Indian Institute of Technology, Gandhinagar

Binary Stiffness Mechanism

Project Proposal

ES 221 Mechanics of Solid

February 2022

AUTHORS:

Complaint stiffeners

(Tutorial Section C)

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1 Problem Statement

In the practical world, miniaturization is needed in all of the mechanisms. It enhances efficiency, and miniaturization in smaller electronic devices enables higher frequency and clock rates. Also, micro-manufactured components are the basic root need for any mechanical mechanism. It could be helpful to increase the accuracy and speed of mechanisms. Generally, to use multiple stiffnesses in the real world, we have to combine multiple mechanisms in a single device to execute our purpose. Instead of using these variable stiffness mechanisms, we can use a binary stiffness complaint mechanism.

To make a mechanism that has two different states for stiffness. One state has a higher stiffness which resists deformation (or motion) for a high amount of force. The other state has very low stiffness (stiffness reduction of more than 95%). This state should allow a motion for a low amount of force.

Also, the mechanism should be:

- ❖ The two states should be generated by using mechanical logic.
- ❖ The mechanism should be made out of only a single material.
- ❖ The mechanism should not contain joints or pinned connections. In this way, it is easy to make this on a small scale.
- ❖ The mechanism should be planer and monolithic so that it can be miniaturized and also easily micro-manufactured.

2 Methodology

Our goal is to execute the whole project in three phases.

- ❖ Fabricating a specimen model to get hands-on experience
- ❖ Perform a closed-form analytical or numerical simulation related to concepts of this course
- ❖ Compare and do analyze the experimental data and simulate data to reach the conclusion

We will use 3D printing technology to fabricate our model. We will experiment with the 3D printed model in our research lab to collect empirical data. We will simulate our model in computer software to collect the computationally simulated data. We could do the same experiments in the software and make a data set. In conclusion, we will map and analyze both the datasets and observe the different possible results according to the ideal world scenario as well as the practical world scenario.

3 Schematics

Two different configurations of the structure

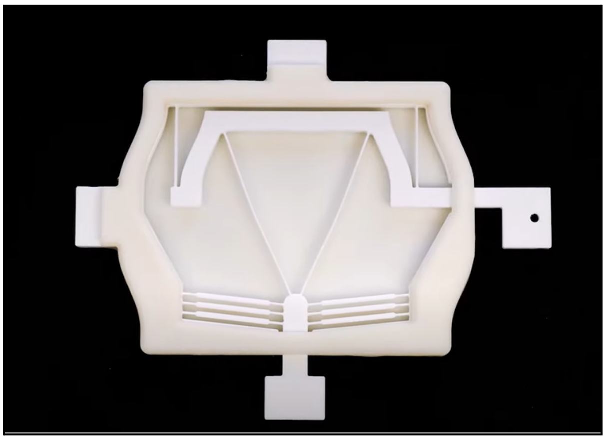
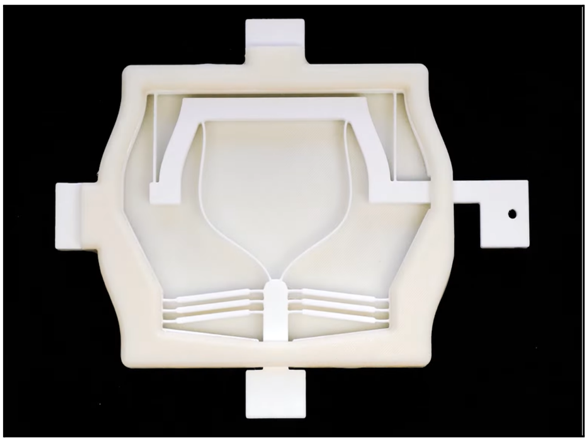
	
