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Experimental Testing Of Flexural Mechanism Made Using Additive Manufacturing

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ABSTRACT

In this work a flexural mechanism are designed using data from the base paper and manufactured using 3d printing and are tested for flexibility, the flexibility is measured in terms of deformation under load and using a graph sheet setup, for fabricate the mechanism poly-lactic acid material is used, and is fabricated on a 3D printer, these models are developed using Catia v5. The results are validated using Ansys simulation results.for making the specimen's printable there are scaled to 25%(75 mm) of their original size (300mm).

INTRODUCTION

The challenge of designing many engineered components is not to maximize their rigidity but to build in an appropriate level of obedience or flexibility. In automotive applications, for example, a next-generation bumper or body panel would absorb and cushion the low-speed impact of an undetected obstacle, a child's toy, or a pedestrian and spring back into its original shape repeatedly without harmful itself or the obstacle. For military, sports, or prosthetic applications, exoskeletons would absorb energy from impact or store and release energy after ground contact as a supplement to human drive.

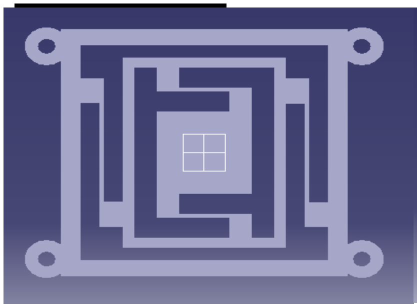
Motivated by these and other types of applications, we are designing and fabricating compliant structures from cellular materials. Cellular materials are materials with planned microstructure in the method of topological preparations of compact base material and voids with characteristic length scales on the order of micrometres to millimetres. Many natural materials such as wood and bone have cellular configurations that serve several functions, including transport, dispersal, flexibility, and lightweight strength. In engineering applications, metallic cellular or honeycomb materials are used in aerospace sandwich structures for lightweight stiffness, strength, and impact absorption, and polymeric cellular materials or bubbles are used for thermal insulation and packaging. In most commercial and research applications, structural cellular materials are intended either to deliver stiffness or to absorb impacts via permanent plastic deformation and collapse.

LITERATURE REVIEW

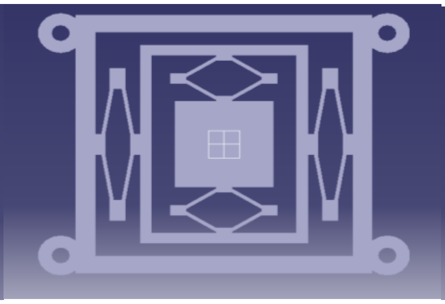
Compliant mechanisms are mechanisms that transmit motion, force or energy by elastic deflection of flexural members instead of movable joints (Howell, 2001). Most of the conventional mechanisms have rigid links and joints to transmit motion and force, and a spring to store and release elastic energy as needed. In other words, movable parts and parts storing elastic energy are separated in conventional mechanisms. In compliant mechanisms, on the other hand, the parts that deform also store elastic energy thus eliminating the need for a separate spring. They have some obvious advantages over conventional mechanisms (Howell, 2001). They do not have joints and thus most of them are available in one piece, which saves on assembly costs. Furthermore, the absence ofbacklash, friction and wear associated with joints in conventional mechanisms are almost negligible in compliant designs. Compliant mechanisms are useful in micromachined applications where fabricating the joints is difficult and failure is often associated with friction and wear in the joints.

The many advantages associated with compliant mechanisms notwithstanding, there are a number of difficulties associated with their design. Traditional kinematics itself is quite insufficient and it usually has to be combined with elastic deformation theory. As compliant mechanisms undergo large displacements, geometric nonlinear effects are to be included in the elastic analysis. Stress concentration effects have to be considered in thin and narrow regions. Howell and Midha (1994) have presented a pseudo-rigid body model for designing compliant mechanisms with small-length flexural pivots. Ananthasuresh (1994) and others have synthesized compliant mechanisms via topology optimization. Subsequent efforts have made use of geometric nonlinearity in finite elements for topology optimization to synthesize large-deflection compliant mechanisms (Saxena and Ananthasuresh, 2001; Pedersen and Sigmund, 2001). In this thesis, topology optimization is used for generating compliant displacement-amplification mechanisms (DaCMs) for sensor applications.

