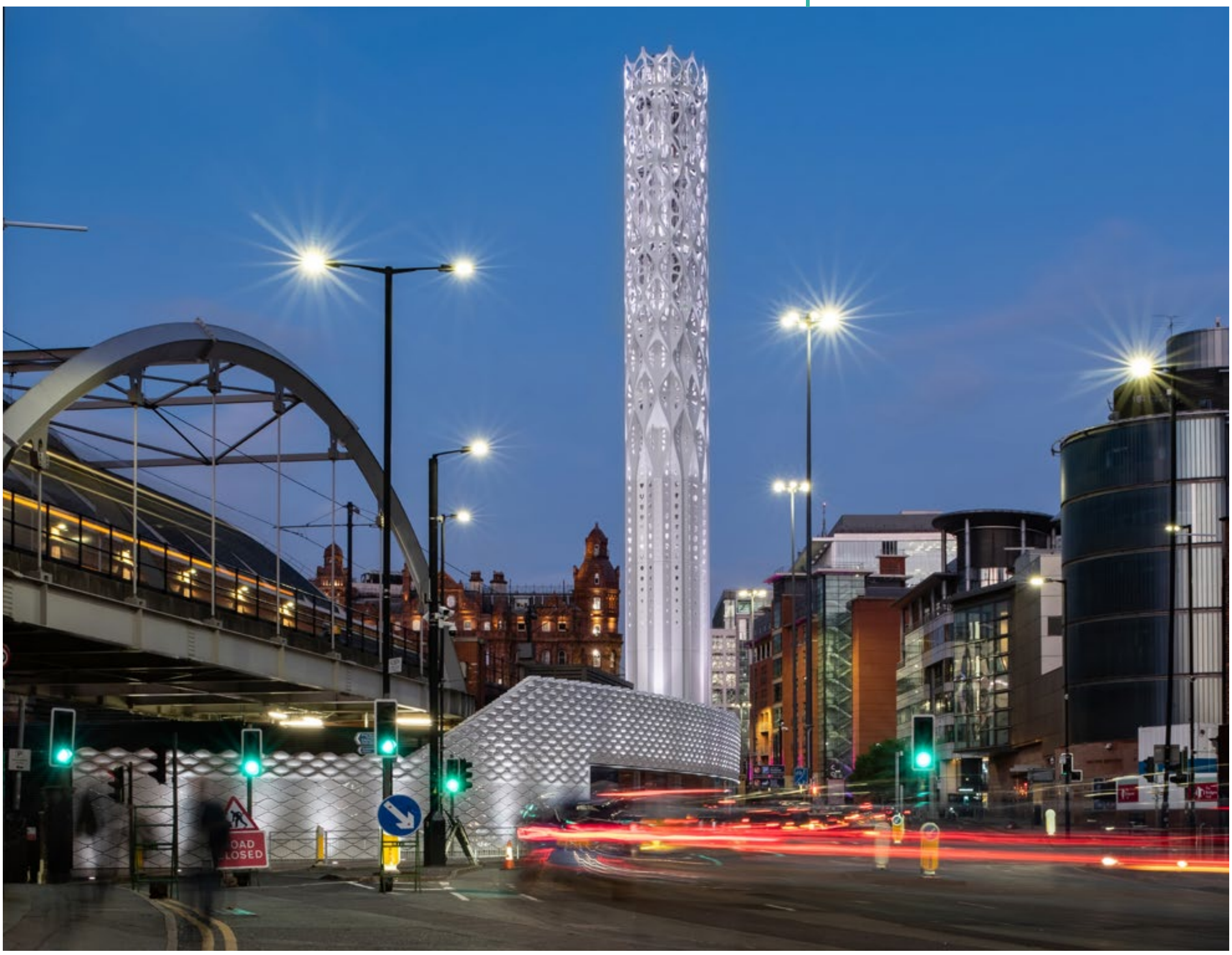
# Tower of Light, Manchester

## PROJECT TEAM

Architect: **Tonkin Liu**
Structural engineer: **Arup**
Main contractor: **Vital Energi**
Client: **Manchester City Council**



