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Steel Foam Anatomization

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Abstract
The central aim of this paper is providing a quality evaluation of the manufacturing, structural use, modeling and properties of steelfoam. Steelfoam features air voids in its microstructure and therefore introduces density in the form of a new design variable in the selection of steel material. The engineering qualities of steel elements can significantly be altered by controlling their density. In this category, improvisation in weight to stiffness ratio is specifically pronounced along with thermal resistivity and energy dissipation. Large scale usage of steel foam in different public structures is not yet demonstrated. Hence, existing uses demonstrating full scale usage of aluminum foams or proof of idea for steel foam in conditions with clear structural or civil analogs are emphasized. The acceptance of steel foam is completely dependent on the method used for production specifically the cost and the resulting properties of the material. And explore several properties of steel foams, viz. compressive, tensile, and shear properties in the computational realm. This study has used the different cell structures as inside the steellic foam and performed the FEA analysis for the foam model using Abacus software and identified the results with the same conditions that are used in existing base study for the future scope.
Keywords: *Steel, Foam, Analysis, Pur, Property etc.*

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I. Introduction

Civil engineering applications remain largely absent, primarily due to poor understanding of the material and its structural properties. However, the material features a high stiffness to weight ratio, excellent energy dissipation, and low thermal conductivity, suggesting that it could become a highly valuable new material in structural engineering. Previous attempts to characterize the mechanical properties of steel foam have focused almost exclusively upon uniaxial compression tests, both in experimental research and in computational simulations. It was also found that experimental calculations and results of different steel foam properties that are obtained from different manufacturing processes may vary significantly. Steel foams are generally light weight steels flourished with a combination of several properties like very low specific weight, high stiffness, good energy absorption quality and high compression strength.

II. Foam Modelling

The Crushable Foam plasticity models were proposed and implemented in order to analyze the behavior in compression of crushable materials (like foams, balsa wood). These models are able to describe the damage in compression characterized by cell wall buckling processes. Two types of crushable foam models are implemented in ABAQUS: volumetric hardening and isotropic hardening. The isotropic hardening model uses for the yield surface an ellipse centered at the origin in the σe-σm stress plane. The yield surface evolves in a self-similar manner, and the evolution is governed by the equivalent plastic stress:

σe2+α2σm2=B2 1

Where σe represents the von Mises stress and σm is the mean stress, α defines the shape of the yield surface in relation with the relative magnitude of the axes.

This parameter is computed based on the ratio between the initial yield stress in uniaxial compression σC0 and initial yield stress in hydrostatic compression pC0:

K=σC0/pC0 2

The specimens (80x80x25 mm) with holes (diameter 16, 28, 40 mm) used in the experiments were modeled in ABAQUS software. 3D 20 node quadratic solid (C3D20) elements were used, with a refined mesh near the hole. A convergence study was carried out resulting the present mesh topology. The boundary conditions represent the experimental setup: 0 displacements of vertical direction were imposed at the bottom side of the specimen, while 15 mm displacements were applied on the top side.

The uniaxial compression experimental stress - strain data (20 points for each foam density) were used to define the Crushable Foam material model. The isotropic hardening feature was implemented by k=1 and the plastic Poisson ratio Vp =0. Self contact on hole edges was defined. A typical result from simulation, vertical reaction force from bottom edge versus applied displacement is shown in figure 11, together with experimental load - displacement curve for foam density of 300 kg/m3 and a 28 mm hole diameter. It could be observed that the numerical result fall between the experimental curves indicating a good agreement.

The model is created using basic part modeling in Abacus. The parts are automatically created, instanced, and the assembly is generated.

Step-1

Figure 1: Model in Abaqus

Dimension = 80x80x25 with 28 mm diameter of hole
STEP-2. Adding the Material Properties
1. Relative density = 0.145
2. Foam density = 1123.75 Kg/M^3
3. Poisson Ratio: 0.05
4. Elastic Modulus= 3150 MPa
5.Abacus Hyper foam Model with Shear Test Data & Uniaxial Test Data
The above properties and the values are added to the CAD model in the Abacus Simulia parameters.

