

ESEP-G 2025 Report

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Name	Tarshit Sehgal
Host professor	Prof. Higuchi Ryo
Home institution	Indian Institute of Technology Bombay
Department at your home institution	Aerospace Engineering
Date of your final presentation	30 July, 2025
Research topic	Origami-Inspired Deployable Space Structures with Programmable Bistability

Overview of your lab work and what you have learned

Project Overview:

My work was related to deployable space structures. One must have observed solar arrays being taken to space in a compact state for easy storage on Earth, and then opening up into something larger upon deployment in space. This is what I was trying to achieve, while also attempting to address some of the current challenges.

Currently, these types of deployable structures need to be opened using actuators and then require a locking mechanism to hold them in place. I looked into the possibility of using origami-inspired bistable structures, which can have a first compact stable state and a second deployed, expanded stable state. This way, there is no need for extra mechanisms to hold them in place.

To accomplish this goal, I studied the bistable behavior of the unit cell that would be used to create the larger structure. This unit cell is called the "Waterbomb Base."

My study focused on simulating the transition of the waterbomb base from its first stable position to its second stable position. I tried to model it accurately and validated my model by comparing the results with those from a previous study. Then I moved on to the next very important part of my study, which was to program the bistable behavior of the waterbomb base unit. This means designing a waterbomb base structure with the required first and second stable configurations, along with the energy barrier needed for the transition between those states. For this, I developed an algorithm using analytical formulations. To test whether this programmability actually worked or not, the analytical results were verified using FEA simulations, which showed a very good overlap.

The study was then extended to examine the behavior of variants of the waterbomb base structure and observe how bistability was affected.

The final step was to design our own structure made of these units, along with its deployment strategy. The FEA simulation of the entire structure is still in progress.

My learnings:

I always wanted to work with multistable structures, metamaterials, morphing structures, and possibly origami-inspired structures. This was something I had planned to work on at my home university, but thanks to my host professors here, I was able to work on a topic of my choice. So, the major learning was to work around these types of structures.

The second major learning was to use Abaqus CAE, the software I used for simulations. The scripting feature in this software allows for automation, which helped me bypass the effort of modeling different structures repeatedly.

Last but not least, I learned a lot about the way of thinking while doing research. During my meetings with professors, I paid a lot of attention to how they looked at my research work and what steps they suggested moving forward. I used to compare their mindset with mine and always tried to develop that same research-oriented mentality.

How do you imagine this experience benefitting you in the future?

I am planning to continue working on this project after returning to my home university, in consultation with my thesis advisor there. I had a discussion with Prof. Higuchi Ryo and Prof. Lu Xin, and both of them expressed interest in the possibility of extending this work and exploring a potential collaboration with IIT Bombay (my home university). They were very welcoming and open to supporting me in the future with this project.

Apart from the research experience, which will definitely help me in pursuing higher studies in the future, and the opportunity to observe how research is conducted at UTokyo, living in Tokyo itself has been an incredibly valuable experience. This exposure could be especially beneficial if I plan to return here for my master's or PhD. This experience of staying among international people at Hakusan House will also prepare me for my future if I go outside India for higher studies.

Other comments

I would like to thank UTokyo and Prof. Higuchi Ryo for selecting me for this program, which has truly been my best summer experience so far. I got to experience so many new things, especially since this was only my second international visit and my first time in Japan. I can definitely see growth in myself—from when I arrived to now, as I prepare to head back home across different aspects, academically, socially, and personally.

A special thanks to Ms. Yuki for her kind and accommodating nature. She managed this program so gracefully, from organizing the bus trip to Hakone, to the drum workshop and the Japanese language classes. I'm truly grateful for this entire experience, and I hope to come back here in the future for sure.

Comments from your host professor

Mr. Tarshit Sehgal has undertaken impressive numerical research on deployable space structures during his short stay with us. Despite the limited duration of his visit, he demonstrated remarkable initiative and productivity. He independently proposed an original research topic, actively collaborated with our team, developed and validated a robust numerical model, and successfully demonstrated the feasibility of an origami-inspired structure for potential space applications. We are confident in his capabilities and look forward to seeing how he further develops and expands his research upon returning to his home university.

Host professor's name (signature or seal)