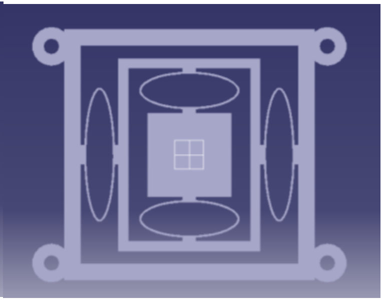
MODELING



Stiffener model



Trapezoidal model



Elliptical model

Slicing details

Software - Ultimaker Cura

Layer height - 0.2 mm.

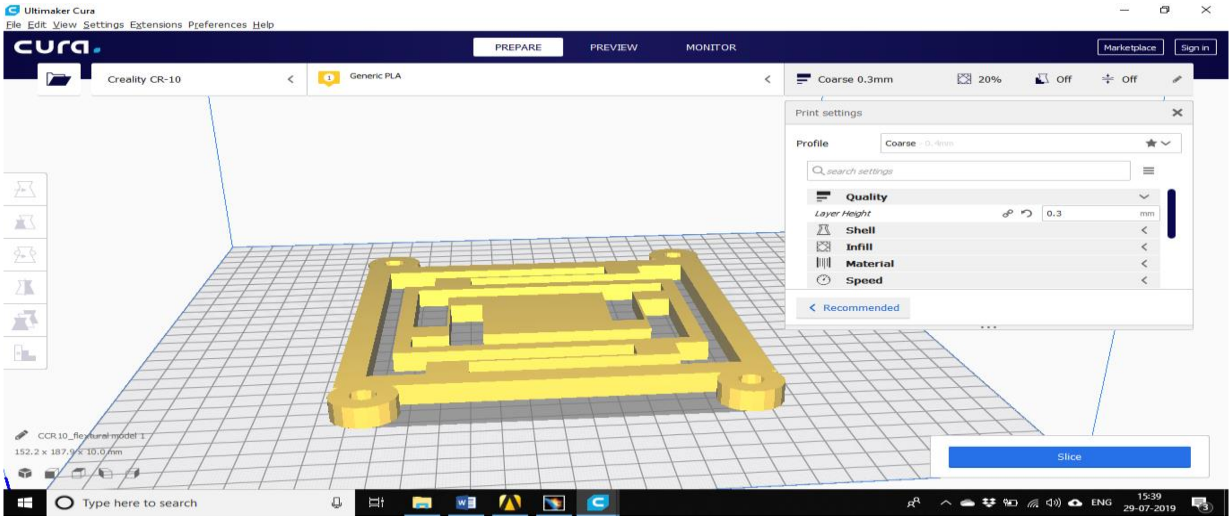
Wall thickness - 0.8 mm.

Material – PLA.

Bed temperature – 60 C.

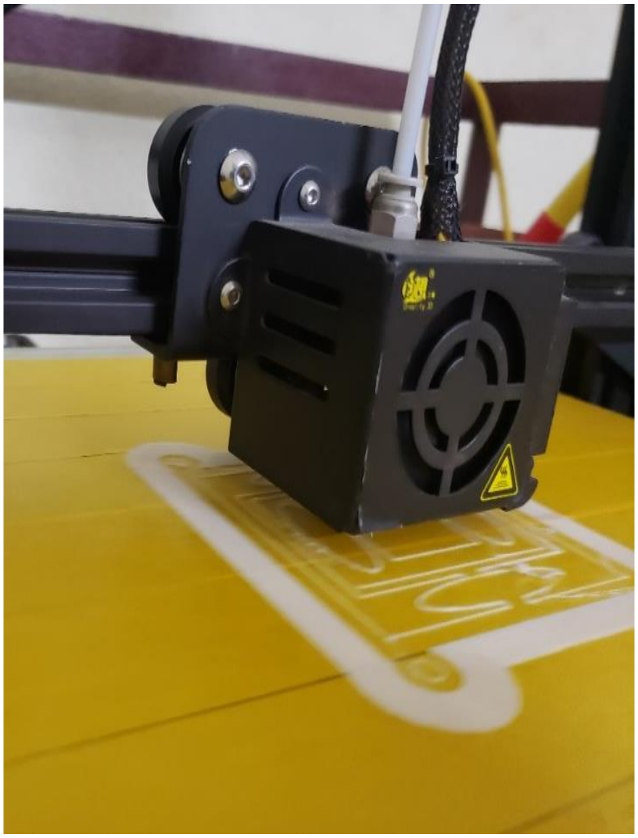
Nozzle temperature -200 C.