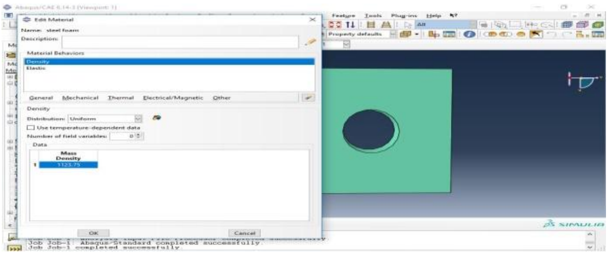


Figure2: Editing Steel Foam material Properties in Abaqus Simulia

Meshing and Point Generation:

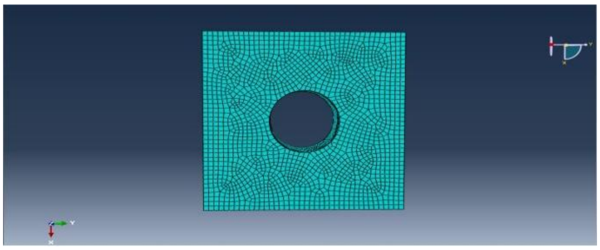


Figure 3: Meshing Applied to Steel Foam Model and Points Generated (22490)

III. Analysis Of Material

Load Analysis:
Load is applied to the steel foam CAD model in steps and the displacement is obtained for each load.

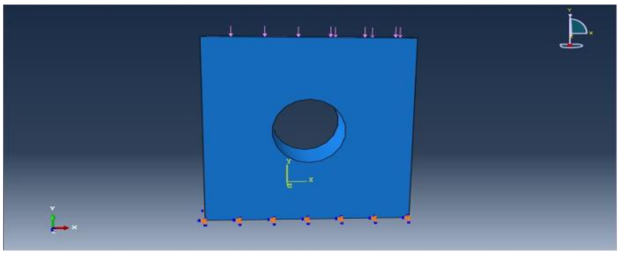
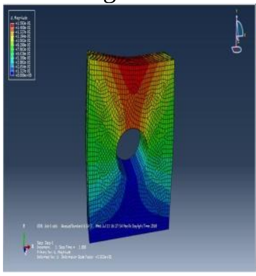
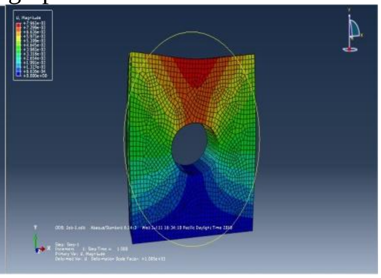
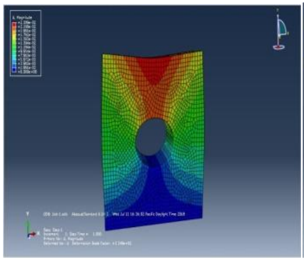
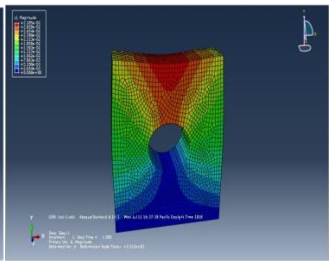


Figure 4: Load Applied

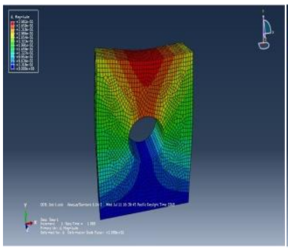
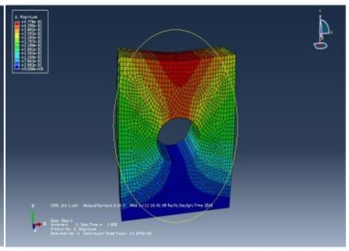
The displacement versus load curve generated and graph is obtained as shown below:

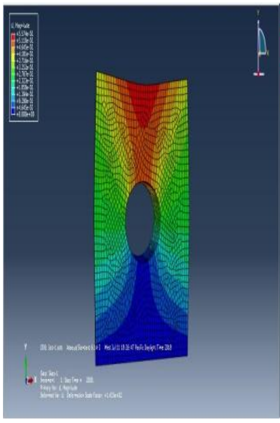
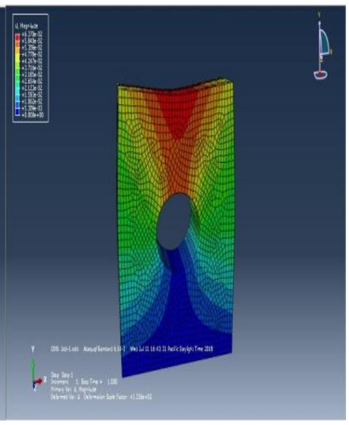
Case 1: 0.2 KN ***Case 2: 0.4 KN***

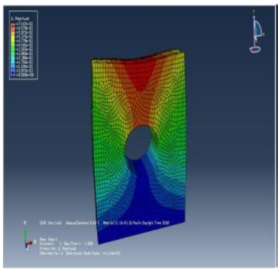
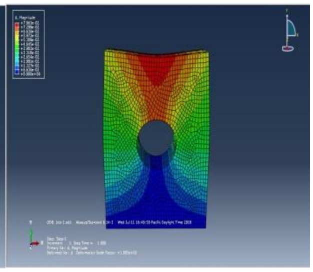
Case 3: 0.6 KN ***Case 4: 0.8 KN***

Case 5: 1 KN Load ***Case 6: 1.2 KN Load***

Case 7: 1.4 KN Load ***Case 8: 1.6 KN Load***

Case 9: 1.8 KN Load ***Case 10: 2.0 KN Load***

The graph showing the relationship between load applied and corresponding displacement is shown below:

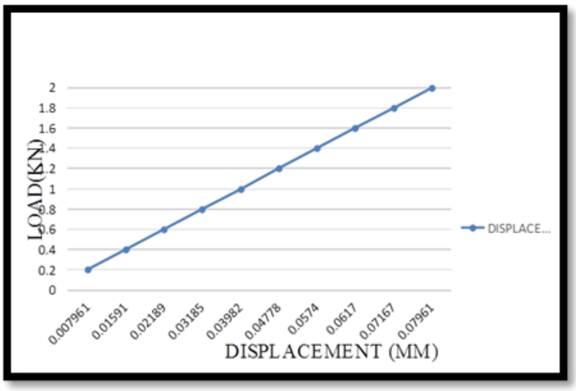


Figure 5: Load (KN vs Displacement (in mm)

As can be observed with the applied load there is a linear increase in the displacement, which conforms to the rigidity of the materials and efficiency of steel foam material.

IV. Compression Analysis:

The compression applied at 18.5 KN is shown in the below figure:

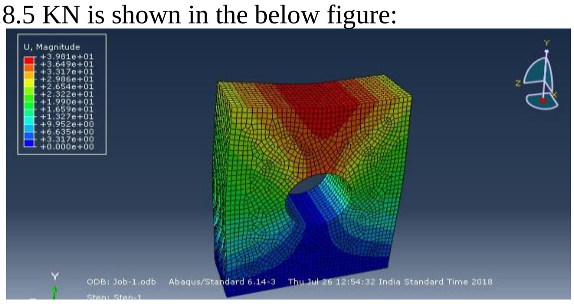


Figure 6: Compressive strength test in Abaqus simulia

The stress vs strain curve is given below:

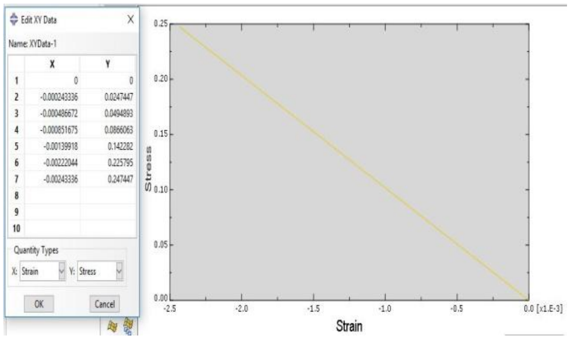


Figure 7: Compressive strength graph

V. Tensile Strength Analysis

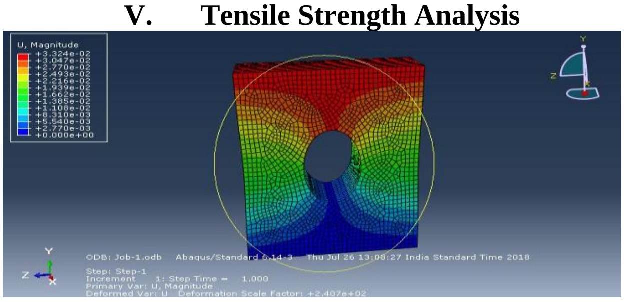


Figure 8: Tensile Strength Test at 20KN Load

The performance of the material in the form of a stress vs strain curve for tensile strength is as given below:

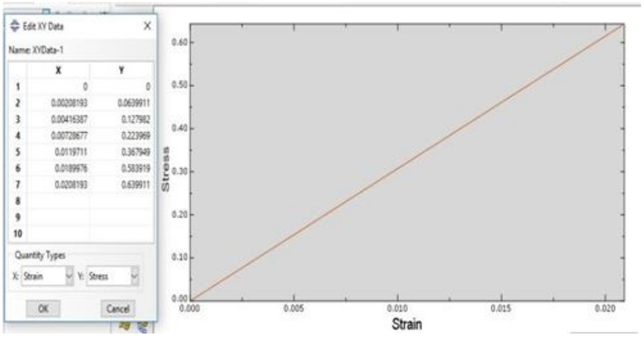


Figure 9:Stress vs Strain Result

The performance with respect to PUR foam the steel foam shows better result in terms of structural integrity with load applied. A comparison chart is as given below:

VI. Comparison Analysis

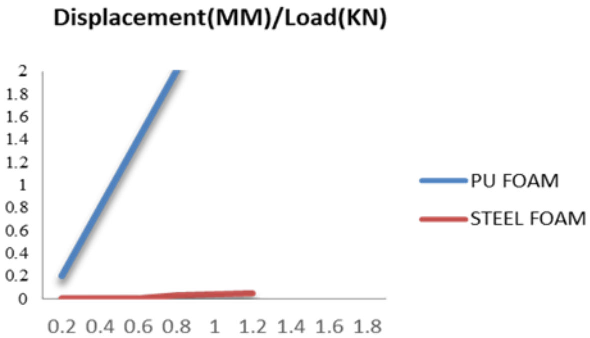


Figure 10: Comparison of PUR FOAM with Steel Foam

VII. Applications

1-Partition Wall
2-Slab
3-Mobile House
4-Interior etc.

VIII. Conclusion

1.Comparing with the results of the base paper for the applied load it is observed that the displacement in steelfoam is much less as compared to the PU foam for the same applied load under same condition on same geometry.

•2. For in the case 0.2Kn load, where Pur foam is approx. 0.2 mm, while in case of steelfoam it is .007961 mm and for the case of 1.2 Kn load the displacement observed in Pur foam is between 3 to 5 mm while in case of steelfoam it is .04778 mm.

•3.It is observed that the density of the steel foam is much less as compared to the steel block hence can be beneficial to reduce the weight of the structure due to its light weight.

Through this computational research guided by the requirements of potential future structural applications, a greater understanding of the mechanical properties of steel foam has been reached and analysis has been presented to show the load handling capabilities of steel foam. The compressive strength and tensile strength of the steel foam material has also been found to be higher. Thus, the usage of steel foams and further research into the mechanical properties can be envisaged as a future work.

Acknowledgements

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