Bees Are Sentinels of the Earth: The Hive – A Responsive Ecology

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This chapter is based on the case study of the Hive in *Aluminium Flexible and Light*, which is the fourth book in the Towards Sustainable Cities series, written by Michael Stacey and published by Cwningen Press.¹ It incorporates Philip Beesley’s reflections on the Hive. *Aluminium Flexible and Light* also contains the case study of Protocell Mesh (2012-2013), a collaboration between the author, his students and Philip Beesley.² The Towards Sustainable Cities research programme has quantified and qualified the in-use benefits of aluminium in architecture and infrastructure. This research is funded by the International Aluminium Institute (IAI) and the core research team is Michael Stacey Architects in collaboration with KieranTimberlake.
The Hive, UK Expo Pavilion, Milan, Italy: Artist Wolfgang Buttress, 2015

The overall theme of the Milan Expo was: “Feeding the Planet: energy for life”. \(^3\) The masterplan of the Expo was designed by Herzog & de Meuron. Wolfgang Buttress, an artist based in Nottingham, England, won the commission to design the UK Pavilion in a limited competition, which included A_LA, Paul Cocksedge, Barber & Osgerby, David Kohn and Asif Kahn. A diverse selection of artists, designers and architects chosen by the client, UK Trade & Investment, a non-ministerial department of the British government. As observed in *Aluminium Recycability and Recycling*, pavilions are very public, highly visited and the closest our industry has to an experimental architecture.\(^4\)

Wolfgang Buttress’ response to the theme of the expo was to focus on the humble honeybee, its role as key pollinator of crops and the current risk to the well being of the apian population. He observed: “Bees are incredibly sensitive to subtle variations and changes in conditions and their environment... So the bee can be seen as a sentinel of the earth and a barometer for the health of the Earth.”\(^5\) He also took inspiration from Richard Buckminster Fuller; ecologically, philosophically and for the tectonics of the Hive. In particular Buckminster Fuller’s Montreal Biosphere, the United States’ 1967 Expo Pavilion.

The delivery of the complete experience at the UK Pavilion involved Wolfgang Buttress’ studio embracing a series of multidisciplinary collaborations. His ambition for the UK Pavilion was “to integrate art, architecture, landscape and science.”\(^6\) To design and deliver the Hive Wolfgang Buttress led a multi-disciplinary team of collaborators including: executive architect BDP Manchester, who were also the landscape architect, and structural engineer Tristan Simmonds of Simmonds Studio. His experience of complex geometries included working on Marsyas sculpture for Anish Kapoor, whilst at Arup. This digitally delivered lightweight fabric structure spanning 135m enveloped the space of the Turbine Hall at Tate Modern, London, during 2002.

The pavilion site in Milan was 100m deep. It was laid out as a narrative journey through an idealised fragment of a British landscape, with an orchard and a wild flower meadow culminating in the Hive. Placing the pavilion firmly within the English picturesque landscape tradition, delivered utilising twenty-first century technology. However, no bees were imported into Milan from the UK.
The Hive is a fascinating combination of Euclidean geometry and accretive complexity that is probably only possible using three-dimensional computer modelling. It is a 14m cube with a 9m spherical void at its core and it is lifted 3m off the ground plane by 18 circular hollow section steel columns, which are 139.7mm × 5mm. These columns rise 5 meters to meet a 10.8m diameter ring beam. The hive was assembled in 32 horizontal layers of aluminium components, with 6 layers below the ring beam to complete the base of the spherical void. It is assembled accretively as bees would a
hive. The layers are linked to form truss-like assemblies. Aluminium was chosen in preference to stainless steel for economy, weight and relative ease of machining the components.

The structure was parametrically optimised via close collaboration between Wolfgang Buttress Studio and the structural engineer Tristan Simmonds, to communicate the idea of a beehive, yet forming a robust structure. Tristan Simmonds describes the “basis of the Hive geometry is a radial hexagonal grid that is rotated slightly at each layer to give a twist. It is generated by repetition.” He recalls the design process:

Wolfgang Buttress’ Hive stood out from other early ideas immediately. The beehive is one of the most iconic structures in nature. We find beauty in its geometry and surprising precision but it is also a piece of pure functional efficiency that has been honed by a billion generations of bees. The initial sketches succinctly conveyed a beehive with three main simple ingredients: the hexagon, horizontal layers and an internal void. The fourth ingredient was that it wasn’t simple. The underlying concept was simple but the object itself, filigree and complex.

