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NUMERICAL INVESTIGATION ON AUXETIC STRUCTURES AND THEIR EFFECT IN IMPACT AND BLAST LOAD

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Abstract - Material with a negative poisson's ratio is termed as auxetic materials. A negative poisson's ratio implies a lateral strain under application of load, that is it expand laterally when under tensile load and contracts under compression loading.
This study aims to investigate the effect of structural, impact and blast load on auxetic structures through a numerical simulation using ANSYS workbench 2022R1.
In the preliminary stage of study a three dimensional finite element model of conventional beam and auxetic beam with different shape like square, star and chiral structure with a counter-rotational core cell is developed. In the next phase, the behavior of conventional beam and auxetic beam under structural and impact load is analysed. And the results are compared. In the final stage of study, a optimal auxetic beam is obtained.

Key Words: *Auxetic structures, structural load, impact load, , Finite element model, ANSYS*

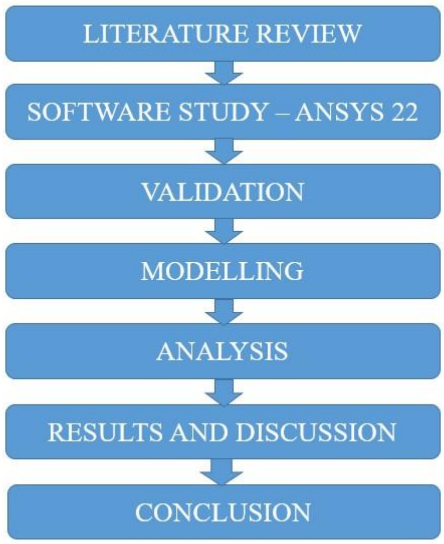
1.INTRODUCTION

From the daily life experience, when the material is stretched, the material not only becomes longer in the direction of stretch but also becomes thinner in cross-section. The behavior of the material in this case under deformation is governed by one of the fundamental mechanical properties of material, that is, Poisson's ratio.
Poisson's ratio of a material is the ratio of the lateral contractile strain to the longitudinal tensile strain for a material undergoing tension in the longitudinal direction; that is, it shows how much a material becomes thinner when it is stretched. Therefore, most of the materials have a positive poisson's ratio. In case of counterintuitive behavior of auxetic material, it undergoes lateral expansion when stretched longitudinally and becomes thinner when compressed.
The network is deformed by hinging of the ribs forming the network in case of honeycomb structure. It is observed that, for individual cells having the conventional hexagonal geometry, the cells elongate along the y -axis and close up along the x -axis in response to stretching the network in the y -direction, giving a positive. By maintaining the same deformation mechanism (rib hinging) but modifying the honeycomb cell geometry to adopt the reentrant structure, the cells of the network now undergo elongation both along and transverse to the direction of applied load in Fig.1.1. Hence the reentrant honeycomb deforming by rib hinging is an auxetic structure. Generally this structure is anisotropic; that is, the value vof when loaded along the x -direction (vxy) differs from that when loaded along the y -direction (vyx). The theory of elasticity is scale-independent and so the structure that is deforming may be at a macroscopic or microstructural level, or even at the mesoscopic and molecular levels.

2.OBJECTIVES

- To study the effect of structural load on conventional beam, square auxetic beam, star auxetic beam and chiral structure with a counter-rotational core cell auxetic beam
- To study the effect of impact load on conventional beam, square auxetic beam, star auxetic beam and chiral structure with a counter-rotational core cell auxetic beam
- To compare conventional beam and auxetic beam

3.METHODOLOGY



4.MODELLING

Numerical modelling plays a key role in structural engineering during the design stage in order to anticipate the structural behaviour and during the service life of an already built structure in order to evaluate its current performance

Conventional beam of size 3800×1000mm is modelled in ANSYS software. Auxetic structure of different shape like square, star, chiral structure with a counter-rotational core cell are provided with rib thickness of 2mm and cell angle 60°. There are 3 models in total including conventional beam and its description is given below

