Profile

Francis Archer has designed extraordinary structures, not all of them built. The engineer for London's Garden Bridge talks to Jackie Whitelaw about how creativity is never wasted.

Being a structural engineer is never straightforward and certainly not when many of your commissions are for public arts projects funded all or in part by private donors. Arup Associate Director, Francis Archer, estimates that 20–25% of the projects he has worked on over the last 20 years have not been built, often because the money available has never quite kept up with clients' visions for their schemes. Or the projects have been casualties of high-finance business deals.

Archer was the engineer for Daniel Libeskind's cancelled Spiral extension (Figure 1) for the Victoria and Albert Museum (V&A) in London. And he is still engineer for Thomas Heatherwick's Garden Bridge in the capital, the prospects for which seem to have faded to zero since the job found itself £70M short of funds. He was also the brains behind what would have been the exquisite Crystal Theatre at the heart of Victor Hwang's Battersea Power Station project, before the developer sold on for £400M the site he bought for £1 and new plans replaced the original vision.

But nothing good is ever wasted. The concepts developed, and the intellectual rigour of innovation, have all been fodder for the Archer schemes that do make it off the drawing board. 'What I have also learned,' he says, 'is that you get most of the money from donors at the beginning. The first 50% is 10 times easier to raise than the second, and it might be better to tailor ambitions to work with the money you have in your hand. Great buildings, with the original concepts intact, will still be created.'

Despite disappointments, Archer has in his portfolio many gorgeous structures that display his engineering abilities.

These include the Cape Town Silos in South Africa with Heatherwick and Arnhem Central Station (Figure 2) in the Netherlands with UN Studio. And as a very big example, next year the eyes of the world will be on the unveiling of the Grand Egyptian Museum in Cairo – the largest museum on the planet and home to Egypt's ancient archaeological story and the treasures of the pharaohs. Archer worked with architectural practice Heneghan Peng (Box 1) to win the open competition in 2003 and then did five years of design, including creating a 50m high, 22 000m² translucent stone wall held up on cable nets and strung across a fractal pattern of steel grids.

Bringing maths to structures

The mathematics implied by the word fractal are very important to Archer's story. He is a mathematician by education. All his structures sing with beautiful, complex geometry. And his designs use the latest developments in maths, such as aperiodic tiling and fractal patterns, to create advanced geometric grids and position textures in pleasing order. The fractal pattern used at the Grand Egyptian Museum was first developed on the V&A Spiral.

Figure 1 Unbuilt Spiral extension for V&A Museum, London

Archer grew up in India where his father was a minister and his fascination with maths and physics flourished with few distractions. His academic career began with a first-class honours degree in mathematics at Imperial College London. This was followed by a PhD in theoretical physics at Cambridge University where he was part of Stephen Hawking's group. There was also a spell at Princeton University in the USA.

Figure 2 Arnhem Central Station, the Netherlands

'But after 10 years in academia doing very abstract research in maths and physics, I realised that I had reached my limit, in fundamental research at least, and wasn't going to make breakthroughs in the fundamental questions I was attracted to. And I didn't want to continue primarily as a teacher, I wanted to understand more things.

'I had an obsessive character, no responsibilities beyond myself at the time and a very unbalanced life, and I knew I needed something that was interesting and challenging,' he says. The switch to structural engineering was somewhat arbitrary, but I could see that I could master it and was attracted to it because it was basically 18th century physics – Hooke's law relating stress and strain plus a good understanding of materials.'

Archer then hit the problem that he had no engineering education. 'Through an uncle I had got hold of a list of firms and put together a CV, but all the HR departments said no, there was not even the offer of an interview. But then luck played a part and I met Sudhakar Prabhu at Pell Frischmann and he took me on, for which I am always grateful.'

Archer's arrival at Arup aged 27 was the result of a letter direct to Philip Dilley, again bypassing HR, who invited him in for a chat with himself and buildings guru Cecil Balmond. They liked what they saw and made Archer an offer. A day release MSc course in structural engineering got him the qualifications he needed, 'but I was useful from day one,' he says. 'Maths is always useful.'

Forming a supramind

The work was something of a revelation, introducing Archer to world of the arts. 'Before I became a structural engineer, I had never linked engineering and maths to the arts. I thought I'd be interested in the tallest buildings, the largest bridges, but when there is an infinite choice of what to build, it's what you choose and why you decide to do it that is really interesting. I understood that design is not about the maths but about deciding the most appropriate answer.'

