

Rigidly foldable Rotational Erection System (RES)

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Abstract

Rotational Erection System (RES) is a design method to make three-dimensional (3D) structure from a single sheet with systematic cuts and folds. It is Origami extended with cuts or Kirigami folded into 3D shapes (Figure 5). This study introduces a geometrical method to make RES rigidly foldable by adding a few crease lines to the typical cut and crease patterns of RES (Figures 1,2). The result of numerical analysis of the folding sequences suggested the method is applicable for structures with rigid elements. The analysis is also useful to design non-rigid foldable RES with stiffer materials such as sheet metal to control the bi-stable characteristics and elastic limit of live hinges. It can be used for fabrication method to fold RES in sheet metal to keep hinges at arms in elastic state and to enforce the hinges at hub-tab, tab-arm and tab-base to plastic deformation (Figure 3).

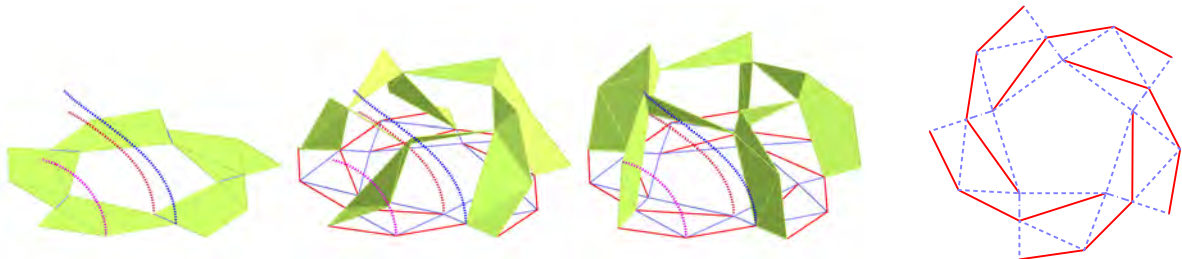


Figure 1: Pentagonal rigidly foldable RES with flat arms:
folding sequence and cut & crease pattern ($\alpha=72^\circ$, $\beta=90^\circ$)
three curves: locus of vertices, the hub is not shown.

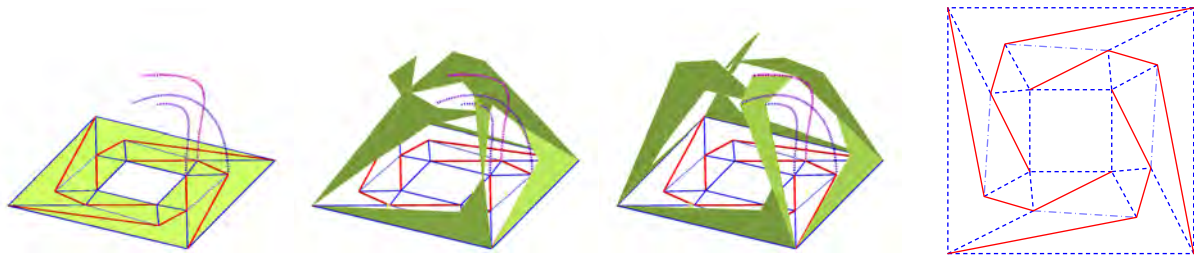


Figure 2: Square rigidly foldable RES with angle arms:
folding sequence and cut & crease pattern ($\alpha=90^\circ$, $\beta=60^\circ$)
three curves: locus of vertices, the hub is not shown.

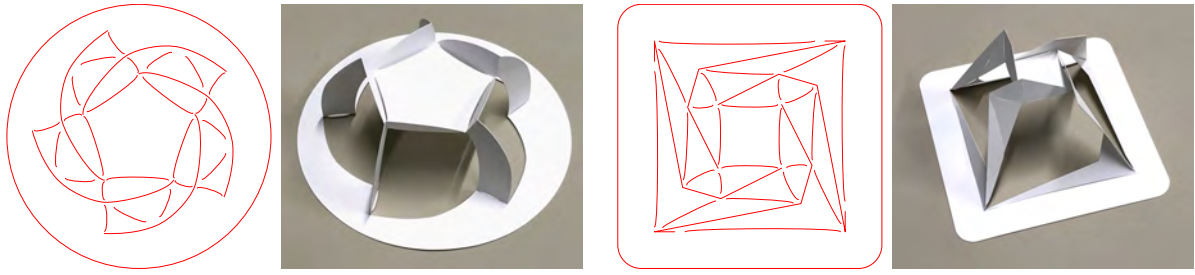


Figure 3: Sheet fabrication with rigidly foldable RES
cut patterns and paper prototypes

left: pentagonal hub ($\alpha=72^\circ$, $\beta=90^\circ$, 90mm dia.), right: square hub ($\alpha=90^\circ$, $\beta=60^\circ$, 90mm sq.)

