Ultra-Large Space Structure Design applying ORIGAMI Engineering

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Introductions

Space Solar Power Satellite (SSPS) is one of the ultra-large space structures whose concept was proposed more than 50 years ago. However, it is difficult to realize because of the structural scale. The International Space Station (ISS) is the representative example of large space structures, but its size (area) is almost equal to a soccer court (length:100 m, width: 70 m). On the other hand, the required size for the SSPS shown in Fig.1 is about 2.5 by 2.5 km on the side, which is on the order of kilometers. Furthermore, since transportation to space is essential, no matter how large the structure, it can only carry a volume that fits inside the rocket fairing (about φ4m x 10m for H-IIB). Therefore, it is necessary to fold a large-area structure compactly. (Only if you don't consider the space building. If space building and/or construction is possible, only materials will be transported, and the structural concept / design concept is a different way of thinking.) And not only volume but also weight is a transportation restriction. Therefore, in order to achieve a kilometer's scale SSPS, it is necessary to construct a large structure using a lightweight and a deployable structure, with as few launches as possible and assembly in space.

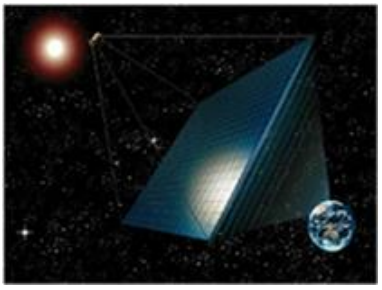

Fig.1 Space Solar Power Systems integrated power production and Supply ©Japan Space Systems

Fig.2 Origamis considering the paper thickness: Miura-Ori (Upper Left), Double Accordion Folding (Upper Right) and Spiral Folding (Lower Middle)

Foldable Plate Structures

Focusing on ORIGAMI and ORIGAMI Engineering, foldable and deployable space structures is researched. Fig.2 shows the packed configurations of the origami designed so that storage efficiency does not deteriorate due to the thickness of the paper. Even if it is thin like paper, the effect of its thickness cannot be ignored as the size of the structure increases. Therefore, it is important for space structures to fold them compactly by the folding patterns as shown in Fig.2. However, since antennas for SSPS are composed of panels that are thicker than paper, it cannot fold even if these folding methods are applied as they are. Therefore, the new folding pattern applying Miura-Ori for the plate structure is developed and its configuration is shown in Fig.3. By using this folding pattern, even thick objects such as blocks can be stored in the state shown in the figure below. Furthermore, this foldable plate structure is mounted on the microsatellite "HIROGARI" and has succeeded in demonstrating deployment in outer space.

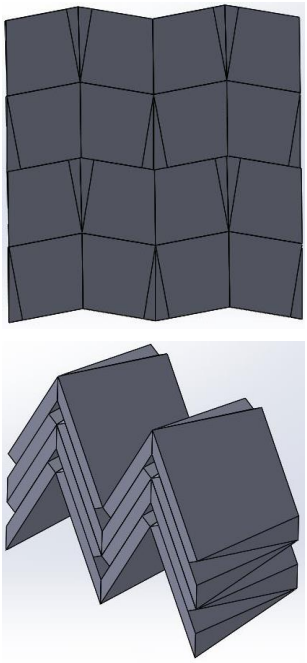

Fig.3 Foldable panel with Miura-Ori Pattern