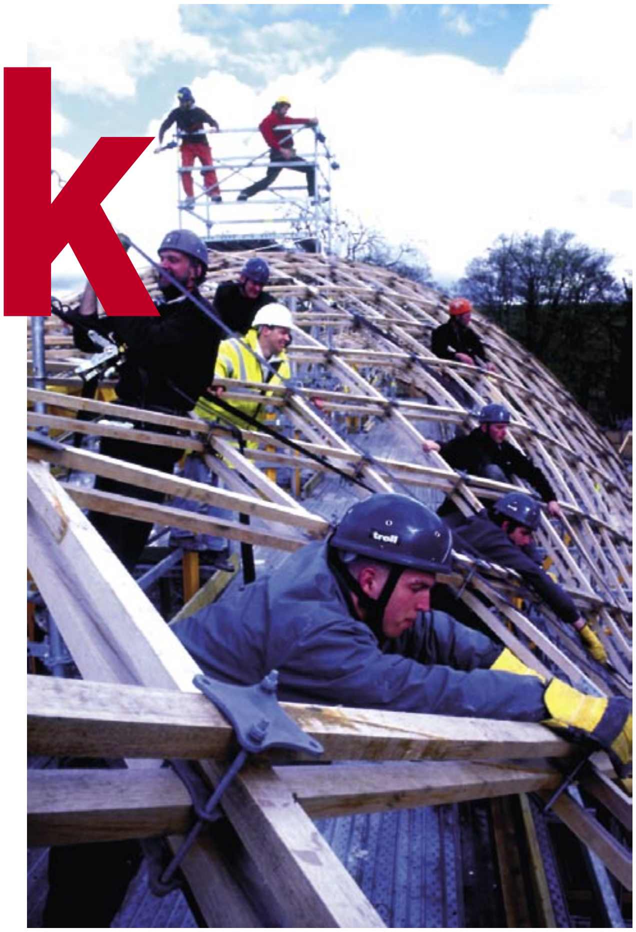
feature

gridlock



Buildings for the most part reflect an imagination divorced from the forms of nature. The ideal world of geometry, over the centuries, seems to have arrived at an architecture based primarily on rectilinear thinking, of squares and its 3D analogue; the box. Within the last thirty years though, designing from nature and imitating organic form has become increasingly popular. Examples of such buildings are on the increase, if not exactly common-place. **Oliver Lowenstein** discovers one of the better examples...

"One doesn't have to look too far in the world of big architecture for projects which wow the public imagination; think of the Eden Project's biodomes, or Frank Gehry's Guggenheim Museum. Or from another angle, the complexity architecture theorised by Charles Jencks and built by the likes of Greg Lynn.[1] "

The long thin band of the South Downs stretches from the southeast coastal climes of Eastbourne, to near the approaches to one-time Wessex capital, Winchester; around eighty miles, or four good day's walking. Come down from the ridges, into the underhill and valley below, look up, and these hills are an impressive, if unthreatening, friendly vista - gentle and soft to the eye.

Looking at the soft downland horizon, the lines of nature come into play. The ridge repeatedly offers beautiful effortless curves, wide semi-circular cambers which begin to fall shortly after they have begun to rise. These ridges are yet another momentary glimpse into organic form, which, as with so many other parts of nature, the human eye finds endlessly appealing.

And now, nestled on the edge of the Southdowns, at the Weald and Downland museum, Singleton[2], another up-to-the minute design from the nature aesthetic is currently emerging from within its tree-surrounded site. Looking at its three rippling domes its debt to the forms of nature are immediately apparent, not least those soft curves of the nearby hills. The distinctive appeal of this building is its marriage of organic form to a thorough-going and innovative sustainable aesthetic. Firstly, it is a timber-based building. Next, it utilises a groundbreaking engineering technique in the 'gridshell'. Lastly, as a consequence of these first two, it is infused and constructed, literally, out of the ethos and spirit of carpentry.