Table 4.1 Model name and description

Model name	Model description
CB	Conventional beam
SQ	Square shape
ST	Star shape
CH	Chiral structure with a counter-rotational core cell

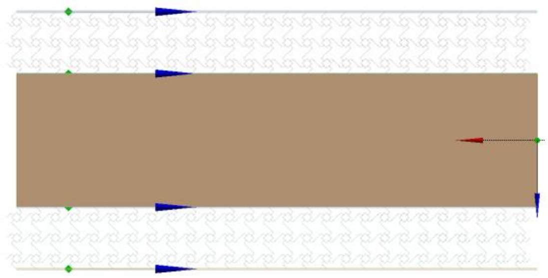


Fig. 4.2 Assembly of beam on ST auxetic beam

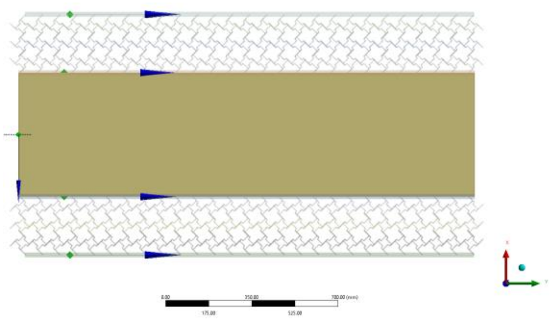


Fig. 4.3 Assembly of beam on CH

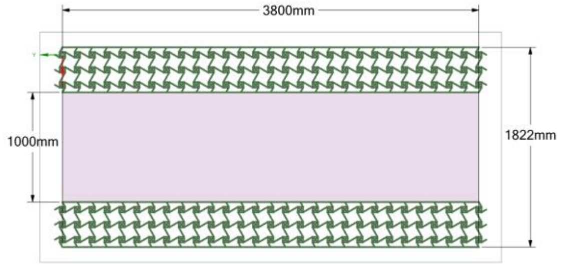


Fig. 4.5 Assembly of beam on SQ auxetic beam

5. STRUCTURAL ANALYSIS

Stress due to static structure was analyzed by using ANSYS software. A uniform load of 1000N is applied to different models.

