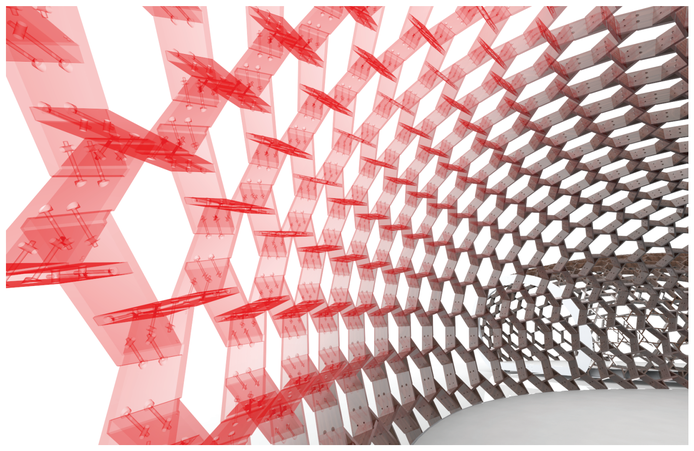
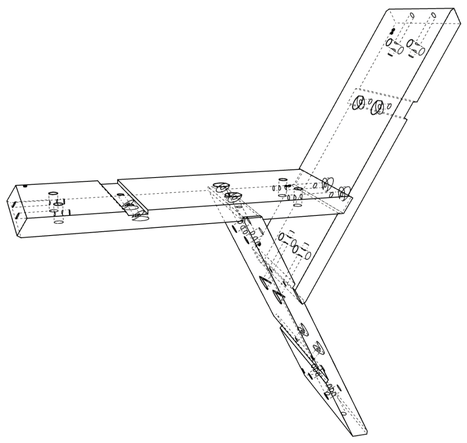
Designing KREOD

evolute.
the geometry experts

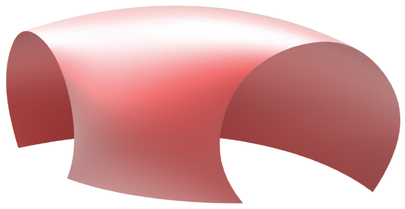
KREOD is a ground-breaking sustainable sculpture and London's newest architectural landmark. The brainchild of Chun Qing Li, Managing Director of Pavilion Architecture, KREOD is an innovative architectural sculpture, organic in form, environmentally-friendly and inspired by nature. Resembling three seeds, these pods combine through a series of interlocking hexagons to create an enclosed structure that is not only magnificently intricate but secure and weatherproof. KREOD functions beautifully both as an architectural landmark and an imaginative exhibition space - its three pods can be combined in a variety of configurations or installed as free-standing forms.



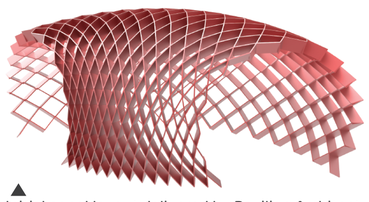


Design for fabrication

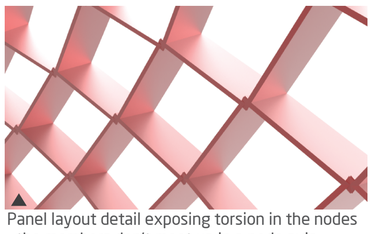
As part of the design team, Evolute was responsible for rationalizing KREOD's complex input surface, designing the panel layout, the parametric detailing of the wooden members and outputting the production geometry for fabrication. As with any ambitious project, KREOD's design and manatufacturing constraints updated dynamically based on available resources.



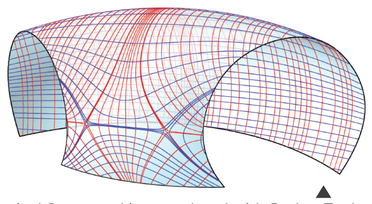
▲ Original envelope surface, designed by Pavilion Architecture



▲ Initial panel layout delivered by Pavilion Architecture

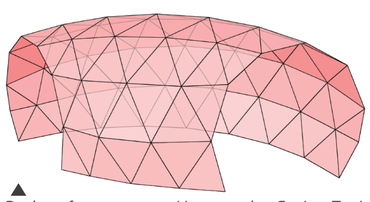


▲ Panel layout detail exposing torsion in the nodes - the members don't meet up in a node axis

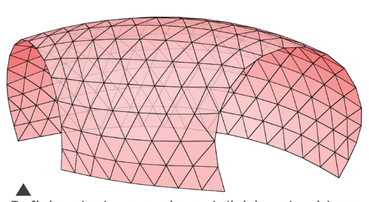


▲ Principal Curvature Lines produced with EvoluteTools. This analysis reveals that the initial panel layout lies almost diagonally in respect to the principal curvature lines, therefore it is impossible to eliminate torsion in the nodes with the intial setup.