Describing the evolution of the design as "a quick Darwinian process". Simmonds observes:

The process could only be achieved by writing software. We assumed that every task in the design would have to be carried out time and time again and so each task was automated as much as possible. We spent day and night writing code, however, the assumption proved correct. Eventually a complete redesign involving detailed analysis models, design code checking, structural optimisation of 70,000+ elements and outline drawings could be turned around in a few days. On a conventional project this can take months and typically only happens once.

Specialist fabricators Stage One were appointed as main contractor by UKTI before the design completion and advised on the selection of the design team. Stage One fabricated the components of the Hive in York, using approximately 50 tonnes of aluminium. The total number of components that form the Hive is 169,300 and almost all of them were fabricated from aluminium.
The components of the Hive were fabricated from 6082 TS aluminium alloy and all remained mill finished. For Wolfgang Buttress rawness was a key principle specifying materials ‘throughout the pavilion [that] are generally unprocessed and patinate naturally.’ The components are primarily cut from 10mm thick aluminium sheet, however 15mm and 8mm gauged aluminium were also used. Aluminium tubes or rods join the flat plate top and
bottom cords of each truss-like layer. Stage One used laser cutting, waterjet cutting, and machining to fabricate the components. The spacer plates in the node connections were laser cut. All the radial and circumferential truss plates were waterjet cut and the rods and node tops were machined. Mark Johnson, CEO of Stage One, records:

> Over 4,500 CAD hours went into developing workshop drawings before machining, finishing and packaging each component in specific batches. Each item was etched with its own reference number relating to specific positions within the Hive’s complex warren of hexagonal cells, ensuring our crew could complete the on-site construction in good time.

The manufacturing took Stage One five months, working 16 hours a day. The total time on site in Milan, from starting the ground works in November 2014, was only six months. Stage One deployed 12 people on site, working piece by piece. The first layer was completed in January and the structure of the pavilion was all installed by April, in readiness for the opening of the Expo on May Day 2015.
Early in the process of designing the Hive, Wolfgang Buttress found that Dr Martin Bencsik was conducting research in the behaviour of bees, based at Nottingham Trent University, School of Science and Technology. Wolfgang
Buttress considered him to be undertaking amazing research. “By measuring vibration signals, he can interpret bee communications. This is a significant step towards understanding their behaviour and the impact of external conditions and changes. Our central idea was to use these research techniques to connect a beehive in the UK to our pavilion in Milan.”

In the void at the core of the Hive visitors experience sound and light that is a direct response to beehives in Nottingham. The bespoke LED light sources respond to accelerometers within the beehives. Stage One “designed,
prototyped, refined and manufactured one thousand four-colour (RGBW) 
‘pixels’ [LEDs] bright enough to be seen in daylight.”\textsuperscript{16} The 891 light sources 
are arrayed around the void on each of the 32 levels. Stage One’s use of real 
time three-dimensional computer based “visualisations of the many lighting 
effects saved a great deal of time once on site.”\textsuperscript{17}

Dr Martin Bencsik and Dr Yves Le Conte are collaborators on research 
funded by EU Framework Programme 7 that aims to help arrest the decline 
in European Bee population.\textsuperscript{18} Both scientists were delighted to contribute 
to the UK Pavilion:

Figure 6  Looking up to the glass floor of the Hive, which is at terrace level. Expo 2015 UK Pavilion
(Credit Hufton + Crow)
The results of scientific explorations are most thrilling for the researcher, when he/she is at the forefront of human knowledge. By inviting us to contribute to his artwork, Wolfgang Buttress has given us the opportunity to allow the visitor to share the thrill of scientific discovery. We have supplied live honeybee vibrational data to the UK pavilion, for the visitor to hear both bees’ sounds and vibration pulses.19

The experience in this void is sound and vision, “a dynamic soundscape, ever changing and unique at each moment: a collaboration between human and honeybee. A live feed from Nottingham beehives is streamed to the pavilion in Milan, which “trigger noise gates at particular thresholds, opening sympathetic harmonious stems pre-recorded by musicians, This is mixed with sounds captured from the bee colony.”20

Philip Beesley, of Philip Beesley Architect and Professor of Architecture at the University of Waterloo, reflects on the Hive:

Wolfgang Buttress’s Hive is structured as a dense cloud of hexagonal aluminium plate cells filling a ghost-like rectangular solid boundary, rendering a dissolving monolith that rises high above the fairground. Within this bubbling foam is cut the central form of a sphere, forming a pure void within the hovering mass. An oculus caps the sphere, opening the mass to the sky. The lower end of the sphere is positioned one storey above the ground level of the site, covered by a transparent glass floor whose perimeter echoes the oculus above and supports a compact space for occupants housed within the diffusive mass within the heart of the hive. Groups of angled legs raise this spherical chamber high above the level of the ground, clearing the site below. The lower level presents an aerial shadow-play where the figures of occupants exploring the inner space above float, visible through the dense filtering screens of the hexagonal meshwork structure. The floating scene is surrounded by the converging swarm of thousands of structural cells, progressively organized into multiple horizontal layers with gradients of warping organized around a converging polar array with chiral orientation focused around the oculus above and floating floor below. The horizontal aluminium plate cells are stayed by vertical arrays of angled tubular struts radiating from each cell vertex. LED fixtures mounted on each vertex facing the void interior make the interior spherical boundary into a constantly-shifting chimera.
Is this a distinctly new architectural form-language? The Hive exemplifies a deliberately unstable, open boundary, defined by delicacy and resonance – perhaps the very antithesis of the firmitas that has defined Western architecture since Vitruvius uttered his famous paradigm. Monumental scale is achieved by aggregating small-scale elements using simple progressive gradients of progressively shifting dimensions made possible by contemporary parametrics and digital machining. Inflections of component jointing systems within profiles and castings provide an understated celebrated ornament, an embroidered cellular textile writ large.

Following the implications of this hovering, diffusive aggregate, we could imagine families of architecture founded on adaptation and uncertainty. A building system using an expanded range of reticulated screens and canopies is implied, constructed from minutely balanced filtering layers that can amplify and guide convective currents encircling internal spaces. Writ large, these qualities speak of involvement with the world. Within this vanguard city fabric, the thermal plumes surrounding clusters of human occupants offer a new form of energy that could be ingested, and diffused, and celebrated. The resonant, dissolving swarm of Buttress and collaborator’s aluminium the Hive provides a potent example of a distinctly new kind of adaptive architecture.\textsuperscript{21}

The aluminium of the Hive has not been recycled after the closure of the Milan Expo. A better option was found. The pavilion was disassembled and reassembled in Kew Gardens, London. It reopened to the public on Saturday 18 June 2016. The detailing of the Hive with all bolted connections has facilitated is relocation, it is another example of the benefits of design for disassembly (DfD), as discussed in \textit{Aluminium Recyclability} and \textit{Recycling}.\textsuperscript{22} Kew Gardens, founded in 1840, is the world’s largest collection of living plants and a very appropriate second location for a pavilion inspired by pollinators.
Figure 7  Inside UK Pavilion by Night. Courtesy of UKTI (credit Hufton + Crow)
Aluminium Flexible and Light: Towards Sustainable Cities by Michael Stacey can be downloaded, with the other three books in the series from: www.world-aluminium.org/publications/tagged/towards%20sustainable%20cities/

Endnotes


Figure 8 The aluminium meshwork of the Hive, (credit Carlos Alba)
9. Ibid, p. 64.
10. Ibid.
13. Mark Johnson, CEO of Stage One, in conversation with the author during February 2016.
17. Ibid.

Michael Stacey, BA (Hons) BArch (Hons) RIBA FRSA, is Convenor of Michael Stacey Architects. His professional life combines practice, teaching, research and writing. His practice has been recognised by national and international awards, including twice winning the Shapemakers Award for the Innovative Use of Aluminium, a Bureau International du Beton Award and an Award from the Campaign for the Preservation of Rural England. Key projects include: East Corydon Station, Aspect II Integrated Cladding System, Thames Water Tower, Enschede Integrated Transport Interchange, Art House in Chelsea, Expertex Textile Centrum, Ballingdon Bridge, Craft House and Flexihouse. The award winning Aspect II Integrated Cladding System is the subject of world-wide patent. In 2013 The Renault Centre, 1982, which he worked on at Foster Associates, now Foster + Partners, was listed Grade II. He has taught architecture studio at Liverpool University, Penn Design, London Metropolitan University, the Architectural Association and The University of Nottingham.