

# The cult of the gridshell

Oliver Lowenstein

Under brilliant autumn blue skies, Exeter University's Streatham campus is ablaze with trees and plants bursting with colour. The campus cascades down the side of a hill, turning the grounds into a veritable wooded botanical wonderland, a vivid contrast to the rectilinear modernist red-brick university-scape.

Walk a few hundred yards, though, to one of the university's main thoroughfares, and you come upon a newly reworked part of the grounds, a series of eddying, curved contours, doubling as in-situ seating and steps, across the main campus concourse. On the far side, a set of red-brick buildings stand at different levels, rising sharply and vertically upwards. Yet in between, sinuous shapes run around this suite of campus buildings, slipping down the levels, over newly added spaces or as part of glass curtailed extensions, until the roofs join and curve up to create a new glass covered atrium and hallway entrance. This is the Forum, an ambitious £48 million investment by the university, with the largest – to date – and newest form of timber gridshell in Britain as its centrepiece. Both the design of the gridshell, and the redevelopment of the

entire site is by one of Britain larger firms, WilkinsonEyre (WE), who have a reputation for projects that bridge the divide between architecture and engineering. These include the award-winning Singapore Gardens, which itself incorporates a hybrid steel gridshell into its habitat glasshouses.

The arrival of this latest iteration in a line of timber gridshells in the UK represents a new chapter in a story, which is both unusual and unique to the British scene in a variety of ways. Opened over summer 2012, the Forum gridshell also chimed with the 10th anniversary of the opening of the first British gridshell, the groundbreaking – if primitivist – Weald & Downland Open Air Museum building by Cullinan Studios (until recently Edward Cullinan Architects).

The lattice weave of the Downland gridshell is both wall and canopy in one with the tension forces holding the structure in place, without the need of posts or walls to support it. The Exeter Forum, in contrast, replaces this holistic integrity with a nodal system and separate glulam beams in the shell structure. For some this abandons the core of the gridshells' engineer-

ing elegance, while for others the WE building looks ahead.

Exeter Forum is the largest continuous gridshell in the UK to date, with 3200 m<sup>2</sup> roof structure. It's also the first free-form timber gridshell, using a triangulated nodal system developed by the projects engineers, Buro Happold. The use of the gridshell is partial; the shell's diamond lozenges roll over the meeting space and street inside the Forum's airy atrium, drawing together two previously discreet buildings. Where the deck flattens out, a more traditional post and beam form takes over.

The organic sinuous form didn't happen immediately. As Buro Happold project engineer Jonathan Roynan states, it was inspired by the work of the Italian architects, Fuksas, and the "very organic" flow forms which their steel gridshells achieve in different sections of their buildings. The Milan-Rho trade fair in Italy is a case in point: here the undulating roof forms one continuous surface, with transitions in flows which depend on the sections, including flatter and more rounded areas with funnel forms. "The obvious question emerged," recalls Roynan 'why can't you



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- 1-2 University of Exeter Forum, Exeter 2012  
Wilkinson Eyre Architects with Buro Happold  
External view from the landscaped campus and internal view of the connecting "street"
- 3 Multihalle, Mannheim 1975  
Frei Otto with Carlfried Mutschler
- 4-5 Weald & Downland Museum, Chichester 2002  
Edward Cullinan Architects with Buro Happold

do that with timber?" The timber envelope helped WE achieve a BREEAM Excellent rating, along with a set of other sustainable features, including a SUDS system, bioswales and a ground source heat pump.

Exeter Forum's free flowing forms are a new departure, waiting to be developed further. But both the pragmatic involvement of Buro Happold, one of Britain leading structural engineering companies, and the appeal to organic form and its relationship to landscape connects this building to the Downland gridshell and the other major gridshell exemplar, the Savill Gardens visitor centre by Glenn Howells Architects, which opened in 2006 in Windsor's forest parkland as the gateway to one of the British Queen's garden's. The parkland's oak was specified, locally milled and then prepared for Savill, helping burnish the sustainability credentials of timber gridshells, already well established by Downland and its history.

*From Mannheim to the present day*

That history is woven into the origins of Buro Happold, and particularly its founders, the late Edmund 'Ted' Happold, Ian

Liddell, and Michael Dixon, are key to the emergence of gridshells in Britain. All three were central players in the engineering team working with the German engineer-visionary, Frei Otto, on the first Mannheim Multihall gridshell experiment, which was completed in 1975.

During its heyday of the late 1960s and early 1970s, Otto's fabled Institute of Lightweight Structures (ILS) in Stuttgart, was the driving force for a stream of experiments in light-weight structures, arguably climaxing in the 1972 Munich Olympics arenas. Constant throughout ILS's lifetime was a research focus on how natural forms could uncover what Otto termed the 'minima', or optimal efficiency in engineered structures. Without computers to do the number-crunching, the engineering, physics and math was carried out more directly by the engineers involved.

Even so, Mannheim's elementally organic structure did suffer extensive lath breakages, and, once completed, it seemed unlikely that another gridshell would be attempted.