Model

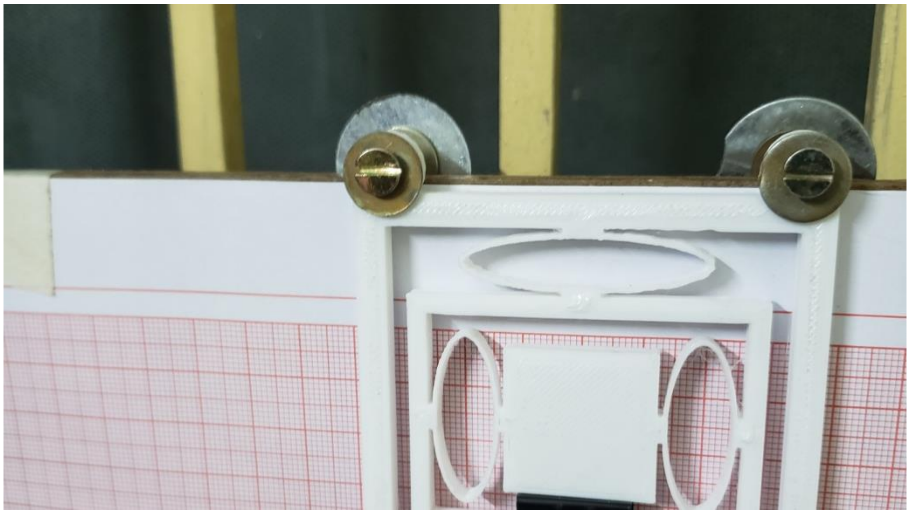


Creality CR-10
Generic PLA
Coarse 0.3mm
20%
Off
Off
Profile: Coarse - 0.4mm
Layer Height: 0.3 mm
CCR10_flextural model 1
152.2 x 187.9 x 10.0 mm

Model after importing into



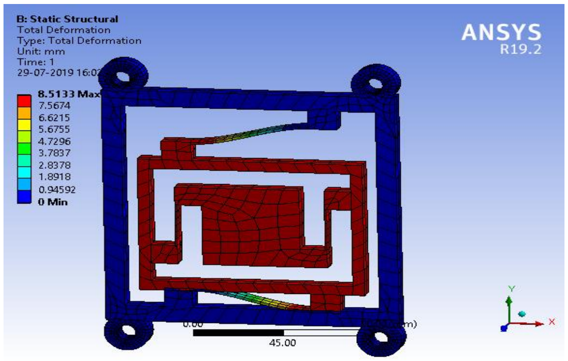
Preview of printing initial layer



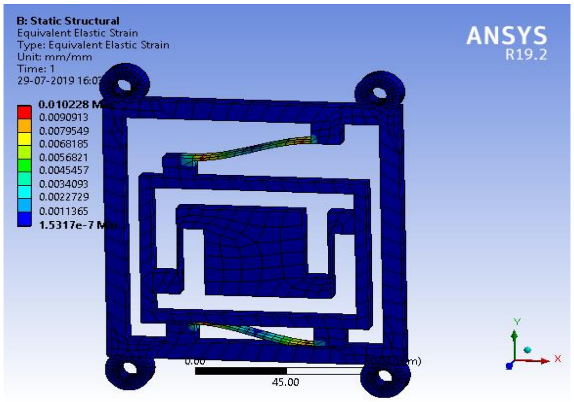
After arranging the graph paper under the specimen for taking readings

Static structural analysis of model with web stiffener (X direction)

