Let there be Light

Writer Liz Light

In the first weekend of December 2012 a giant reflector was barged down Auckland harbour from Hobsonville. It was then hoisted onto the top of the ASB North Wharf building that was under construction in the Wynyard Quarter.

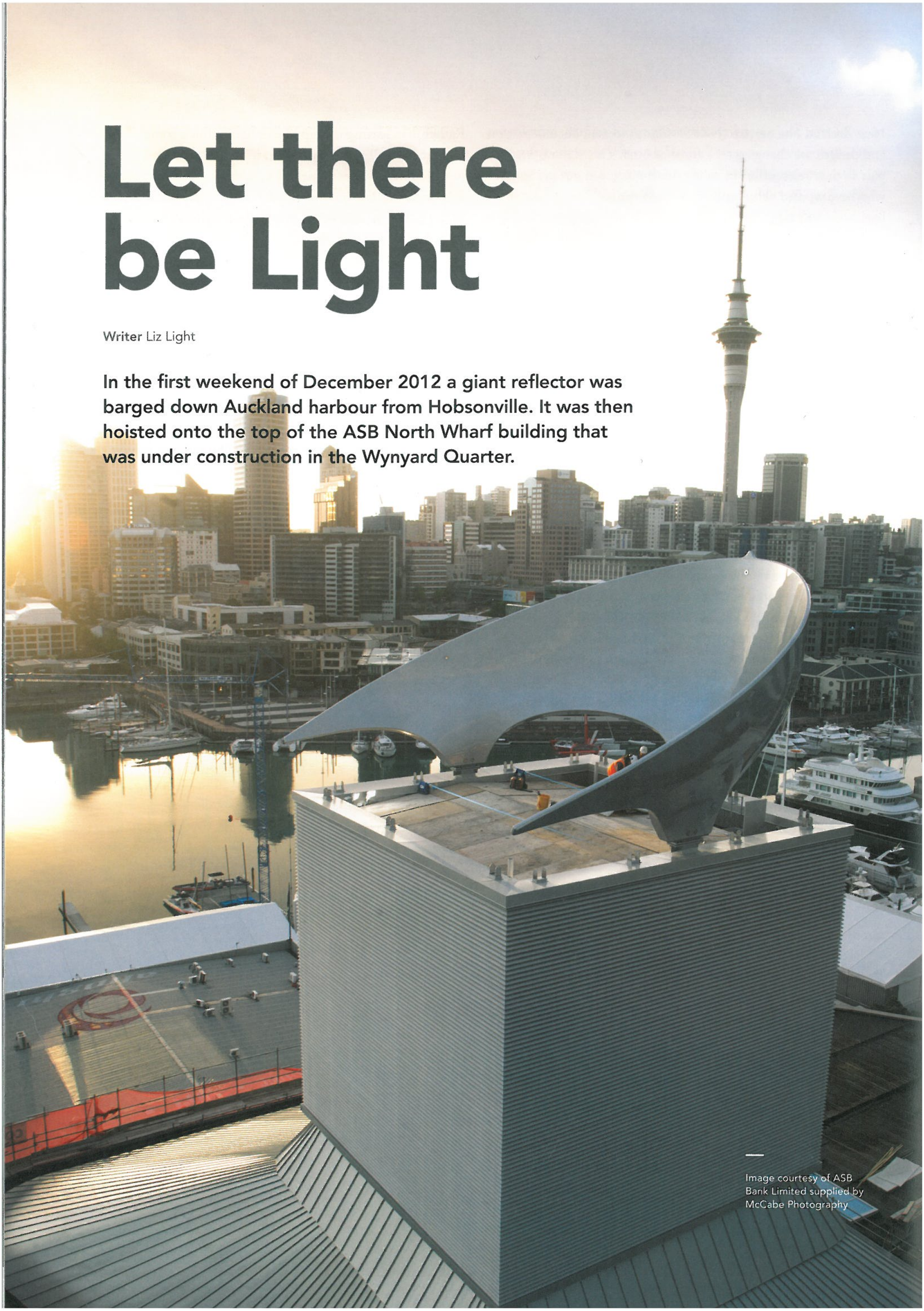


Image courtesy of ASB Bank Limited supplied by McCabe Photography

The reflector, officially called the Helioflek, is a sickle-moon-shaped half-collar that seems to float above the large square funnel on the city side of this exciting-looking building. Functionally, the structure reflects natural light from different angles and, as the sun moves around, light penetrates the building through the funnel, into the atrium, the surrounding offices and Te Wero Lane, which runs between the building's two main sections.