This remained the case until the late 1980s, when a slow fuse of events set in

train the beginnings of a second gridshell, this time in Britain. It began with Otto being approached by an English furniture making school which had bought a local woodland waste-wood to build with. Otto was introduced to Hooke Park by Ted Happold, who had in 1976, set up Buro Happold with his ex-Arup colleagues in nearby Bath, and who saw Hooke Park Dorset woodland as uniquely suited to build on the timber experimentation that they had been involved in at the ILS.

Hooke Park, initiated by furniture maker John Makepiece, is a small and mysterious chapter from sustainable building culture's prehistory, with Otto designing a greenwood ribbed structure workshop (1989) and a prototype living space (1987) in the middle of the Dorset woods. They are still very much in use today, having been bought and taken over by London's Architectural Association as an out-of-town projects base, in 2002.

Not long after Otto's experiments in British, locally sourced, lightweight structures, Ted Cullinan and his team were brought in to design a masterplan for the working woodland school. While the masterplan was never implemented, and Cullinan finished only one rough and ready greenwood student dorm, Westminster Lodge (1999), this work did introduce the Cullinan team to Otto's work and begin a long-standing working relationship with Buro Happold. Not too long after they formed a team with Happold, they began working on the Weald & Downland museum competition.

The Downland museum was completed in 2002. It has become Cullinan's best-known, and something of a cult, building, bringing on a far away look in the eyes of certain kinds of British architect. Ted Cullinan connects this appeal to how "the composition of good architecture is so difficult that architects open their arms with joy to ready-made engineering solutions that do at least some of the composing for them." The double curvature form



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- 6 The Savill Garden Visitor Centre, Egham 2006  
Glenn Howells Architects with Buro Happold  
External view from the park
- 7 Westminster Lodge at Hooke Park, Beaminstor  
1995; Edward Cullinan Architects



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also symbolises the eighty-mile stretch of thin, gentle rolling South Downs hills in which it is located.

Like Mannheim, the Downland gridshell is a working example of the beautiful simplicity of the gridshell's core engineering concept. For Cullinan's engineer, John Romer, Downland "exemplifies the efficient use of structural materials," with the total weight of the timber lath grid amounting to a mere 8 kg per square metre of space enclosed. According to Romer, it is estimated that the green oak structural elements have less than 5% of the embodied energy of an equivalent steel or concrete structure.

#### *A contemporary tradition takes off*

The Downland gridshell opened the floodgates – both real and in terms of imagination – among British architects. While the three large showcase projects are well known, a stream of smaller and attempted realisations have been emerging from different studios in different parts of the country. Glenn Howells persuaded an uncertain Crown Estates that such a structure would be fitting for their first contemporary building. Savill Gardens opened in

2006, to much attention and plaudits. Since then, the architects have added a further, smaller gridshell structure on the entrance site, while also looking for other projects to realise further iterations. These include a saddle-gridshell structure designed but languishing undeveloped for the Sherwood Forest Centre, Nottingham, and an up-market motorway service station near Gloucester. "In material terms gridshells are incredibly lean. In terms of time, design, and commitment, they're very hungry. You have to find the right client," says Glenn Howells, adding that Savill Gardens gridshell's double curvature "minimizes the bending, allowing the shallowness to be four times that of a simple beam."

Michael Hopkins used a version of the form for a pavilion within the Northumbrian Alnwick gardens (2006), integrating structural form into the signature composite timber and steel detailing. DRMM also applied the form to both their Monkseaton, Newcastle, school design, and a new specialist college for the deaf, also, as it happens, in Exeter, although neither were realised. The latter may still appear if the funding is forthcoming. In Scunthorpe, Buro Happold's collaboration with Andrew Wright Associates for the town's new sports and swimming pool complex (2011), started the research into nodal systems which has been subsequently refined at the Exeter Forum. Smaller projects also keep on turning up, including an experimental gridshell by students on this year's AA's Hooke Park 'Design & Make' course, while some of the ticketing and stalls facilities at the Olympic Park in London were gridshell designs. In the next eighteen months or so, two new gridshells will expand the conversation. Foster & Partners' giant Crossrail Canary Wharf station project, sitting above a multi-level transit hub, is 300 metres in length, and uses almost 1500 glulam members for a translucent ETFE canopy of 11,500 square metres. If Fosters push the integration of gridshell into their hi-tech aes-

thetic, Jerry Tate, an ex Grimshaws associate who has been central to the realisation of the Eden Project's biome, will begin the first gridshell country house this summer, fusing a biomimetic approach, which assimilates permaculture into the organic, flowing design.

#### *Structural purity versus design freedom*

One can raise questions regarding which of these structures are 'true gridshells.' Wiehag, Canary Wharf's Austrian glulam supplier, are promoting the project as a gridshell, but more strictly it is a dia-grid shell structure, the shell a regular diamond lattice. Some define any gridded shell structure as a gridshell, whether self-supporting or not. Another former member of Grimshaw's Eden Project team, Exploration's Michael Pawlyn, accepts that W&D is the only true gridshell at scale, "but then I think there is a danger in pursuing a perfect realisation of one idea (structural purity) to the exclusion of other important ideas such as a connection to the landscape. We have to recognise that architecture needs to reconcile many, sometimes opposing, factors."