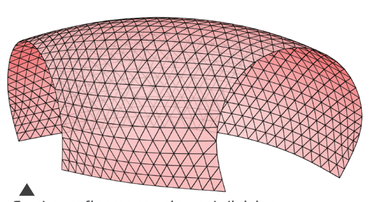
Geometry rationalization



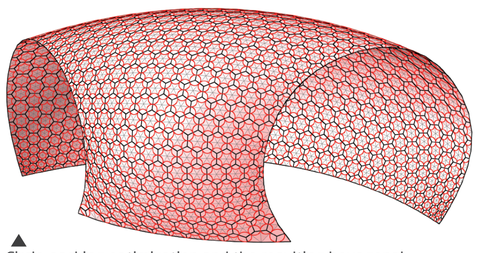
▲ Design of a coarse panel layout using EvoluteTools Lite



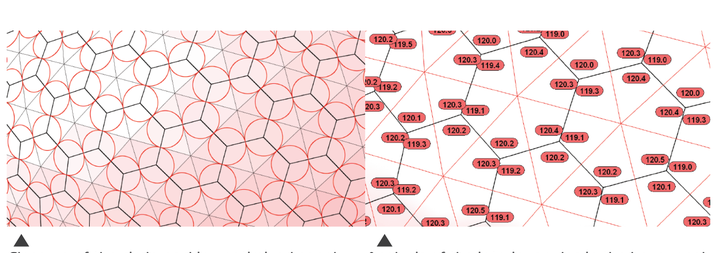
▲ Refining the layout using subdivision algorithms



▲ Further refinement using subdivision



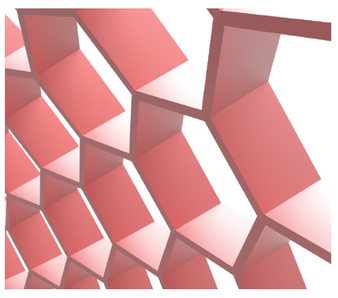
▲ Circle-packing optimization and the resulting hexagonal panel layout, produced with EvoluteTools Lite



▲ Close-up of the circle-packing optimized panel layout, revealing the relation between the triangle and hexagonal layout

▲ Analysis of the interior angles in the hexagonal panel layout, after just a few optimization steps all angles are extremely close to 120 degrees

Embracing sustainability, Li adopted simple manufacturing and wood planks as building material, avoiding complex CNC milling. The initial panel and beam layout provided by Pavilion Architecture was asking for complex, uniquely fabricated nodes in order to take the loads of the structure, raising the fabrication costs significantly. Looking at the principal curvature lines allowed us to understand how we can achieve a torsion free structure with simple joint assembly that would lower the manufacturing costs. After analysis, Evolute proposed a torsion free hexagonal panel layout, as the dual of a circle-packing optimized triangular mesh.

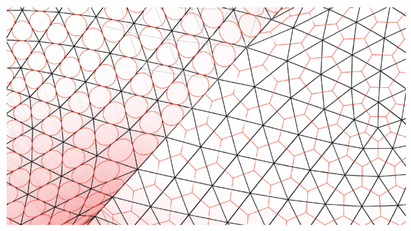


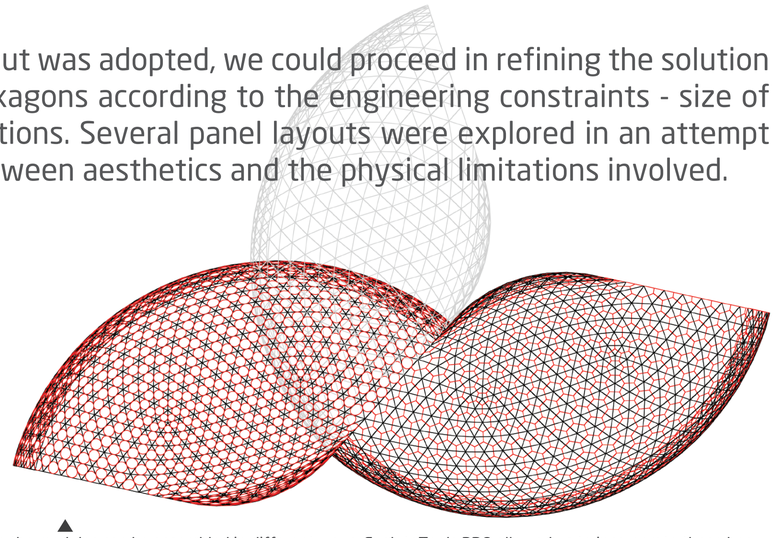
▲ Members generated upon the hexagonal panel layout carry no torsion, the beams meet precisely in a node axis

The circle-packing optimization forces the incircles of each triangle to be tangent to the adjacent corresponding incircles, as pictured below. After one step of subdivision, the hexagonal panel layout is achieved, carrying crucial features that lower the fabrication costs - the angles around each vertex are 120 degrees, allowing prefabrication of node elements if needed.

Once the hexagonal panel layout was adopted, we could proceed in refining the solution for an even distribution of hexagons according to the engineering constraints - size of hexagons and boundary conditions. Several panel layouts were explored in an attempt to find the perfect balance between aesthetics and the physical limitations involved.