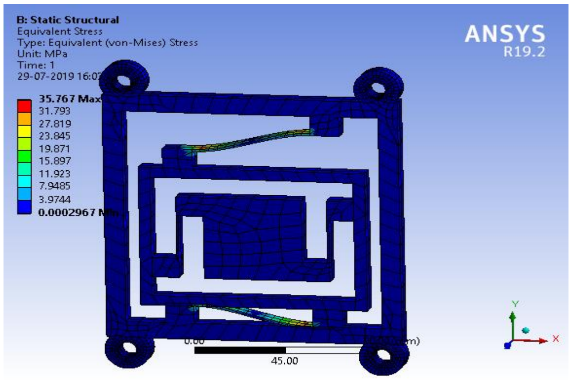
Total deformation



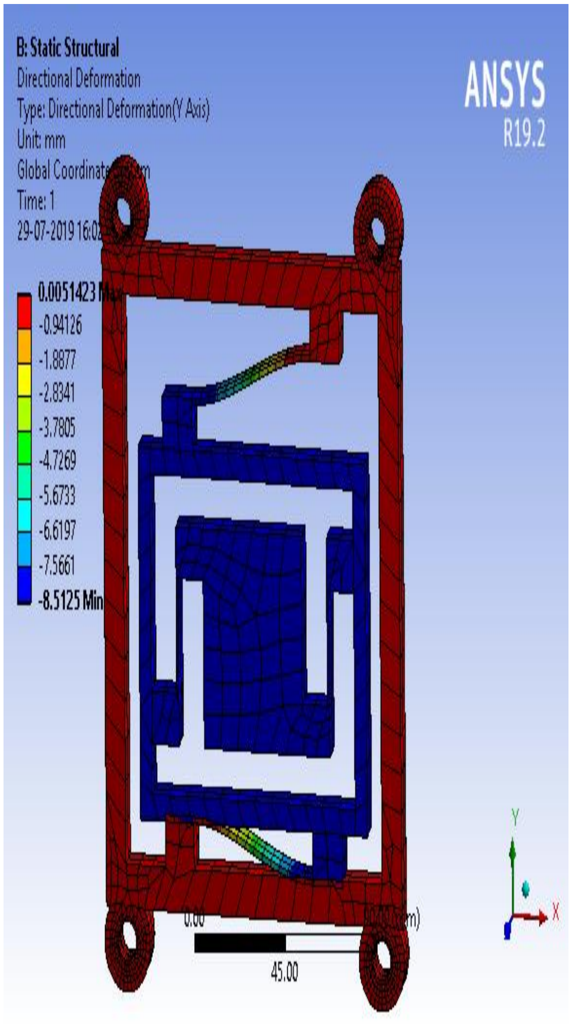
Elastic strain



Equivalent stress



Directional deformation



REPORT

Experimentation results Tables

X direction loading model	experimentation
web stiffener	7
elliptical stiffener	3.6
trapezoidal stiffener	2.2

Table

Y direction loading model	experimentation
web stiffener	5
elliptical stiffener	2
trapezoidal stiffener	2

Table

Simulation results Tables

X direction loading	deformation(mm)		directional deformation(mm)		elastic strain(mm/mm)		equivalent stress(Mpa)	
model	min	max	min	max	min	max	min	max
web stiffener	0	8.5133	-8.5125	0.005142	1.53E-07	0.010228	0.000297	35.767
elliptical stiffener	0	4.367	-4.3666	0.003148	1.51E-07	0.007023	0.000522	24.539
trapezoidal stiffener	0	3.9151	-3.7651	0.003139	1.60E-07	0.00574	0.000552	19.73

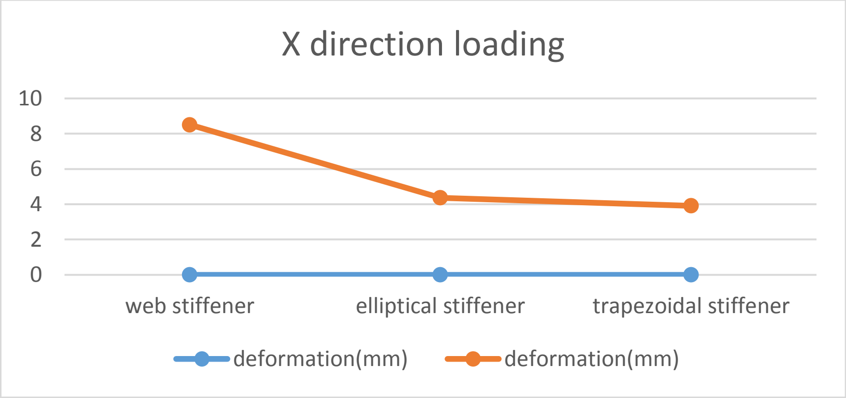
Table

Y direction loading	deformation(mm)	directional deformation(mm)	elastic strain(mm/mm)	equivalent stress(Mpa)

