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## LOW-COST AND LOW-IMPACT CARDBOARD FORMWORK

WASTE CARDBOARD AS AN ALTERNATIVE FOR  
SINGLE-USE CONCRETE FORMWORK

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### CONTEXT/PROBLEM

This work explores alternatives to single-use formwork for concrete-based construction and forming alternatives for housing in low-resource development contexts. Fully or partially prefabricated structures that employ reinforced concrete to make building elements typically depend on expensive formwork made of wood, plywood, or aluminum – materials that often end up in landfills after one use. These strategies are affordable for large-scale initiatives and routine construction in developed economies. There are, however, fewer forming options for professionals and self-builders working in low-resource environments. This research seeks to take advantage of the abundance of waste cardboard — and the material properties inherent in it — to design, fabricate, and test low-cost/low-impact formwork to support housing construction with elements made of concrete.

The work combines low-tech and low-skilled methods with high-tech and computational design methods and tools. The aim of the research is to design and prototype formwork produced with waste cardboard and sheet vinyl retrieved from the waste stream.

### METHODOLOGY

The first experiments consisted of designing Miura origami patterns and translating them to post-consumer cardboard sheets using a laser cutter. The Miura pattern allows the cardboard and/or vinyl surface to adjust to different panel sizes (Fig. 1). Next, we fabricated cardboard slabs and made a supporting mold to enclose the origami pattern (Fig. 2). In casting panels, the concrete mix is applied and vibrated by hand, and the formwork is removed after 48-72 hours. The resultant panels (pictured here) are approximately 16" x 30".

### RESULTS/FUTURE WORK

We performed two sets of experiments: one at Penn State and the second in Seoul, South Korea, using local waste cardboard and vinyl in both instances. Figures 2-4 shows the Korean prototype and how the formwork keeps its quality after repeated use (at this point in the experimentation, six panels were made using the same formwork). The system is easy-to-design, fabricated by hand and/or with a laser cutter, and uncomplicated to strip apart. The formwork is lightweight and easy to transport. Critically, the system uses materials retrieved from the waste stream — materials that replace new and expensive options without compromising the end product. The major challenge was to find the proper ratio for concrete preparation to obtain a uniform texture and clean finish.

Future work will focus on developing prototypes with different origami patterns and will test how to make the origami mold adjustable to cast panels of different sizes with the same mold. Another line of work is to develop an origami formwork for casting columns, beams, stairs, and blocks.