This is the first gridshell building of its type attempted in this country. As a project it began five years ago. In terms of building it has been on site fourteen months and looks set to being completed this winter. The museum, which specialises in the preservation of old vernacular buildings, needed a base to carry out a wide range of its repairs, preservation research, and education commitments. Its guiding spirit Christopher Zeuner, had long envisaged the potential for a project of this nature at Singleton, and in the mid-nineties the newly launched Heritage lottery funding enabled him to contemplate commissioning research into such a building. Given the lottery brief was for exciting, ground-breaking architectural proposals, Zeuner and the museum began to draw together a project team which would combine a leading edge, innovative approach combined with the rural and traditional skills ethos of the museum. Sadly, Zeuner would not see the project out, due to his death early this year. After tendering a plan which emphasised the sophistication of its timberwork, Cullinan's, the mid-sized London based-practice, with a strong eco track record, came on board in 1996, along with the structural engineers Buro Happold and quantity surveyors Boxall Sayers. The sustainable building issues were implicit in the project right from the beginning, with the museum underscoring the use of local resources and material, the need for a low-energy design, and an emphasis on employing a skilled workforce from West Sussex. An application was duly submitted, which both unnerved and excited the Heritage Commission in equal measure, as it envisaged the building of a timber gridshell; a form which had little precedent, and meagre research to justify risking public money. The Commission's imagination had been tempted though, for it committed a £70,000 design grant to develop the project.

A building was developed, which in effect comprised two separate parts; the lower half would be the museum's archive centre, and the upper section used for restoring and repairing the many vernacular buildings which the museum owned. The gridshell was to act as the skeleton supporting the outer body. The low energy remit was to be fulfilled by using a thermal system which would tunnel three earthtube shafts four and half metres into the Sussex chalk, collecting the underground heat, at a constant 65 Fahrenheit degrees, thereby storing up the summer's warmth, for the winter months. A very small fan system was to create negative pressure in the plant room, drawing air through the tubes at a slow rate through the building, with heat generated by a LPG gas-fired burner. Solar heating and photovoltaic cells had to be rejected at this juncture, in part because of expense and because the buildings situation would render them ineffective. Still, the running costs were envisaged to be low; the building containing no sizeable electricity drains.

All this was fairly straightforward, particularly for Cullinans, as one of the country's best known low-environmental impact architects. What was far less clear, and what the team sat down to figure out next, was how to develop a gridshell which would actually deliver when it came to be built. Not only this, but almost more importantly, to make a watertight case which would convince the Heritage Commission it would really work.

Gridshells are, at core, lattice shell structures, shellshapes pocked with diamond lozenge holes. Because of their shell properties they are phenomenally strong, and don't require internal supports. They are usually made out of steel, aluminium and concrete - the new British Museum courtyard roof is a recent example of a steel version. Surprisingly, perhaps, there is a tradition of timber gridshell engineering which reaches back to the turn of the last century when German and French engineers were putting onto paper gridshell plans for agricultural buildings. From there the design was adapted for first world war zeppelins, and in World War II became the body design of Wallace Barnes' famous Lancaster bombers. But the real year zero for gridshell is 1975, when the eminent German Architect, Frei Otto, unveiled the first real gridshell building in Mannheim. Originally a temporary horticultural exhibition hall, this set piece of engineering futurism is today a listed building. A member of the Ove Arup's original engineering team described it as one of the most advanced buildings of the twentieth century. Since then? Well, not very much. In the interim years since 1975 two buildings have emerged in Japan, one out of timber, the other from bamboo. Japan's submission at the Hannover 2000 Expo was also a gridshell, very similar in shape to Weald and Downland, but twice the size, constructed from cardboard tubes. Whether it truly constitutes a gridshell building is something of a moot point, since it has already been dismantled.

The scarcity of timber gridshells is perhaps understandable. They're very complicated to engineer and to build. One problem has been the high timber break rate - this was a real problem at Mannheim[3] . Another has been the lack of wood technology up until now to produce laths long and strong enough to create effective structures. But in the intervening twenty-five years the parallel revolutions in glue and wood technology has meant the project team could realistically contemplate laths with spans which Frei Otto could only dream of. The results of the research came up with the Swiss glue manufacturers, Collano's, recently developed polyurethane glue; super strong, yet environmentally sound. This would be used to bond six pieces of timber together into the impressively long 35 to 50 metre laths. French oak had been sourced, used for quality and cost, and could be cut in France, into much shorter 6m laths, 35mm by 50 mm in section. From there it could be shipped to Britain, and next transported to specialist, timber processors, Grecon Dimter in Newcastle. There the imperfections would be cut out, leaving high quality sections ranging from 300mm to 1400mm in length. These would be finger jointed back together again to form the 6m 'improved timber, before being returned to Sussex to form the extra-long laths.