ASB North Wharf will be sustainable and its owners are planning to attain high Green Star ratings from the New Zealand Green Building Council when it is completed in June 2013. The reflector is part of an innovative series of sustainability-driven design features to push natural light into the building to reduce the use of artificial lighting. Part of this is the inclusion of light and occupancy sensors, which will automatically switch artificial lighting off when it is not required and on when it is.

The original concept for the reflector was that it would be made of steel, so the infrastructure beneath it was engineered to support the weight of steel. However (as can happen during a design and planning process, which can be organic), the client and architects decided that fibreglass composites would be a better solution. Pure Design & Engineering (PDE) was contracted to design it and Yachting Developments to build it.

Pure Design & Engineering specialises in advanced fibreglass composite structures with an emphasis on the marine industry. The company has been involved in the hull and wing design for many America's Cup yachts and round-the-world race yachts. Presently PDE works with Emirates Team New Zealand supplying composite engineering and three-dimensional modelling, plus two-dimensional draughting and composite and metal finite element analysis.

Andy Kensington, founding partner of PDE, says the reflector stretches 10 metres from front to back, is six metres high and weighs five tonnes. "We had to come up with a practical and cost-effective way of designing the reflector – and during design we worked closely with Yachting Developments about the construction process and the mouldings that were required.

"This is a very stiff and strong structure and is designed to withstand winds of up to 200 kilometres per hour."

"Basically, the concave and convex surfaces are made from a sandwich of carbon E-glass [a type of fibreglass] with two skins. The skins are made from carbon fibre and E-glass and they sandwich a 12 millimetre structural HP60 PVC [polyvinyl chloride] foam core between them. The double-skinned exterior is separated by a framing grid between 100 and 300 millimetres thick that has a carbon fibre/E-glass web core which carries the shear force and wind loading between the two surfaces. The non-structural parts of the cavity are filled with polystyrene foam."

The reflector is attached to the top of the funnel at three places by box-like feet (350 millimetres deep, 420 millimetres wide and 480 millimetres high) that fit like a sleeve over the top of steel feet-stubs integral to the funnel. Each foot is secured by two 60-millimetre-diameter stainless steel pins.

Mr Kensington explains that in profile the reflector design can be compared to a large curved I-beam that works structurally as an I-beam would, with the internal carbon fibre (the flange of the I-beam) carrying compression and tension. "The principles are similar to steel in terms of compression and tension but the strength of fibreglass is in the direction that the fibre is laid. Besides connecting to the inner core, the fibre runs vertically from the three feet at the attachment points, and webs out on both sides to the top of the structure. The loading increases as the structure tapers down to the legs. There is a band of fibre around the waist to provide additional strengthening."

The design process started with sketches of the reflector structure, then PDE undertook detailed analysis of it based on the required wind and earthquake loadings, and included many


Image courtesy of ASB Bank Limited supplied by McCabe Photography.

different wind angles. Then PDE produced a set of drawings detailing the composite requirements, the laminate specifications and strengthening requirements.

"This is a very stiff and strong structure and is designed to withstand winds of up to 200 kilometres per hour. We used Abaqus Finite Element software to analyse the structure and its stress and deflection loadings. This led to the understanding of how much carbon to use and where it needed to be placed. The software uses mesh with elements and nodes to approximate the geometry and calculates the displacement and stresses at each node."

The construction process involved creating a moulding for the inside curve of the reflector, just as boat builders create a mould for the hull of a fibreglass boat. The first composite sandwich was laid over this. Then the internal framing structure was built and the polystyrene placed around it. This was faired to become the mould for the exterior layer of sandwich composite.