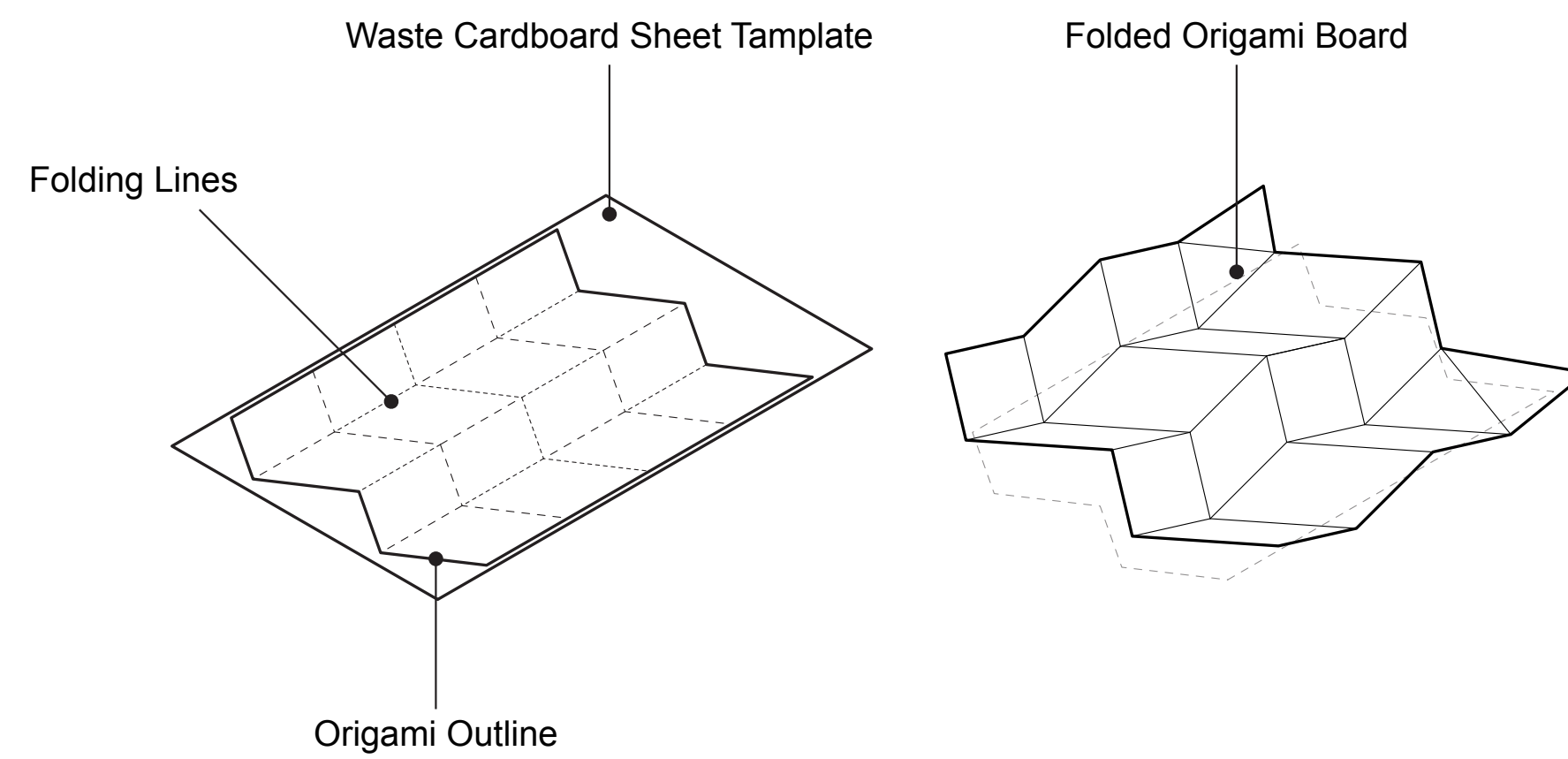


FIGURE 1: THE ORIGAMI PATTERN IS DESIGNED USING A PARAMETRIC TOOL AND THE SIZE IS DEFINED BY THE MATERIAL DIMENSION. THE TEMPLATE CAN BE USED TO CUT THE CARDBOARD BY HAND OR WITH A LASERCUTTER, IF AVAILABLE. ILLUSTRATION: J. DIARTE & E. VAZQUEZ

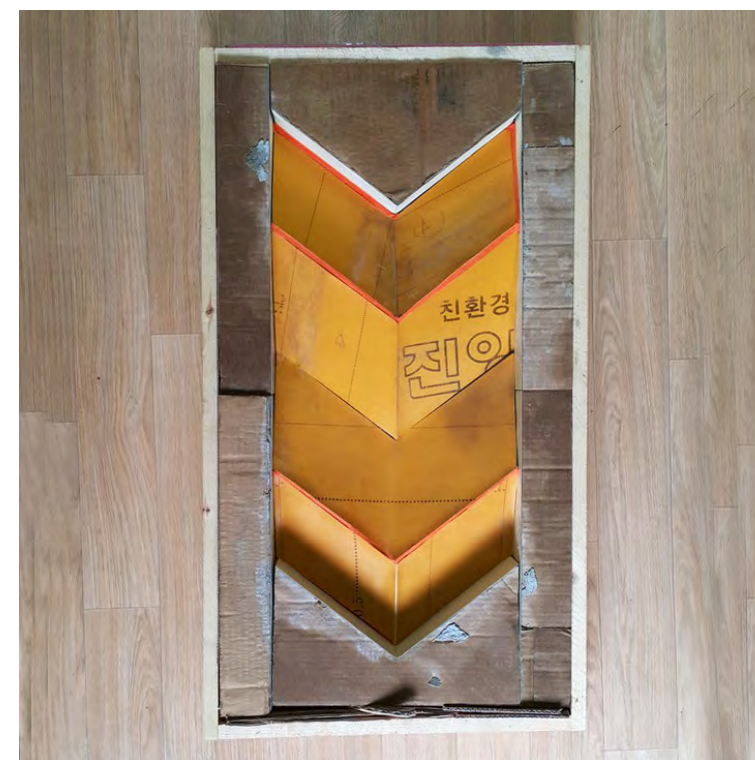


FIGURE 2: MIURA BOARD PATTERN WITH "ENCLOSING" SUPPORT MADE OF A CARDBOARD SLAB. PHOTO: M. SHAFFER



FIGURE 3: UNCASTING THE CONCRETE PANEL. PHOTO: M. SHAFFER



FIGURE 4: THE FORMWORK CAN BE REUSED SEVERAL TIMES THANKS TO THE KOREAN VINYL (OBTAINED FROM WASTE FLOORING VINYL). THE FORMWORK KEEPS ITS QUALITY FOR REUSE. PHOTO: M. SHAFFER



FIGURE 4: FINISHED PANELS AFTER UNCASTING. PHOTO: M. SHAFFER