Position when the switch is closed.	**Position when the switch is open.**

Image Source

The three main components of the structure

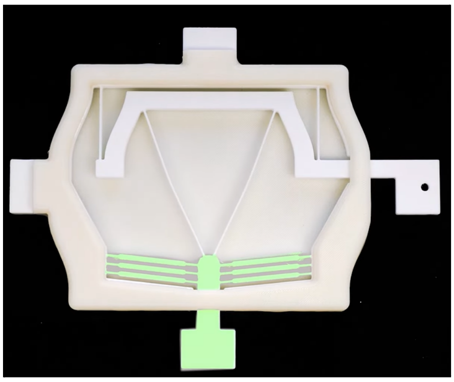
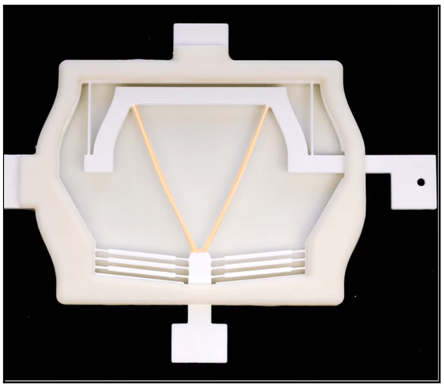
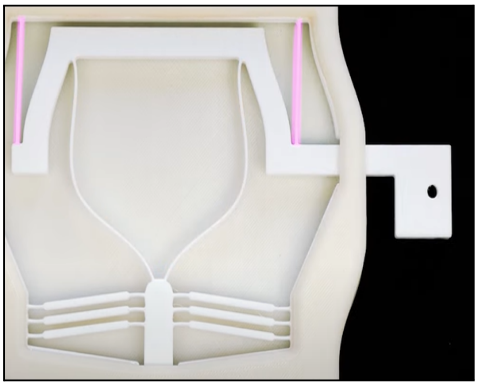
		
Bistable Switch	**Angled Flexures**	**Parallel Flexures**

Image Source

The diagram shown above is the "**Binary Stiffness compliant mechanism**" that can achieve two different stiffness states by triggering a simple switch. One state is very compliant, while the other state is very stiff.

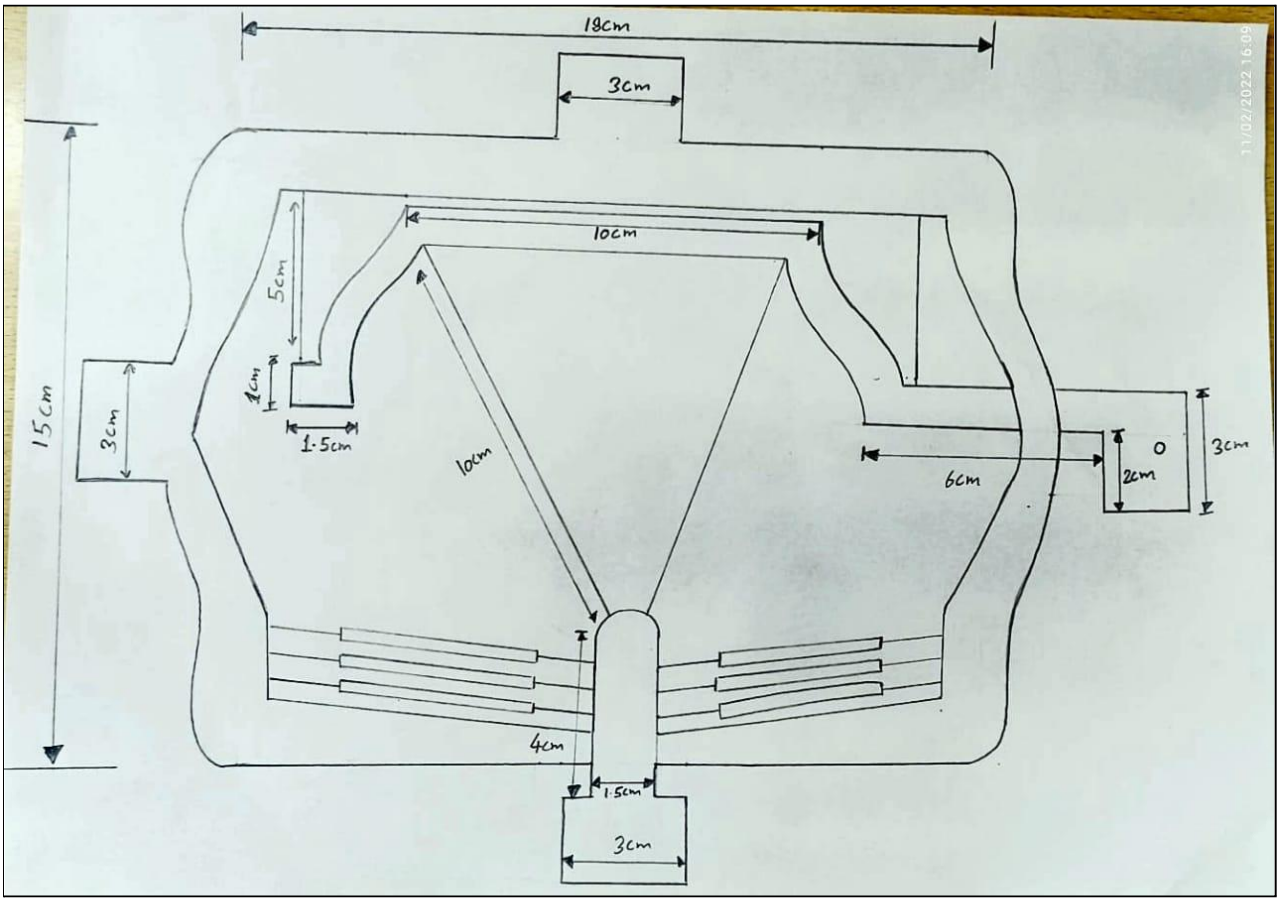
The mechanism consists of three components:-

