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The Woolbeding Kinetic Glasshouse

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Extended abstract

Fig. 1. The Glasshouse in closed position in its environment.

Fig. 2. View of the Glasshouse in open position.

Designed by Heatherwick Studio and engineered and built by Bellapart, with the collaboration of EOC and Eadon, this unique kinetic glasshouse is set on the National Trust Woolbeding gardens in England (Fig. 1). The glasshouse emulates, in a bigger scale, a diamond-shaped Victorian terrarium of glass and aluminium that gently opens (Fig. 2) and closes its 15m long "sepals" like a flower.
In its closed position, the glasshouse is a 14.5m high building with a 15m diameter base and a maximum diameter of 19m at the base of its 'kinetic' roof, at 2.8m from the ground level. Its twenty-sided façade is cladded with Insulating Glass Units and anodized aluminium profiles and flashings, while the main structure is made of tapered welded custom made profiles of mild steel that meet in sharp angles and complex nodes.
To allow its movement, the glasshouse relies on 10 hydraulic cylinders (one cylinder for each Sepal) activated from a control panel located inside. All the necessary sensors, cables, piping and machinery are either concealed (inside the structure or underground) or disguised in order to do not affect the architectural vision. Furthermore, safety and fail-safe operations were a mayor concern during design and construction, having a major impact both in the mechanisms control system and the structural verification.
When closed, a pneumatic gasket system inflates to achieve a weathertight building envelope. This approach was selected by Bellapart in order to accommodate the installation tolerances (±15mm) as well as the wind induced movement (±5mm). The system was tested both in a prototype in Bellapart's workshop as well as on site, achieving the desired complete watertightness and a maximum of 3 air changes per hour.
For the structural verification, several scenarios and positions of the glasshouse were considered, from fully open to fully closed including an accidentally left open sepal.
This was part of the safety concerns, so the resistance of the structure under all probable and improbable positions was verified under ULS loads, either factorised (for the probable) or non-factorised (for the improbable or accidental).
Furthermore, as any element with cyclical movement the glasshouse is under fatigue loading induced by its dead load. Therefore, a significant engineering effort was dedicated to precisely model the edgy and complex nodes with an advanced FEM software in order to fully capture the stress hotspots that may originate a fatigue failure. This was the dimensioning case for most of the nodes even if the number of cycles was relatively low (50,000 over 60 years).
Regarding fabrication, templates and special welding procedures were used to achieve the necessary tight tolerances, as well as guarantee the absence of significant residual stresses. In the same way, bespoke construction procedures and provisional parts were developed to allow for its transport, assembly and erection.