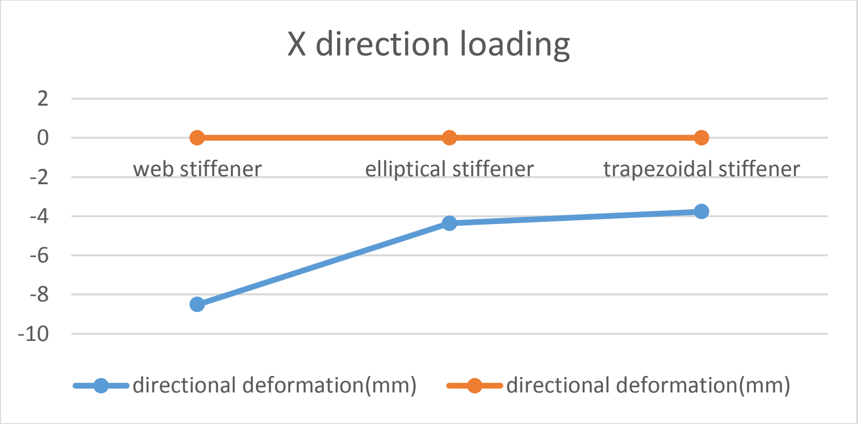
model	min	max	min	max	min	max	min	max
web stiffener	0	4.5914	-0.00329	4.5863	8.97E-08	0.015195	0.000285	52.949
elliptical stiffener	0	2.3839	-0.00713	2.3838	2.14E-08	0.003197	4.62E-05	11.19
trapezoidal stiffener	0	1.8459	-0.00524	1.4595	1.64E-08	0.003426	5.70E-05	11.956

