Dynamic Façade Unplugged Snapping Façade

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Snapping Facade explores a sustainable building envelope design strategy that utilizes elastic instability to create dynamic motion at the building envelope.

The building envelope controls heat gain and loss, allows views for visual comfort, and provides natural light. Advances in the high performance glass industry have made the use of glass ubiquitous. The reflection and refraction of glass represents the dynamic, bustling activities of our cities while diverse lifestyles and programmatic functions are expressed through the façade of our buildings. However, in the United States, buildings account for 41% of energy use and 38% of CO2 emissions. The increasing need for high performance buildings and advancements in manufacturing industries have facilitated the design of dynamic building envelopes to replace traditional, uninspiring shading controls. Built dynamic façade systems such as Abu-Dhabi Investment Council Headquarters by AHR Architects, dynamic roof shading at Aldar Central Market by Foster + Partners, Hoberman Associates and Adaptive Building Initiative and Kiefer Technic Showroom by Giselbrecht+Partner are based on mechanical actuators which need additional energy consumption to operate and require complex maintenance.

Advances in material science and engineering have also contributed to the mission of smarter building envelope. For instance, electrochromic glass uses voltage to change light transmission property. Other Smart glass such as Suspended Particle Devices can provide the similar function and form-changing polymer sheet can be installed in the glazing units. Compared to the mechanical dynamic shading, these glass systems can efficiently provide substantial energy saving with low cost, however the façade design becomes independent gears added to the irrelevant building design.

Snapping Facade suggests an alternative approach for the design of dynamic facade systems that use a “snapping-induced motion” to open and close apertures, providing shading for the building. The prototype explores using weakening-induced bands tied within the elastic threshold which, produce “snap” deformation with minimal stimulus. Traditionally, unstable movement within the building construction is considered as an undesirable occurrence but, the Snapping Facade aims to harness the characteristics of elastic instability by applying it as an opening and closing mechanism using the embedded energy within the materials. Without complicated maintenance, users can participate in the dynamic movement of the building envelope for play, fun, and energy saving.

This elastic instability is already utilized in kids’ products such as Rubber ball poppers and Snap Bracelets. Foldable car window shades also use the property of snapping. As for building, the snapping bands will be explored with patterned metals, plastics, and/or wood veneers. The engineering of intentionally applied weakening building components will be also tested. The membrane between the bands need be tested through metal origami, fabric, and other hybrid methods to find optimal folding mechanism.

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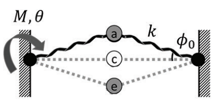

FIG 2(A)

In Figure 2 (A), the concept of snapping-induced motion is illustrated using a simple bi-stable structure, which has an initial bended shape with the angle of θ_0=30° and the spring stiffness of k.
Then, its strain energy stored in the structure U can be analytically obtained with respect to the applied angle θ. Figure 2(B) shows its two stable configurations which are denoted by (a) and (e). The first zero strain energy (a) is corresponding to the initial configuration of the structure (i.e., θ=0°), and the second zero strain energy (e) is observed at the applied angle of θ=60°.
aalso be analytically obtained with respect to the applied angle θ (see Figure 2(C)). At the beginning of the motion (i.e., near the configuration (a)), the applied clockwise moment M increases as the angle θ increases. However, once the angle θ reaches at the configuration (b) having θ≈10°, the structure automatically jumps to the configuration (f), and then it stabilizes at the configuration (e) having θ≈60°. Consequently, this automatic snapping motion of Δθ≈50° can be achieved by applying only θ≈10°. This motion amplification can be enhanced by a proper structural analysis and design. Upon an counter-clockwise moment, the structure moves from the configuration (e) to (a). This kind of motion can be repeated due to the elastic nature of the system.

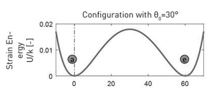

FIG 2(B)

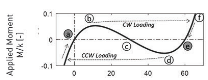

FIG 2(C)

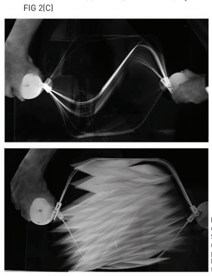

FIG 7. Physical Simulation of Snapping motion using white styrene band by the author. The Snapping motion is successfull. The tested membrane between the two bands are white painted mylar sheet(Polyester Film) with Miura based origami pattern. It needs further study to find optimal folding mechanism.

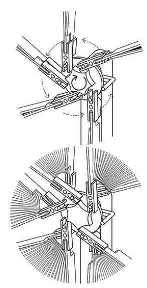

FIG 6. Modified Geneva Stop to actuate 5 or 6 moduels with one stimuli

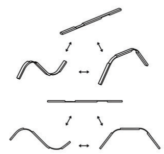

FIG 1A*. Concept of snapping-induced motion with Weakening-induced bands (double induced)

FIG 1B*. Weakening-induced bands (single induced)

* The weakening induced thickness is exaggerated in this diagram

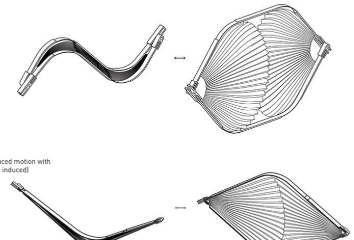

FIG 3. Base module of the sanpping deformation

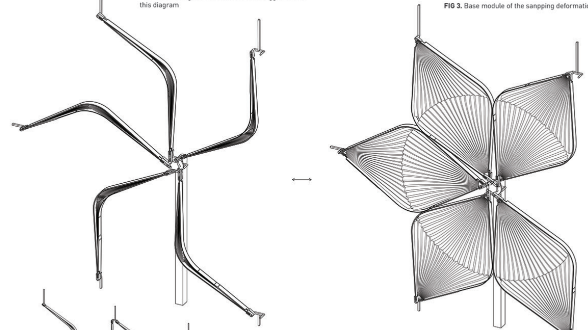

FIG 4. One group has 5 modules reacting to one actuation

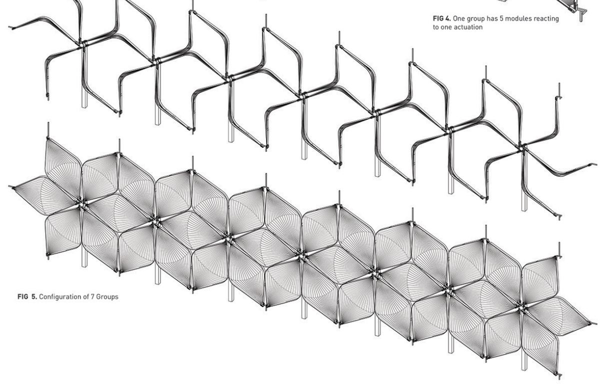

FIG 5. Configuration of 7 Groups