But Archer was not, and will never be content to be, the technician to someone else's vision. 'I have never been happy to be an isolated specialist, I want to know why I am making a building and be involved in its development.'

In his view, great design requires the forming of a 'supramind' from a multiple set of individuals whose minds complement one another. 'Architects and engineers need to collaborate,' he says. 'Architecture brings history, politics and economics into play in design and architects themselves have to be jacks of all trades. But buildings are more and more complex now and architects need help. Isolating and telling consultants what to do is not the best way forward; you need unity and empathy in the entire core design team.'

Archer worked closely with Balmond for a decade. He appreciated Balmond's ability as a publicist as well as an engineer, and his skills in business and in building relationships with big name architects such as Libeskind for the V&A Spiral. His engineering he learned from Bob Lang, also on the V&A. 'He could make complex structures like the Spiral, which unwound into a single form, look like something a contractor could understand,' Archer remembers.

Again with Balmond's introduction, Archer got to see the workings of another great architectural practice – UN Studio for the Arnhem Central Station in the Netherlands. He also had a new mentor at Arup, architect turned structural engineer, Charles Walker – now director of the Zaha Hadid practice. 'He had strong opinions and a loud voice (a sign that there are no secrets). And it was refreshing to see a new perspective on structural engineering from someone who understands architecture and also the potential of new technologies, and geometry.

'And the geometric vision of Ben van Berkel and Tobias Wallisser for Arnhem was inspiring,' Archer recalls. 'It was that of the entire building being one single surface, starting calm at one end and turning into a whirlwind in the transfer hall.

'I understand surfaces, this was my subject

BOX 1. PARTNERS IN DESIGN

Francis Archer's closest architectural collaborator is architect Shih-Fu Peng of Heneghan Peng. He has worked with Peng on dozens of competitions and winning examples include the Grand Egyptian Museum in Cairo (Figure 3), the Giants Causeway Visitor Centre in Northern Ireland (Figure 4) and the Palestinian Museum. They are currently working together on the Canadian Canoe Museum and the competition for the London Holocaust Memorial.

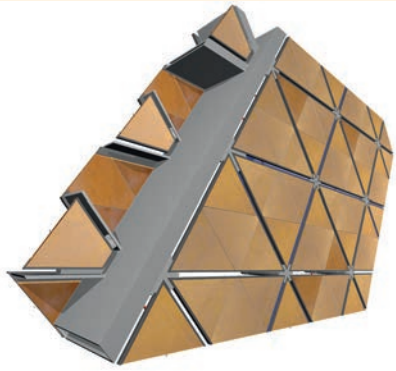
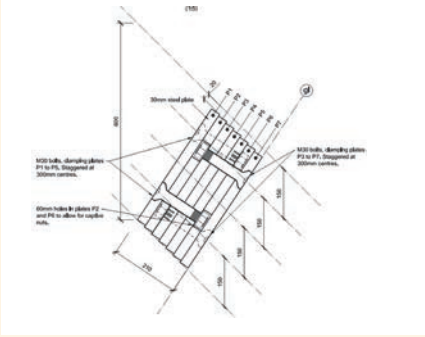


Figure 3 Translucent stone wall for Grand Egyptian Museum



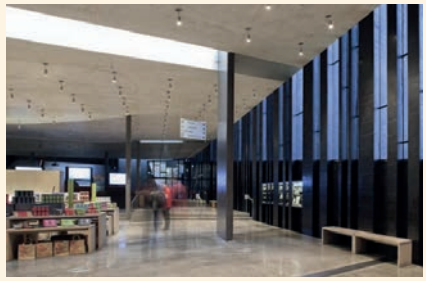


Figure 4 Giant's Causeway Visitor Centre, Northern Ireland

as a mathematician. It's possible to make a multistorey building out of a single surface where both vertical and horizontal structures – the walls and the slabs – are actually just zones of the same single surface. And there is no specific threshold between floor and wall. Also, surfaces are topological beings, they can be stretched and need no columns, for instance. But at Arnhem the span was too long and flat and needed additional mid-span support.

'I could see how this might work with the introduction of a peeling away of the roof into the floors below – the surfaces could be topologically defined by just drawing their free edges and then stretching the surface between these (like creating soap bubbles).'