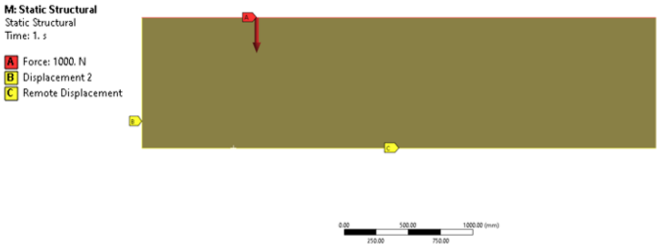


Fig. 5.1 Boundary condition for CB

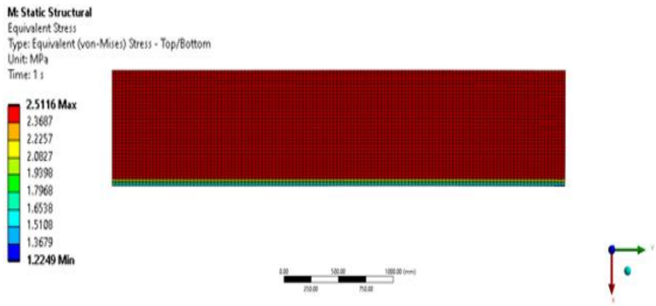


Fig. 5.2 Equivalent stress of CB

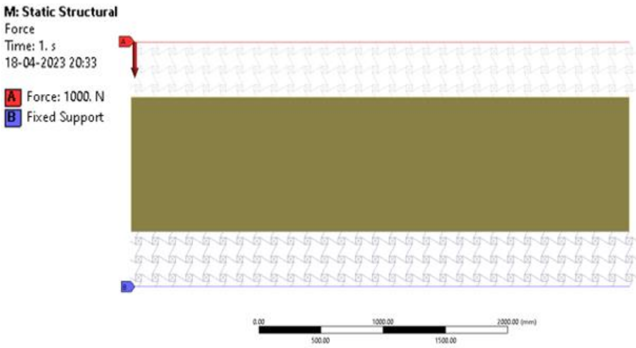


Fig. 5.3 Boundary condition for auxetic structure

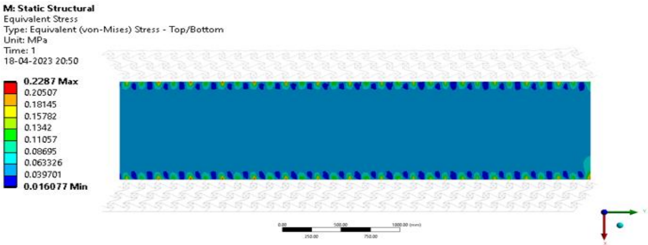


Fig. 5.4 Equivalent stress of SQ

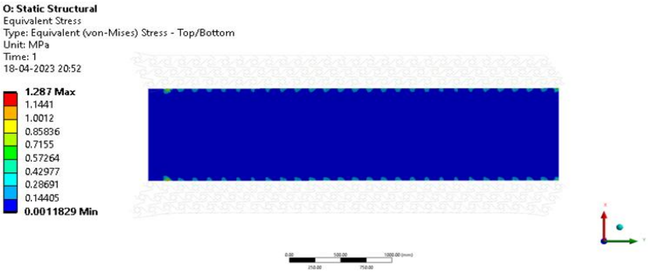


Fig. 5.5 Equivalent stress of ST

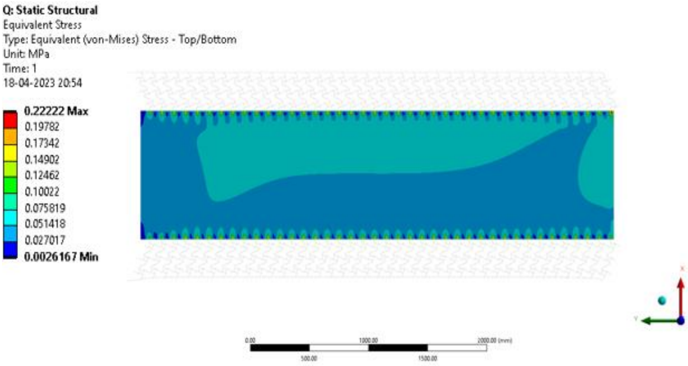


Fig. 5.6 Equivalent stress of CH

6. IMPACT ANALYSIS

Stress due to impact was analyzed by using ANSYS software. A load is dropped to the ground from a height of 1m. For impact analysis explicit dynamics is used.

