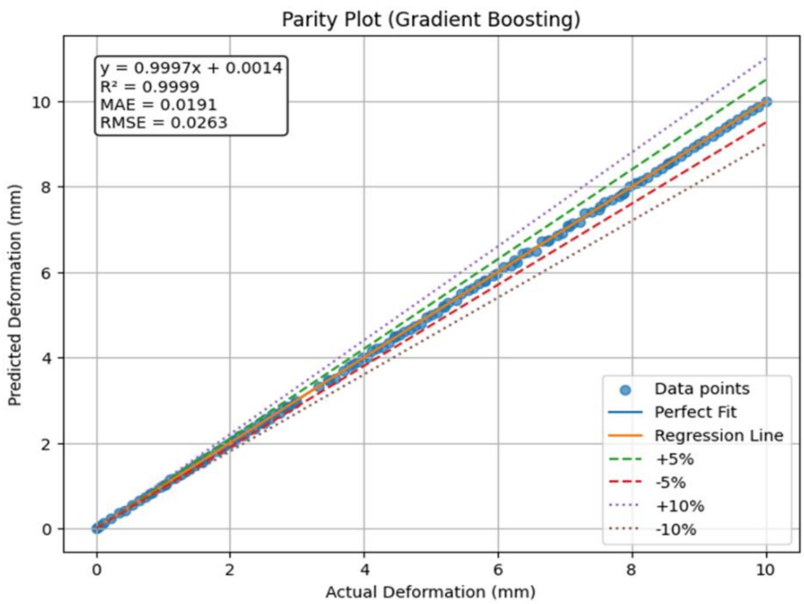
(b)



(c)

DIP-based deformation of elastomeric bearings of different sizes at maximum load levels: (a) 100×150×30 mm, (b) 200×250×50 mm, (c) 400×250×60 mm.

The framework is machine learning based and is still under development and the datasets have been prepared based on experimental and MATLAB outcomes. The models are under development to forecast the deformation behaviour depending on the load and bearing dimensions.



Finally, the project effectively illustrates a combined method with experimental testing and MATLAB-based image processing, and current research on machine learning to predictive analysis is being done.

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Future Scope:

The future scope of this project includes:

1. Implementation and evaluation of machine learning models for accurate prediction of deformation behaviour.
2. Improvement of MATLAB-based image processing for automated and more precise deformation detection.
3. Generalization of the study to dynamic and cyclic loading conditions.
4. Expansion of the analysis of other sizes of elastomeric bearing and material changes.
5. Creation of a real time monitoring system of structural uses.