To prove his hypothesis, Archer made a model. From day one as an engineer, he had been experimenting with physical structural models – from his first ever project for Pfizer HQ in Surrey. There he had demonstrated his idea for the glass roof of two counter-stressed tied arches, the ties of one stabilising the compression in the chord of the other and resulting in a stiff spanning arrangement; and the idea was accepted for the building. The sole survivor of the V&A Spiral is also an Archer model in the museum's architecture section.

For Arnhem, Archer went into the workshop and demonstrated how the surface could be stretched via a model he made with a piece of wire and a pair of tights. The loops and twists he demonstrated were possible are now there for all to see in the freeform completed structure which opened in 2015.

Creative pleasures

Life is not all large structures. One of Archer's happiest times was working on the Libeskind '18 Turns' Serpentine Pavilion in 2001. It was a 'magical and obsessive 10 weeks' creating a structure of unstable shapes that became stable because of their intersections with others.

Shortly afterwards, he took a year's sabbatical to build a house in India, returning to the fray and the notorious (at least within Arup) Advanced Geometry Unit set up by Cecil Balmond. 'The unit was perhaps seen as elitist or even divisive. But with it, Cecil had found us a new client in Victor Hwang who hired us as master planner for the Battersea site. This was a truly intense period and we went wild with all the ideas flowing out.'

Archer was particularly delighted with the Crystal Theatre (Figure 5) that would have shone with psychedelic patterns and used the dodecahedron as its planning grid. 'We created a building with aperiodic geometry which could be read as traditional grid lines, but not just three sets of parallel planes (sugar cube packing) – we had six (breaking up space into truncated dodecahedral)!'

Arup's client Hwang sat with the designers often, sketching with them, dreaming and laughing, and when he particularly liked something large bottles of champagne would appear.

'We had two or three years of very creative design that I am convinced would have achieved architectural and structural notoriety,' Archer says. When Hwang sold the site in 2006, it was a sad end to such a happy time. 'We had great fun and it was inspiring to have a client so excited by our creativity, but ultimately we wanted to build it.'

Alongside Battersea, Archer was developing the Grand Egyptian Museum and shortly afterwards started working with Thomas Heatherwick, including on the concept design for the award-winning Learning Hub at Nanyang Technological University, Singapore. This led to involvement in the Garden Bridge.

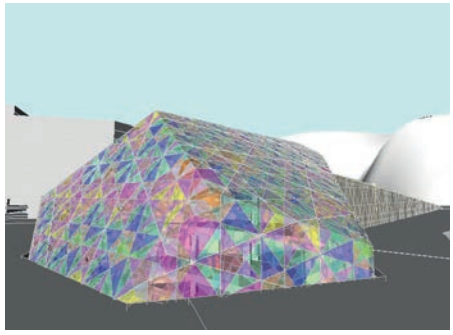


Figure 5
Unbuilt Crystal Theatre, Battersea Power Station, London

Archer is deeply disappointed that the bridge does not seem as if it will be built. 'It was ready to build. The entire structure was to be made from roll-bonded, copper-nickel-clad steel plate to create the idea of bronze planters kissing in the middle of the river. It would have been a national treasure.'

A happier Heatherwick story is the soon-to-open Cape Town Silos project in South Africa, where industrial 20m high unreinforced concrete structures are being turned into a museum. 'This is not facade retention or recladding, we used the original structure and created an atrium by carving a hole in it. We have re-sleeved the tube with new concrete carved to shape that is holding up the original concrete. It keeps the geometry light and sunshine pours down the holes.'

His next project should be for the world's largest self-supporting spiral staircase at Shanghai Opera House and he is also experimenting with robots and timber tension nets. He has also discovered that he does like to teach and is sharing his experience and understanding of the possibilities of adventurous structures with students at the Architectural Association's Hooke Park facility in Dorset (Box 2).

Now he's reached 50, he's more and more conscious that work has to be fun and that you can learn through play, or experimenting.

'Recently, vice chair of the Arup Group Board, Tristram Carfrae, sat next to me and said, "Slow down and enjoy it". It made a huge difference. How can you be at your creative best if you are stressed? Business issues have to be put to one side sometimes to be creative and even if everything you design doesn't get built, you have always learned something to take to the next project.'

BOX 2. EXPERIMENTAL SELF-BUILDS

Small, fast projects, such as the 2001 Serpentine Pavilion, as well as self-build projects at Hooke Park are favourites, as 'nothing beats the intensity of design, fabrication and construction that these bring'.

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