Another method for rigid foldable RES is to add cuts and creases on the hub. This method is useful in cases that need to avoid additional crease on arms (Figure 4).

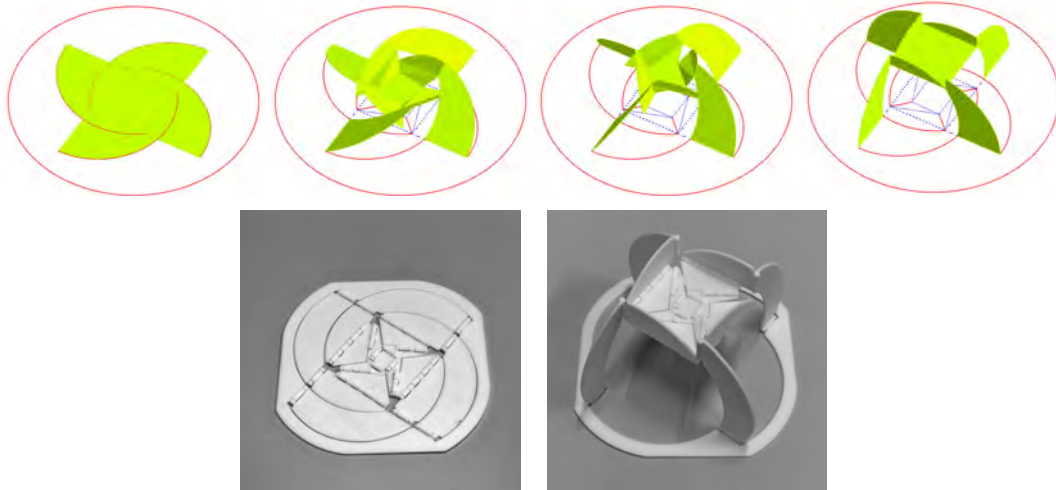


Figure 4: Rigidly foldable RES with cuts and crease in the hub ($\alpha=90^\circ$, $\beta=90^\circ$):
top: folding sequence, bottom: FDM 3d printed model (120 x 120 mm)

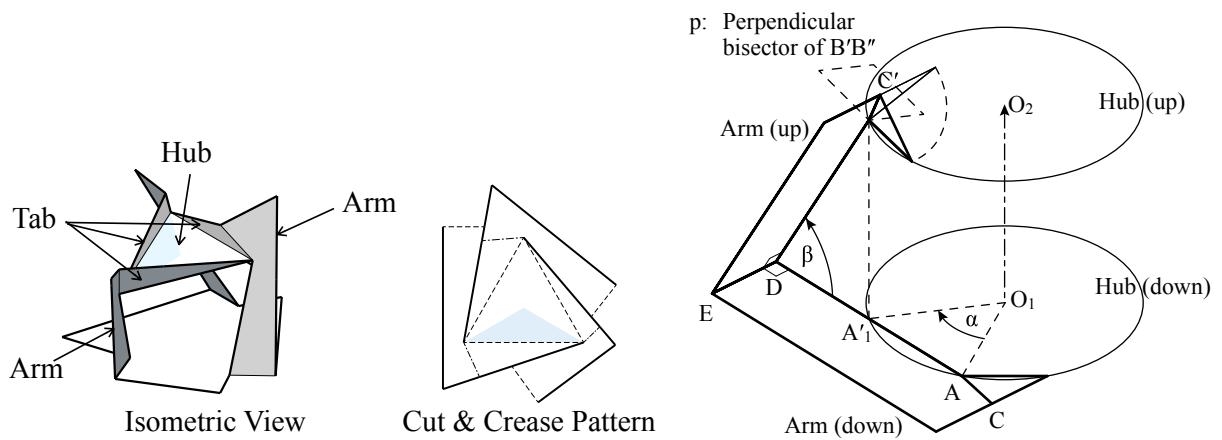


Figure 5: General configuration of RES