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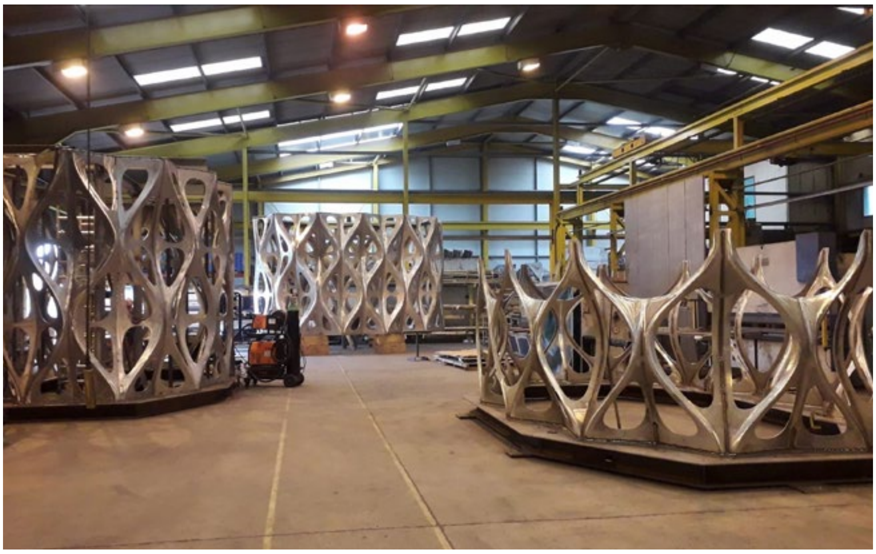
The Tower of Light is a 40m-tall tower that supports the five exhaust flues of a new Combined Heat and Power (CHP) energy centre located in Manchester city centre. The energy centre is a key component in Manchester's Civic Quarter Heat Network project, which will supply several local buildings with low-carbon energy. Due to the city centre location of the site, the need to create a tower with significant architectural merit was a key component of the brief.

The white curved steel perimeter shell of the Tower of Light is the only vertical structure – there is no additional internal frame.

The tower perimeter shell is tailored from 6mm and 8mm-thick laser-cut steel plates which have been curved and welded together to create a stiff, strong shell. The geometric stiffness provided by the curves, folds, and corrugations in the shell enable the thin steel plates to resist buckling without the need for any additional stiffeners. The perforation pattern of the shell is optimised to reflect the flow of stresses in the structure. The perforations and folds in the structure have the additional benefit of making the tower less susceptible to dynamic response to wind effects such as vortex shedding.

The geometry of the shell corrugations and perforations was developed using digital workflows to identify a structurally optimal form. Parametric tools were used to quickly generate and analyse several variations of the geometry, which allowed the design team to study the effect of changes in the form of the shell on the buckling and fatigue performance of the structure.



The perimeter shell structure has the dual purpose of also acting as the façade of the tower. Using the same material to provide both the structure and the façade has a material efficiency benefit over a more conventional braced frame flue tower, which would require a non-structural façade system. A study to compare the embodied carbon of the shell tower with a more conventional flue tower showed that the embodied carbon of the shell tower was lower, with a vastly reduced number of components.

As the forces in the structure due to wind and gravity decrease towards the top of the tower, the shell becomes lighter and increasingly perforated with height, further reducing the steel tonnage.

Due to the high number of edges and corners in the tower shell, there was a risk that a painted corrosion protection system would not be sufficiently durable. Therefore, stainless steel was selected for the tower shell to ensure excellent durability. The tower is painted white for architectural reasons, but this also allowed a lower grade of stainless steel to be used and avoided expensive surface treatments, reducing the project costs.

A series of decks at 4m intervals up the height of the tower support the flues and transfer their load back to the tower shell. The decks also enable access for maintenance of the flues. The site was highly constrained, so the tower design team worked very closely with the flue designer to co-ordinate the design of the deck frames with the positions of the flues. The decks are designed with removable panels to facilitate replacement of the flues if required during the life of the tower.

Belying its apparent complexity, the fundamental geometric principals of the shell structure are deceptively simple. All curved, the panels which compose the shell are developable (i.e. they are singly curved). These singly curved surfaces fit together to form the folded geometry of the shell. This was essential to ensure that fabrication of the tower was practical and cost-effective. Nevertheless, tight tolerances were required, and the structure was fabricated to Execution Class 3 due to fatigue requirements.

The design team issued a 3D CAD model of the tower to the steelwork contractor, who used the model to derive the cutting patterns for each of the 432 shell panels. The perforated shell panels were laser cut from 6mm and 8mm-thick stainless steel plate, before being rolled to the correct curvature. These rolled panels were then welded together to form a series of 4m-high shell modules.

The tower was fabricated as a series of nine modules. Once fabricated, each module was transported to site, stacked on top of one another and fixed together by internal preloaded bolted flange connections at the top and bottom of each module. Installation of all bolts was carried out from within the tower, eliminating the need for exposed working at height, which minimised safety risks during construction.

Flue sections were pre-installed in each of the modules prior to lifting. These flue sections were then connected when the construction of the tower structure was complete.

The Tower of Light is the result of a synthesis of architecture, engineering, and steel fabrication to create a useful and iconic addition to the city of Manchester.

## Judges' comment

This shell lace structure exemplifies perfectly the synthesis of striking architectural form, advanced engineering, iterative technical analysis (Grasshopper and LS Dyna) and craft-based fabrication. A superb example of how design can transform a utilitarian chimney into a piece of urban art, intelligently conceived and impressively executed.