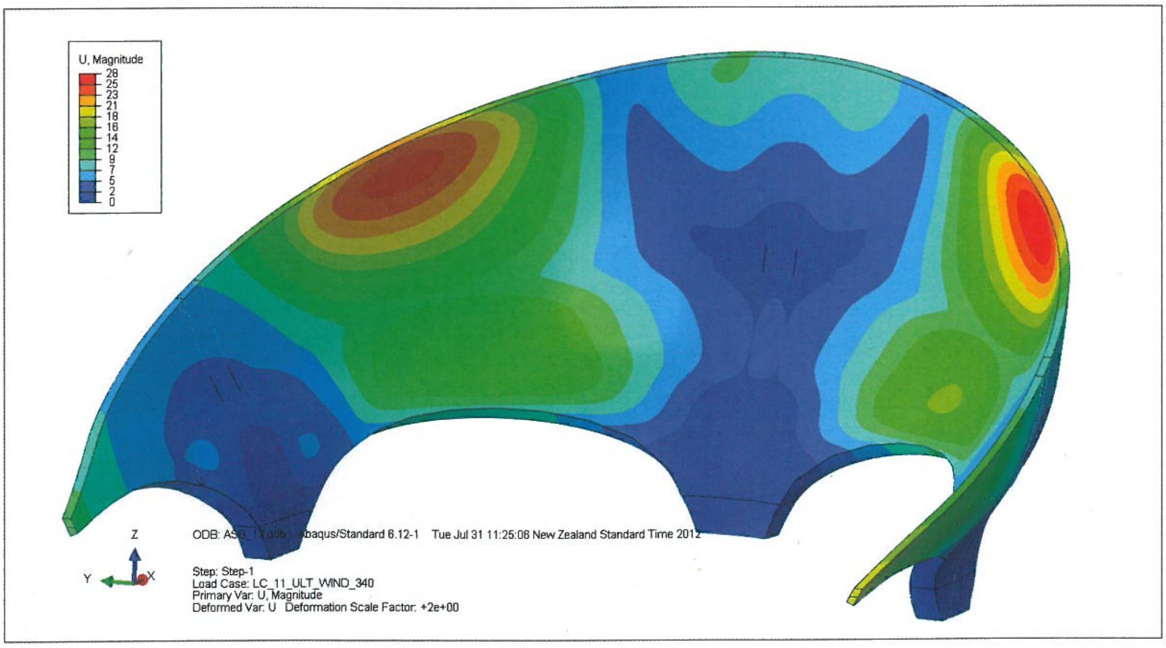
Both sides of the reflector have the same very fine metallic paint finish that reflects light. A bonus is that, aside from being functional, the reflector is an artful addition to an unusual building and when viewed from below it acts as a wide-angle mirror of the city around it.

Although on the face of it the principles and techniques used in designing and building the reflector may appear different from those used in creating a composite yacht hull, Mr Kensington says they are actually very similar.

"The advantage of [using a] composite is that it's lighter than steel. It has high strength-to-weight and high stiffness-to-weight ratios. Composites are versatile but it's important to choose the application level of the technology and techniques; not everything needs to be specified to the high performance levels of large racing yachts."

Mr Kensington says an enormous amount of expertise and intellectual property is present in the New Zealand yacht and boat building industry, but with the high dollar, top-end boat builders are finding it difficult to keep work in New Zealand. Using boat industry skills in other areas and applications is one way to ensure that the expertise stays here.

"Diversification, in these trying times, is a very good thing," he says.



Top Left and Right: The Reflector under construction. Black bands show areas of carbon unidirectional reinforcement used to strengthen and stiffen the structure. The reflector was built upside down over a male mould. Photos Pure Design & Engineering.

Left: Abaqus CAE Finite Element Analysis results showing deflection under wind loading. Finite Element software was used to calculate the stresses and deflections in the reflector. Image Pure Design & Engineering.