- **Compliant bi-stable switch:** Can be triggered to achieve stability in two different resting positions
- **Two angled blade flexures:** Designed to buckle and curve outward when the switch is pressed inward.
- **Three parallel blade flexures:** These swiftly constrain the shuttle and thus restrict it from moving in any direction except along the direction perpendicular to their flat faces when the bistable switch is in its initial undeformed configuration.

Working Mechanism:-

- The angled blade flexors are straight and thus similar to a truss, swiftly constraining the shuttle so it cannot move along the direction permitted by the parallel blade flexures.
- Angled blade flexors buckle(bend) when the bistable switch is pushed inward.
- Thus they lose their constraint capabilities so that the shuttle can freely move with the translation along the desired direction.
- Moreover, the pre-stressed angled blade flexors exhibit negative stiffness in their curved configuration.
- The negative stiffness cancels out the positive stiffness exhibited by the parallel blade flexors, which results in a mechanism that achieves a near-zero translational stiffness.

4 Dimensions (Estimated)



5 Expected Results

We will be plotting the graphs of the Force vs. Displacement for the angular blade flexures and parallel blade flexures and then add them to get the combined blade flexure plot of Force vs. Displacement. We will predict these graphs based on the analysis performed with the help of software, and later on, we will see the difference between the actual result and the ones we predicted.

We will then look into the variation of stiffness and the plots when the bistable switch is triggered and compare it with the untriggered state.

- ❖ Force vs. Displacement for angular blade flexures
- ❖ Force vs. Displacement for parallel blade flexures
- ❖ Using the above result, predict the plot of Force vs. Displacement for combined blade flexures
- ❖ See if there is an interesting variation of stiffness

- All the above points will be checked for both triggered and untriggered bi-stable switch positions

From the data available and based on some research done by the group it appears that for the plots of the Force vs. Displacement will have a region of zero stiffness. This is the combined effect of buckling (negative stiffness) and positive stiffness of parallel blades. We will explain these results more elaborately using the graphs and software like ANSYS and SAP2000.

THE END