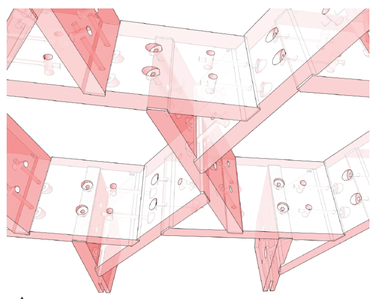
Detail view of the edge fitting between two pavilion modules, enforced with EvoluteTools PRO ▼





▲ KREOD's modular layout requires special edge fitting since the modules can be assembled in different ways. EvoluteTools PRO allowed us to incorporate these heavy constraints in the optimization, ensuring the pavilion's edges will meet up precisely in all configurations.

Parametric detailing

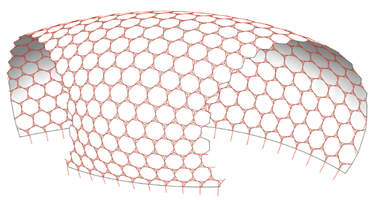


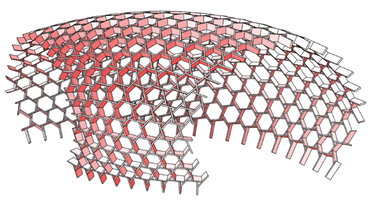
▲ Parametric detailing of the members based on fitting data provided by the engineering team

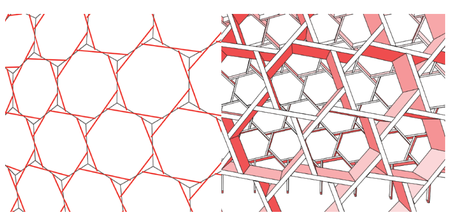
A breakthrough in KREOD's design was brought up by the Ramboll engineering team while designing a connection detail strong enough to take the loads of the structure, elegant and simple to manufacture at the same time. The reciprocal connection became KREOD's signature. Based on this detail design, Evolute coded the generation of the member layout in tune with all the aesthetic and manufacturing constraints.

The parametric generation of the components was programmed in RhinoScript, a bespoke programming language used by the well known CAD platform Rhinoceros.

Parametric beam model based on the reciprocal connection "stick model" ▼



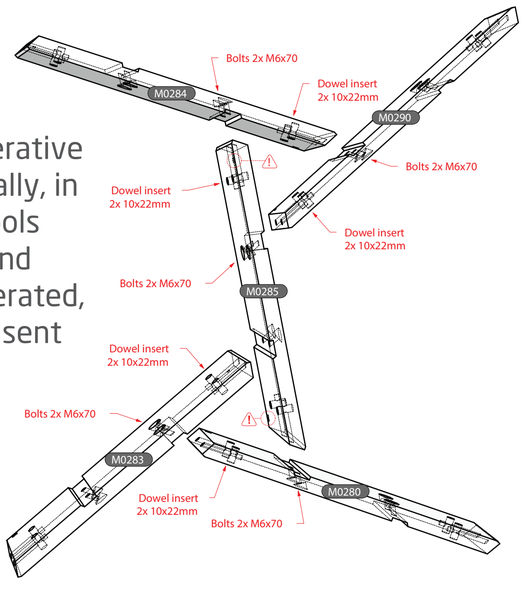




▲ Reciprocal layout generated by rotating each hexagon edge around its normal, the rotation angle adapts to the size of the resulting triangles, as there was a minimum and maximum node size specified by the engineering team

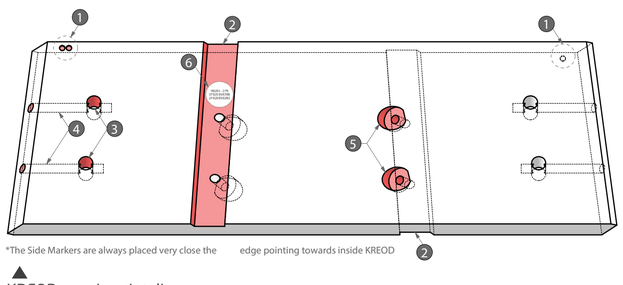
Production data output

When the complete solid model was approved by Pavilion Architecture, Evolute extended the generative code to export all the production data automatically, in a process called "file to factory". Using EvoluteTools PRO and it's powerful RhinoScript interface, around one thousand members were parametrically generated, along with their labeling. The exported data was sent directly to CNC fabrication equipment.



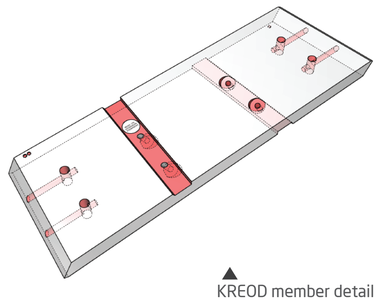
KREOD assembly schematic ▶

1. Side *markers, shallow Ø4mm hole(s)
2. Notch, 1 per side
3. Dowel insert hole, Ø10.5mm, 2 per side
4. Bolt holes, Ø6.5mm, 2 per side
5. Bolt head recess, 2 per side
6. Label, 1 per side, inside the notch



*The Side Markers are always placed very close the edge pointing towards inside KREOD

▲ KREOD member detail



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