Inventing New Bridge Designs

Halcrow find Autodesk Inventor a great tool for bridge design

By Bob Garrett, Head of Marketing, Excitech Computers Ltd

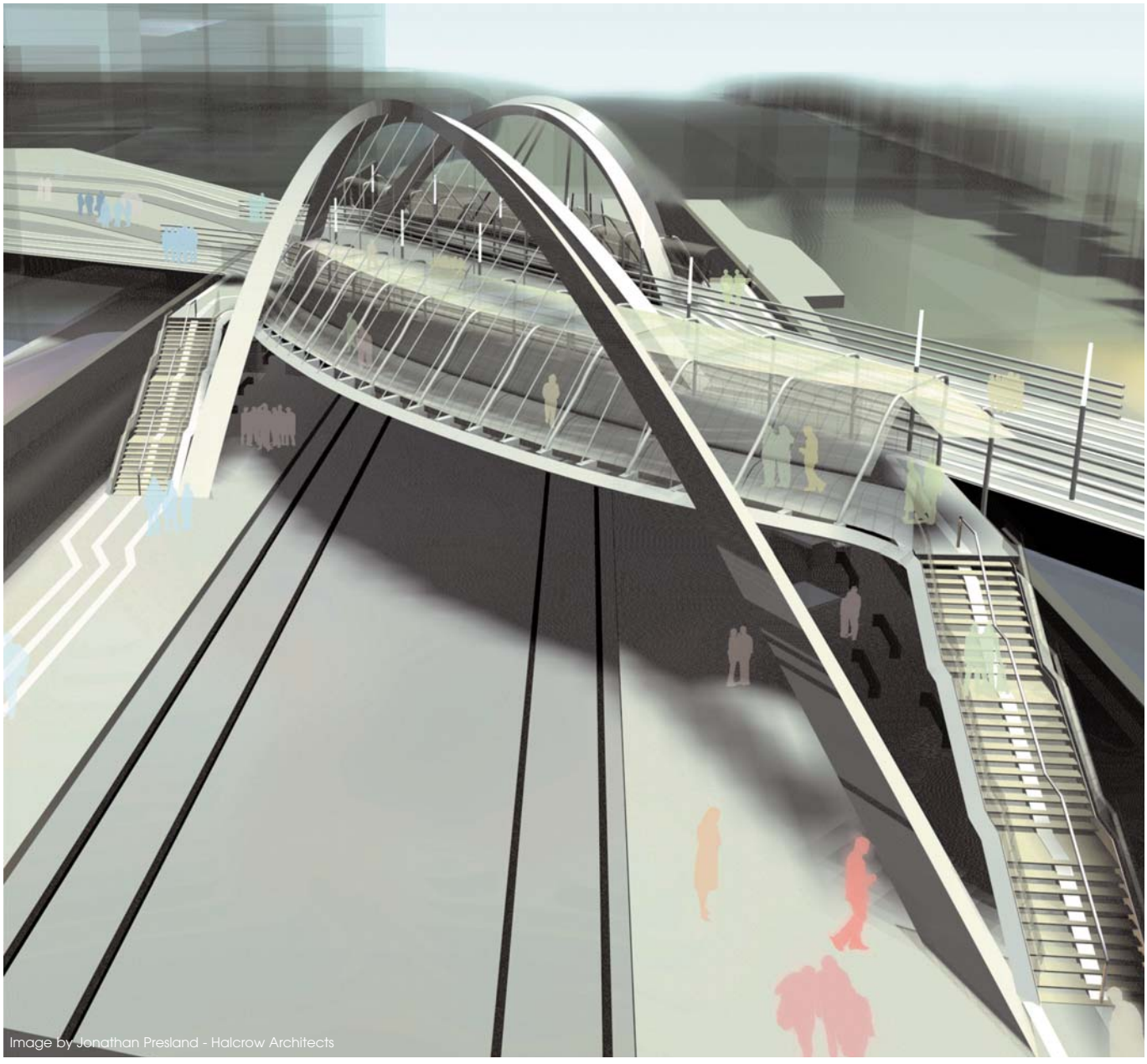


Image by Jonathan Presland - Halcrow Architects

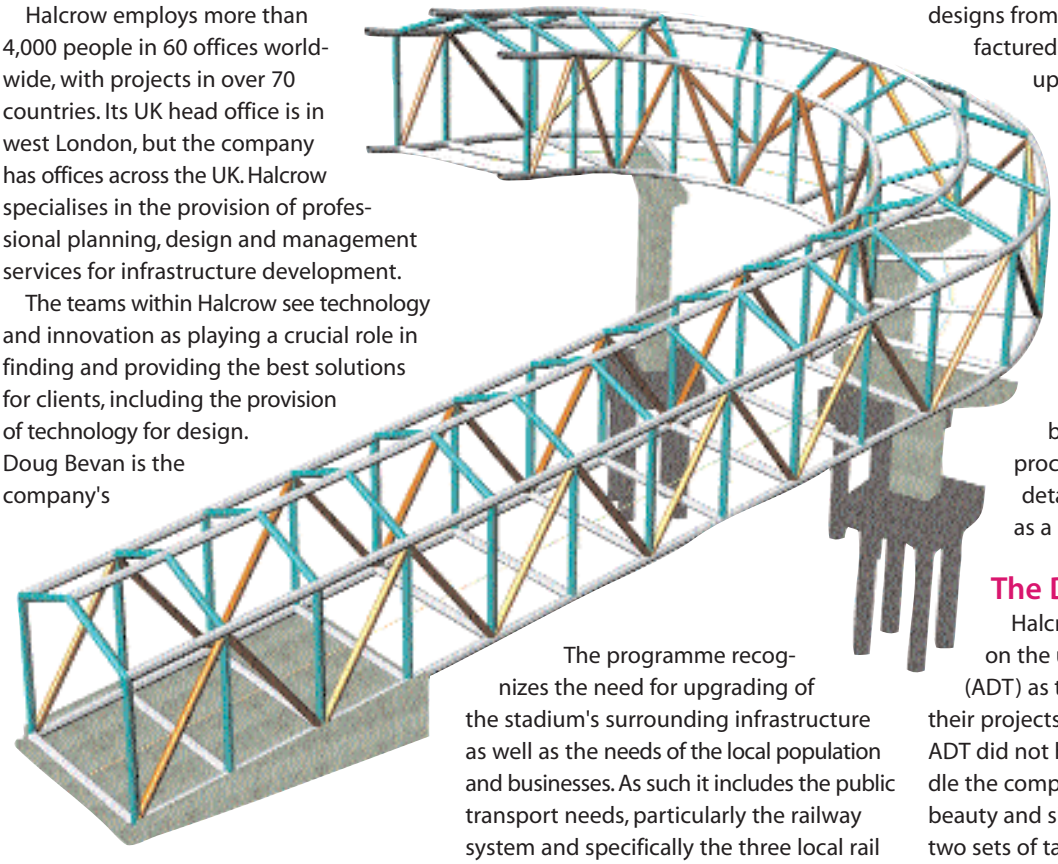
Halcrow have recently started to use one of Autodesk's mechanical design tools, Inventor, to accelerate the design, calculation and review processes for construction projects that involve structures with complex shapes and components.

A project that Inventor has been used on with the aim of modelling complex 3D geometry is an innovative bridge design, which forms part of London's Wembley redevelopment project. The visually simple, but from a design perspective, complex structures were made not just practical but could also be designed with greater confidence, with less effort and in shorter time scales.

This has highlighted to Halcrow the value of such a methodology and given them greater skills which can be used in a wider range of future projects.

Halcrow employs more than 4,000 people in 60 offices worldwide, with projects in over 70 countries. Its UK head office is in west London, but the company has offices across the UK. Halcrow specialises in the provision of professional planning, design and management services for infrastructure development.