Table

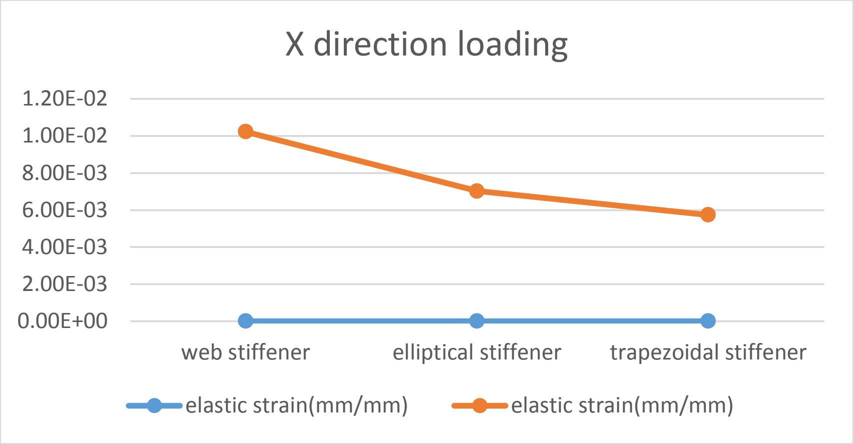
GRAPH



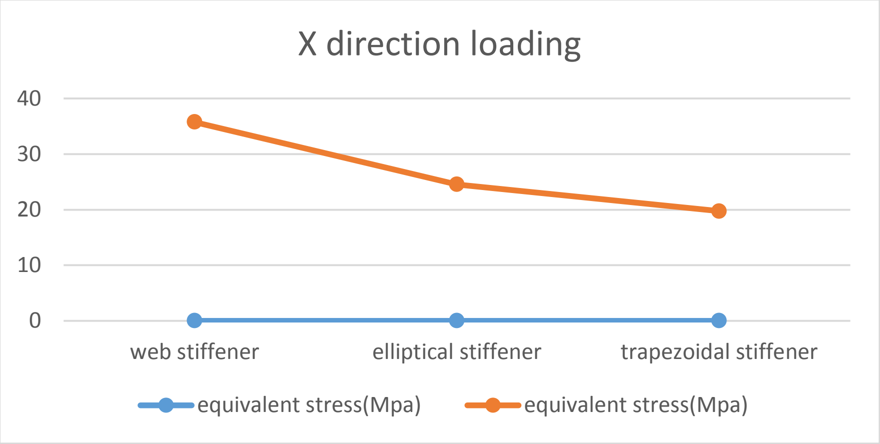
Total deformation



Directional deformation



Elastic strain



Equivalent stress

COMPARISON

Table

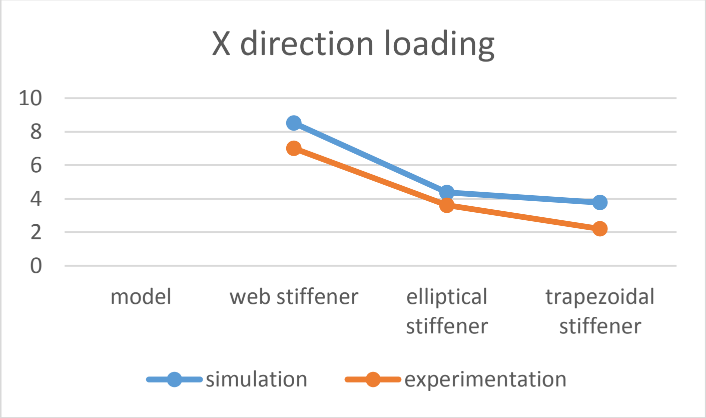
X direction loading model	simulation	experimentation	Deviation in results (%)
web stiffener	8.5125	7	17.76798825
elliptical stiffener	4.3666	3.6	17.55599322
trapezoidal stiffener	3.7651	2.2	41.56861704

Y direction loading model	simulation	experimentation	Deviation in results (%)
web stiffener	4.5863	5	9.020343196
elliptical stiffener	2.3838	2	16.10034399

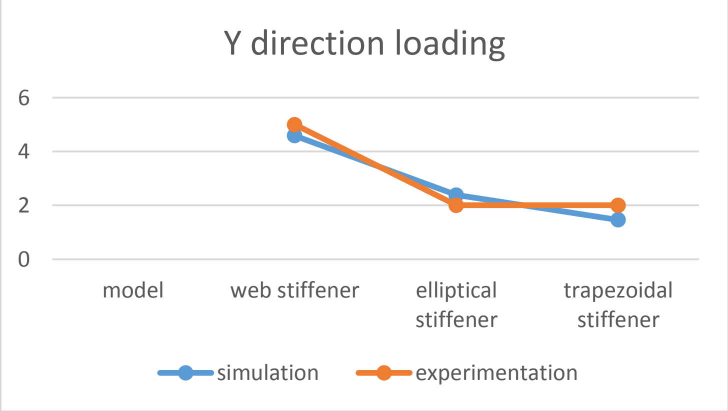
trapezoidal stiffener	1.4595	2	37.03323056

COMPARISON

GRAPH



Comparison between simulation and experimentation results



Comparison between simulation and experimentation results

CONCLUSIONS

This study is mainly concentrated on the behavior of the compliance cellular structures with varying configurations of stiffeners. Compliance cellular mechanisms play a very crucial role in modern sciences, they find their applications in aerospace bionics and robotics etc. in this work three different geometries of cells are studied with different configurations of the stiffeners, both practically and through simulation, below are the observations are made from the simulation study. The following observations are made from the study

1. Web stiffeners are very flexible and are meant for large deformations
2. Lowest deformations occur in trapezoidal model
3. Deformations in elliptical model during experimentation are similar to deformations of trapezoidal model

4. But simulations are a different story, according to simulation results trapezoidal model deformations are much less
5. When we compare the stress and strains in the models they are very less in elliptical and trapezoidal models
6. Hence the life the two models will be high when compared with web model.

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