Fig. 6.1 Boundary condition for CB

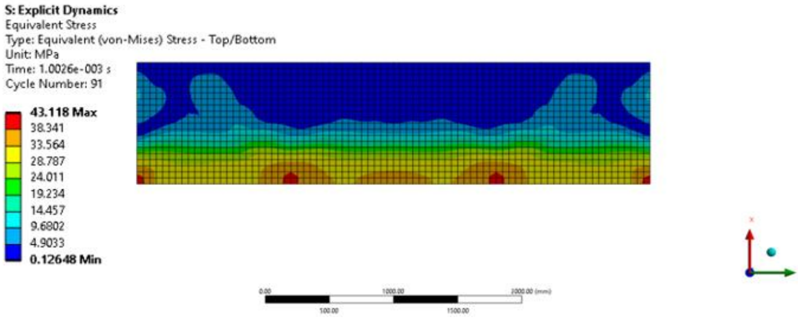


Fig. 6.2 Equivalent stress of CB

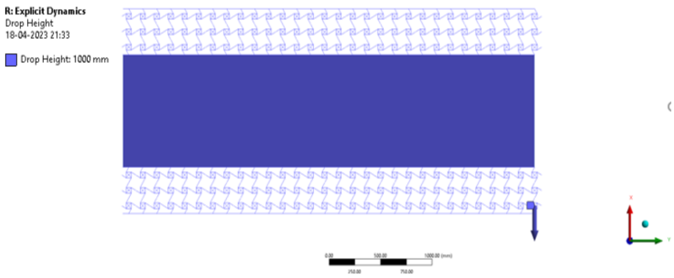


Fig. 6.3 Boundary condition for auxetic structure

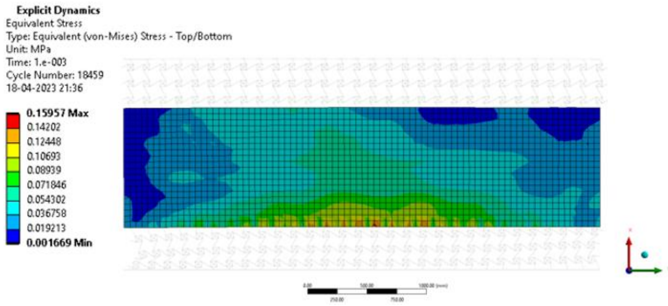


Fig. 6.4 Equivalent stress of SQ

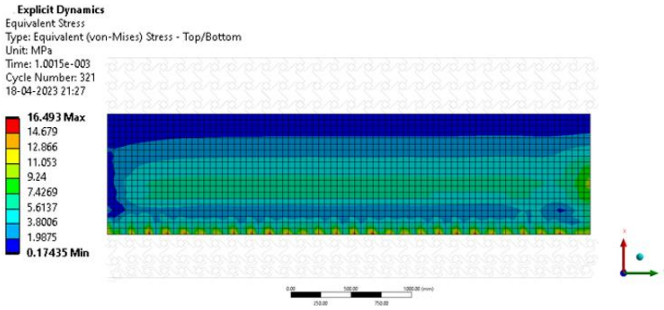


Fig. 6.5 Equivalent stress of ST

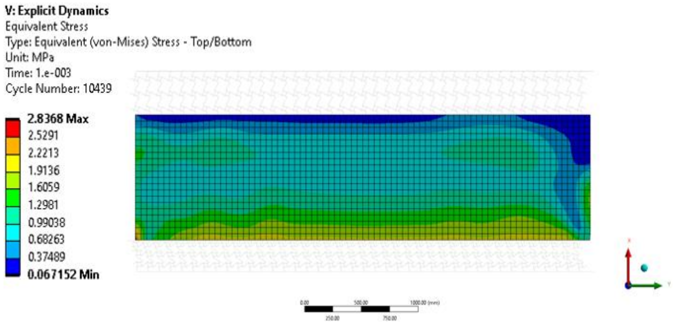


Fig. 6.6 Equivalent stress of CH

7.RESULTS AND DISCUSSION

In this project, a total of 3 auxetic beam specimen and a conventional beam were analyzed to examine the behavior of beam under different loading conditions such as structural load, impact load and blast load.

Under structurally applied load conventional beam shows a stress of 2.51MPa. Auxetic beam of specimen SQ shows a stress of 0.22MPa under structural load i.e, it shows 91.24% decrease in stress compared to conventional beam. Auxetic beam of specimen ST shows a stress of 1.28MPa under structural load i.e, it shows 49.04% decrease in stress compared to conventional beam. Auxetic beam of specimen CH shows a stress of 0.22MPa under structural load i.e, it shows 91.24% decrease in stress compared to conventional beam.

Table 7.1 Percentage decrease in stress under structural load

Model name	Equivalent stress (MPa)	Decrease in stress (%)
CB	2.51	-
SQ	0.22	91.24
ST	1.28	49.04
CH	0.22	91.24