Expanded to include dia-gridshells, the list gets longer, including Grimshaw's The Core (2005), as well as the showcase for Eden Project's second phase; Pringle Richard Sharratt's Herbert Museum atrium; and, on site at present, Hopkins' latest timberbuild after their success with the Olympics Velodrome cable net (2012). This a timber diagrid canopy for the new Living Planet headquarters of the environmental charity, the World Wildlife Foundation, completing this summer. Granted these examples – however gridshells are defined – are not in their hundreds, but compare this to elsewhere. Across the entire Nordic world, one student project, Ville Hara's Helsinki zoo tower (2002), represents the only completed example. Lassila-Hirvilammi's attempt at Kuokkala church (2011) was abandoned after not being able to find engineers and



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- 8 Canary Wharf Station for London Crossrail, London 2014; Foster and Partners
- 9 Herbert Art Gallery and Museum, Coventry 2009 Pringle Richards Sharratt Architects (extension) Interior view of the atrium
- 10 The Savill Garden Visitor Centre, Egham 2006 Glenn Howells Architects with Buro Happold View of the entrance area
- 11 Experimental research pavilion at Harvard Graduate School of Design; Jian Huang and Min-hwan Park with Achim Menges



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carpenters experienced to construct a 'true' gridshell structure. In Germany, Switzerland, and Austria, there are similar lightweight shell structures, for instance Thomas Herzog's Hannover ExpoDeck, technically a ribbed shell, and Shigeru Ban's temporary cardboard Japanese pavilion at Expo 2000, completed in collaboration with Otto. In terms of permanent timber gridshells the surprise is that there appear to be hardly any experiments, none if one applies the strict definition. Across the border, in France it has been Ban again who has introduced aspects of gridshell compression at the Metz Pompidou Centre. What has fundamentally changed in the last decade has been the arrival and rapid development of computer modelling in all aspects of structural engineering and form-finding. Buro Happold's Roynon acknowledges that the ability to engineer the complexity of the Exeter Forum was a result of the arrival of parametrics. "The availability and user-friendliness of the software has moved on a lot since Savill Gardens." Just ten years earlier, without modelling, neither the Downland gridshell, nor the subsequent burst of design activity, would have been possible. Non-computer assisted Mannheim Multihalle suffered 11 000 lath breakages, the Downland, 53, and Savill Gardens, a handful. The spans that can be reached through these interlocking, interwoven shells are substantial; Savill Gardens and the Forum demonstrate this with spans of 90x25 metres, and 80x20 metres, respectively. Neither completely carry the roof load, Savill including a steel edge beam support. And while the proliferation of shell structures has not been extensive on the continent, timber engineering departments have demonstrated an absorption in the convergence of shell structures and computing, specifically robotics and digital fabrication. The most notable examples are Lausanne's I-BOIS, with a focus on timber ribbed shells, and the Institute of Computational Design in Stuttgart, with its

director, Achim Menges, which completed a trio of award winning lightweight timber pavilions in the last few years. In Britain, curiously, despite its trail-blazing live tradition, when it comes to the engineering schools there is absolutely nothing comparable.

*Hugging the earth*

All three main projects – Downland, Savill and now the Forum - hug the ground, mimicking or at least echoing the topographical landscape: in Cullinan's case the South Down hills, and in WE's Exeter Forum instance, the sloping hillside. Yet despite all that these buildings have in common, the three practices behind them couldn't be more different. Cullinan is known for expressively poetic work, Glenn Howells, a more mainstream practice, and WE, working the technical boundary line between architecture and engineering. What is also striking is how, set against the return to more orthodox Modernist aesthetics across the architectural landscape, this type of structure seems to continue to be an ecologically accepted organicist approach which was otherwise rejected in the aftermath of the

nineties rush to computer assisted biomorphic architecture led by Gehry, Hadid and Greg Lynn. The gridshells' organicism, in contrast, emerged from many years of engineer-driven, results-focused experiments on physical models, uncovering and emphasising optimally efficient forms. It is also true to an architecture that is grounded in – and made of – the earth and landscape that surrounds it. While mainstream sustainability may show scant interest in this architecture of landscape for its own sake – Exeter Forum representing the popularising (dumbing down if you will) of the form, with uniform nodal connectors, and the use of glulam - gridshells seem set to stay as a prime timber engineering experiment of choice. Cullinan, true to Downland's primitivism, would like to see "lovely, new greenwood gridshell" experiments and Glenn Howells talks of grossly under-utilised British timber stands, which could, "with research and projects test how we can use these resources fully and imaginatively." With no signs of the fascination abating, both Cullinan's and Howells' suggestions may yet be realized in the coming years.



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