X-Shell Pavilion

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X-Shell Pavilion: A Deployable Elastic Rod Structure
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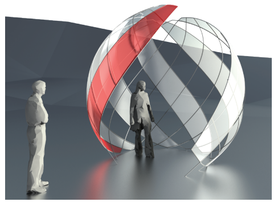
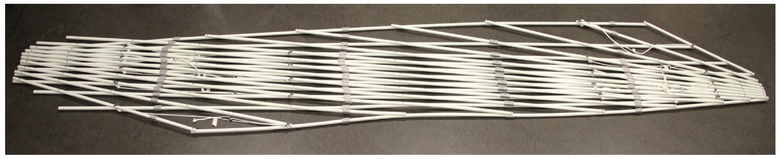
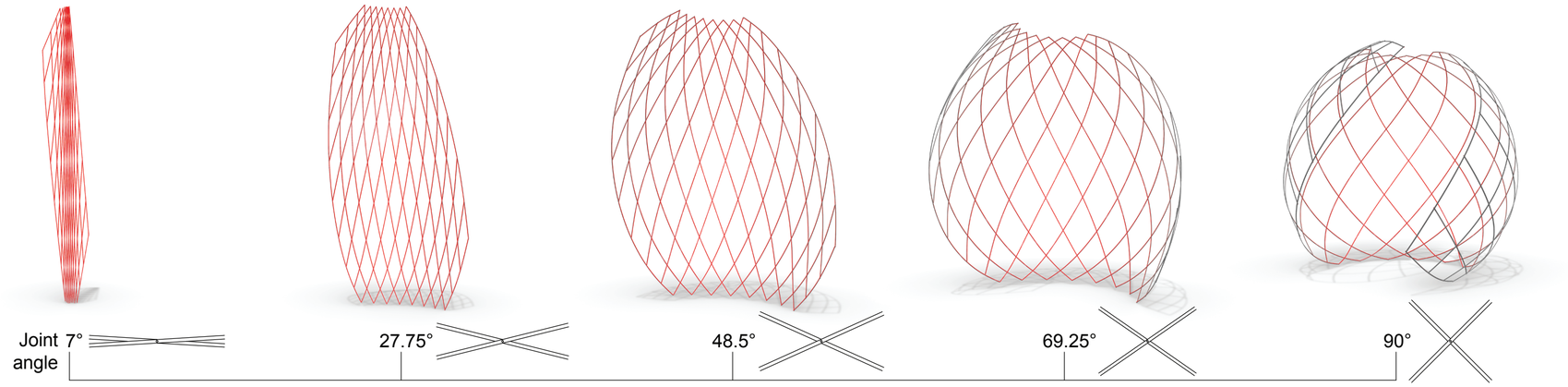


The X-Shell Pavilion is a lightweight structure composed of elastic beams joined in a special layout optimized for easy assembly and on-site deployment.



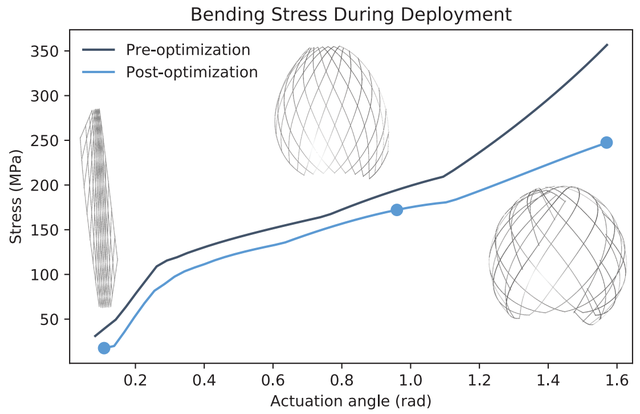
We build the pavilion in a perfectly flat state by connecting its beams with pivot joints.



We deploy the pavilion simply by stretching it open: its curved 3D shape is encoded directly into the flat design, and the shape is robust to imprecision in the deployment process. Our pavilion does not require boundary supports to maintain its shape.