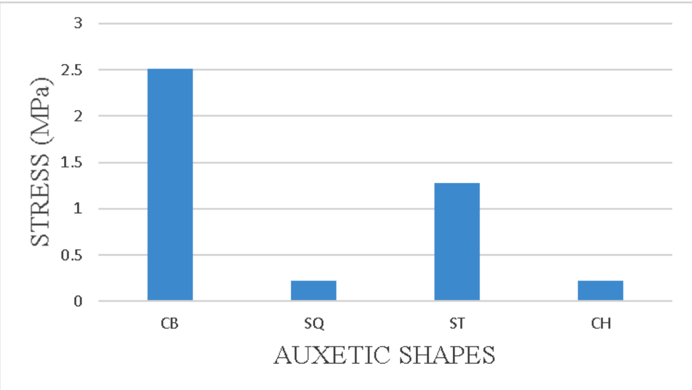


Fig. 7.1 Graphical representation of stress under structural load

Under impact load conventional beam shows a stress of 43.118MPa. Auxetic beam of specimen SQ shows a stress of 0.159MPa under impact load i.e, it shows 99.63% decrease in stress compared with conventional beam. Auxetic beam of ST shows a stress of 16.493MPa under impact load i.e, it shows 61.75% decrease in stress compared with conventional beam. Auxetic beam of specimen CH shows a stress of 2.836MPa under impact load i.e, it shows 93.42% decrease in stress compared with conventional beam.

Table 7.2 Percentage decrease in stress under impact load

Model name	Equivalent stress (MPa)	Decrease in stress (%)
CB	43.118	-
SQ	0.159	99.63
ST	16.493	61.75
CH	2.836	93.42

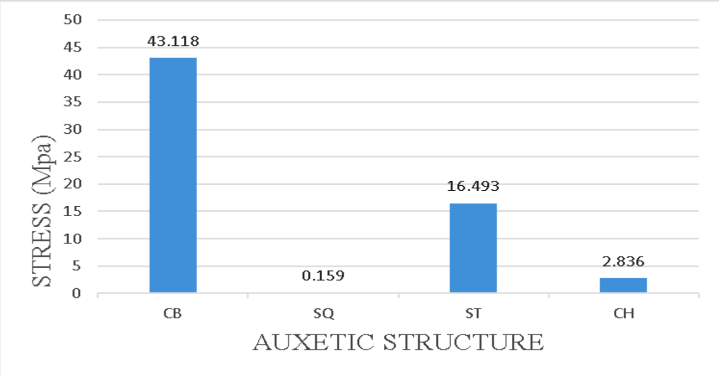


Fig. 7.2 Graphical representation of stress under impact load

8.CONCLUSION

A conventional beam and auxetic beam of different shape was modelled and different loading conditions were analysed using ANSYS. Auxetic beams of different shape like SQ, ST and CH shows a decrease in stress compared to conventional beam under structural and impact. Among different auxetic beam SQ shows a better result. SQ shows 91.24% and 99.63decrease in stress under structural and impact load.

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REFERENCES

[1] A. Alderson, K.E. Evans (2012) Microstructural modelling of auxetic microporous polymers, Material science

[2] Alderson A and Alderson K L (2007) Auxetic materials, Proc. Inst. Mech. Eng. Part G J. Aerosp. Eng. 221 565–75

[3] Alderson A and Evans K E (2004) Rotation and dilation deformation mechanisms for auxetic behaviour in the α-cristobalite tetrahedral framework structure, Phys. Chem. Miner. 28 711–8

[4] Alderson K L, Simkins V R, Coenen V L, Davies P J, Alderson A and Evans K E (2005) How to make auxetic fibre reinforced composites, Phys. Status Solidi B Basic Res. 242 509–18

[5] Andres Diaz, Juan Carlos Alvarez Elipe (2012) Comparative study of auxetic geometries by means of computer-aided design and engineering, Research Gate

[6] Avellaneda M and Swart P J (1998) Calculating the performance of 1–3 piezoelectric composites for hydrophone applications: An effective medium approach

[7] Bouaziz O, Masse J P, Allain S, Orgéas L and Latil P (2013) Compression of crumpled aluminum thin foils and comparison with other cellular materials, Material science

[8] Bulanov A V and Bludova O A (2017) Using auxetics for designing the coronary vessels stents Politech, Student J.

[9] Caddock B D and Evans K E (1989) Microporous materials with negative Poisson’s ratios. I. Microstructure and mechanical properties J. Phys. D. Appl. Phys. 22 1877–82

[10] Choi J B and Lakes R S (1991) Design of a fastener based on negative Poisson’s ratio foam Cell polymer Composite material