There was also the computer revolution. Buro Happold, linked in with the structural engineering department at Bath University, began applying off-the-shelf software modelling to explore the bending properties and behaviour of wood, hoping to ensure the minimum of breakages in the finger joints. Taken together the convergence of this research from the synergies between wood, glue and materials technology, to the simulation and modelling capacities of the digital domain, is a graphic example of how timber design is in the midst of a transformative revolution. This convergence is enabling the potential realisation of radically different, yet low energy, sustainable buildings, which were hitherto too impossibly complicated to construct. Not, it seems, any longer.

At the same time the team sought an open-minded frame carpentry business to carry out the physical construction of the gridshell. The locally-based Green Oak Carpentry Company won this tender, and then in a move upsetting the conventions of the Lottery funding, the project management requested that Green Oak be brought into the team. Unusual as this was, since the commission rules stipulated

contractors cannot be brought in until after a plan had been approved, the team argued that the specialist, hands-on knowledge the carpenters brought with them would be crucial for the project to work. The commission agreed and bent the rules, and Green Oak joined as partners. So with this newly-generated research material, a completed budgetary plan of £1.6 million, (of which 75% was from the Commission, the remainder from the museum) and, as arguably the trump card, Green Oak as project partners, a bid was re-submitted to the Heritage Commission in late 1998. To relief all round the Commission were indeed reassured. With industrial carpenters deep in the mix of the project, and feeling confident that it stood up on paper, they gave the green light.

From there it was only a matter of time before the real work could begin, which it did in early 2000. Only is the operative phrase, as the reality of building has been every bit as tricky as the early problems. It is also at the heart of how the building is capturing the imagination of press and public alike. The notion of the hi-tech new media engineers working in concert with in-the-body carpenters, guiding them to reposition the timber to micro-exact positions, like astronauts working on an earthbound, wooden space-station, stirs the mind, and aptly illustrates the fusion of traditional craft with twenty first century hi-tech. It is a gift for the carpenters as well, enabling them to show exactly what they can do, given half a chance. This in a building environment which for years has been heading in precisely the opposite direction, further and further into pre-fabrication and away from the uses of individual skill. As of this summer they are still fine tuning the positioning of the gridshell.

Whereas prefabricated inorganic materials are built to the exact gridshell shape, wood is a living material, essentially an, albeit stiffer, fabric. This means it can be prepared on the ground flat as a two dimensional lattice grid mat, before being moved into its vertical position, where it will change, or deform into a new, springy, and somewhat provisional shape. When this happens all sorts of surprise and unexpected shapings emerge, as the wood adjusts itself, its random living quality making even a computer model not fully equipped to entirely anticipate how things will turn out. Indeed, knowing how the timber will shape out, and doing so without it being damaged in the process, turned out to be the great quandary. Previous gridshells have been pulled or pushed up from the ground. These resulted in many of the breakages. As a new experiment, this time the gridshell was constructed on a specially prepared, and expensive, PERI scaffolding system, standing initially 7.5 m from the floor. The gridmat was constructed on the raised scaffolding, resting flat high above ground level. Then section by section, the scaffolding was removed, and the laths slid into its shell-like form, each part being cajoled into place by the carpenters, a forest of jacks tightening the position of the intricate crisscrossing laths at the connector nodes, the elaborate whirling weave of the building's surface at last becoming clearly visible. The diamond latticing, comprising two layers of laths, was pulled in different ways depending on their position in the grid. The outer layer was able to slide into larger lozenges, narrower and deeper over the domes, and flatter in the valleys. If this surface form was originally anticipated by the computer's modelling, once the structure was up, much fine-tuning has been needed from human eye and hand, supported by repeated and careful measurement. The lower laths have had to be tightened in relation to their upper partners. It was here that a lot of the fine tuning was done by eye, the carpenters knocking the laths into position, pushing out flat areas and deepening where the building needed greater volume. Once the final shape was reached, the whole building was measured again, comparing what was in front of the team with the shape originally modelled. Depending on your faith in the skill of the carpenters, amazingly, or not, the gridshell was very similar in shape to the original digital model. Once again it showed just how central the GOCC team participation has proved to be.

This carpentry ethic has extended from the large-scale gridshell, right across the building process. To give two examples of the teamwork, firstly the original plan envisaged positioning slotted holes at the crossing points of the laths, but when this was taken to the carpenters, they pointed out how difficult they were to make and the comparative cost involved. After a round of meetings, phone conversations, emails and faxes, a new and refined design solution emerged: the 'nodal connectors', were eventually designed, a combined effort of everyone in the team, from the hands-on carpenters to the engineers and architect. The result was practical in construction, whilst performing several engineering functions within the finished building and is also visually appealing. Similarly some of the laths originally required rows of ten bolts in close proximity to meet the Euro Code 5 timber safety regulations. But GOCC pointed out that green oak would split due to shrinkage, and was likely to split, from this number of bolts. So again by returning to drawings, further computer modelling, and the hands-on work of the carpenters, a solution was arrived at which successfully transferred the load of the lath, whilst meeting the regs and maintaining the stress integrity of the oak.