Design Parameter Optimization

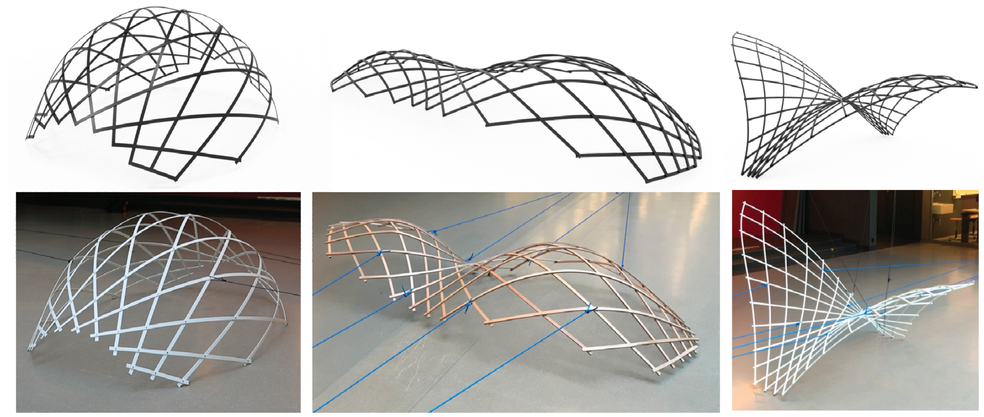
- Nonlinear Optimization for Deployed Equilibrium
- Nonlinear Optimization for Flat Equilibrium
- Step Calculation



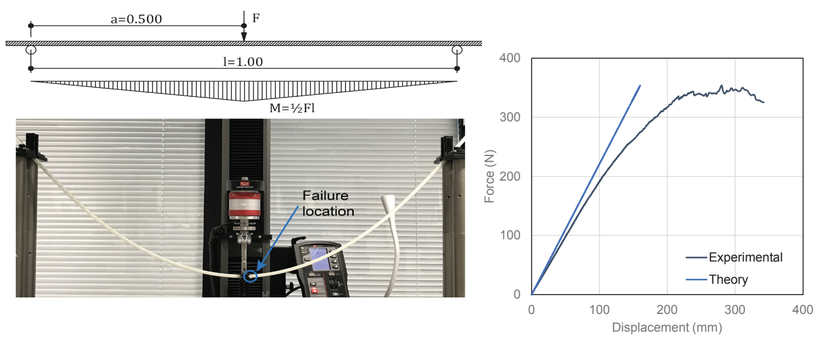
We fine-tuned our pavilion with a state-of-the-art optimal design algorithm incorporating an accurate physical simulation of the assembly and deployed states. This optimization reduces stresses in the beams, producing a structure that is robust throughout its entire deployment path.

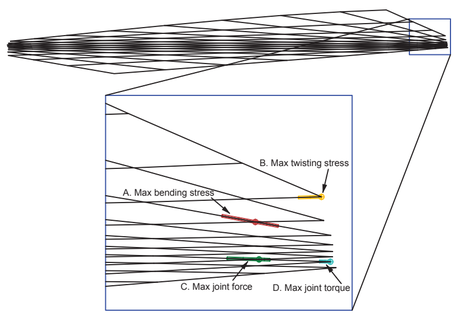
Numerical Simulations

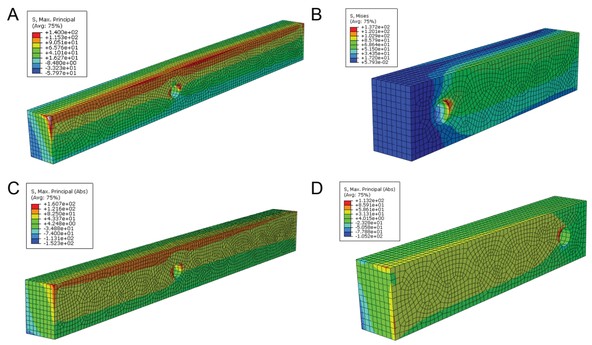
Material Studies



We validated our simulation and design tools with a series of physical prototypes fabricated in a variety of materials. The deployed shapes predicted by our simulation algorithm closely match the prototypes' equilibrium shapes.







We performed material tests to characterize the strength of our GFRP beams, connector sleeves, and rivets. We also ran a detailed finite element analysis on the regions where our simulation algorithm predicted high beam stresses and forces on the joints. These experiments confirmed the robustness of our pavilion design.