Right now, as of high summer 2001, the Down and Wealdland oak latticed gridshell is a remarkable sight to visit. However it won't be staying this way, as come autumn and its testing complete, it is to be

covered in locally sourced Western red cedar cladding. With this finished, the roofing will take on something of a contemporary version of the layered cladding found on Norwegian and Russian churches. At the same time the internal fit out, being implemented by another regional company, E A Chiverton, will begin. This looks like taking over seventy weeks.

If the building is already generating significant interest, once completed it should continue to attract attention, representing an early contribution to a new tradition in building. According to both Cullinan's and Buro Happold there are quite a few enquiries around the practicalities of further building. Given this is a heavily subsidised building, when the economics kick in people may think twice. But the costs are efficient, and so far it is only slightly over budget, comparing well to high-tech buildings, with its planned life of sixty years. All this and its demonstration of the potential of the emergent smart timber futurism should give the high eco-tech end of architecture community pause for thought. That said, my sense is that the sustainability angle isn't completely worked through yet. Buro Happold are only now beginning embedded energy analysis, as part of DTER match-funded research on the gridshells formation. Whilst it will apply usual environmental accounting procedures, it could include a much fuller, more radical indicators system; for instance, the embedded energy of the computer modelling, or the maintenance of the skills base in the social ecosystem, as a part of Life cycle analysis research. As it is the energy expenses of sending the laths by lorry to Newcastle for the finger-jointing, and comparison to steel framing are the kind of things apparently in mind.

It also provides a testament to a new 'hands-on/hi tech' building paradigm; the convergence of developments in wood and related materials technology, and the new capacity for modelling which have been inaugurated by computers, with the skills of the crafts tradition. Add to this the shell properties of the building and the lightweight properties of the gridshell, and it also dovetails into the emergent tradition of 'lightness', becoming a fitting example of how wood can be a suitable candidate in the search for extra-light materials and structures. Considered together this is a very contemporary approach to the continued integration of craft into the creation of buildings. Indeed it picks up elements of a time when craft was a central part of building - the cathedrals of the middle ages - evoking something of a new millennium mediaevalism.

As to the future, how will the gridshell look? 'Son of Frei Otto' perhaps. Both Cullinan's and Buro Happold were vociferous in emphasising the clear green water between the Downland gridshell, and Frei Otto's only building on British ground, Hooke Park's College 1990's workshop. This is certainly the case from a structural and materials sense. It used a ribbed structure technique, alongside being an experiment in the potential of reusing low grade forest thinnings, compared to the gridshell's high grade oak. From an aesthetic perspective, however, there are definite affinities, which centre around an emergent design of organic form. I recall visiting the Hooke Park building in the mid nineties, and being tremendously excited at its form, but also a sense of isolation. That isolation derived from its singularity, it was the only significantly structurally engineered building in the land which considered the dialogue between the languages of organic form and organic materials. It seemed a lonely building. The hope must be that nothing like this happens to the Downland gridshell. So far, the signs look hopeful, with a public tuned towards the curvatures of organic form, by way of the grand millennium projects, alongside an ongoing and growing research and knowledge base, some kind of critical mass may have been reached. If this is the case, the further emergence of an architecture of organic form, yet grounded in organic materials, as this specific gridshell example instances, and more generally, the possible multiplying of examples may well unfold.

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[1] see Charles Jencks' The Architecture of the Jumping Universe, Academy Editions, 1995

[2] Anyone curious to uncover the history of the region, of how its intermeshing of geology with livelihood, will find a treasure trove of information about the regions traditional means to living, from coppicing to charcoal burning to medieval rotational cropping. The main purpose of the museum, however, is the preservation of regional historical buildings, a dozen or so examples of which sit amidst the expansive parkland grounds, a veritable physical database of sorts on a whole range of historical building techniques which have pretty much disappeared.

[3] The article in The Independent (14th may 2001, p12) quoted a 60% break rate. According to Buro Happold this was completely inaccurate, but they didn't know the actual rate.

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