The teams within Halcrow see technology and innovation as playing a crucial role in finding and providing the best solutions for clients, including the provision of technology for design. Doug Bevan is the company's Technical Director of Work Systems and CAD, which means he manages the strategy and implementation of project work systems across the business groups. His remit is not just in CAD but also document management and collaboration systems, as these are seen as an integral part of the design process. Halcrow's main CAD foundations rely on Autodesk applications but with additional software including MicroStation and NavisWorks where the engineering discipline requires a specific tool or a client/project demands it. Even a few minutes discussion with Doug immediately highlights both his visionary views and how strongly he believes that the right design technology can radically enhance their work in many areas - as this article demonstrates.



The Wembley Project

The London Development Agency together with the London Borough of Brent have a regeneration programme for London's Wembley area with particular regard to the new National Stadium currently under construction.

The programme recognizes the need for upgrading of the stadium's surrounding infrastructure as well as the needs of the local population and businesses. As such it includes the public transport needs, particularly the railway system and specifically the three local rail stations, pedestrian marshalling areas and public access.

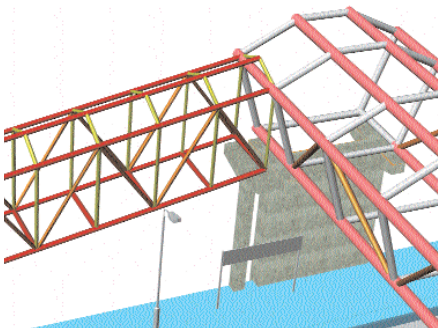
One access route to and from the stadium passes by Wembley Stadium Station; a route which is expected to have some 19,000 pedestrians passing through, with 7,000 wishing to use the station when major events take place. To handle these demands a new pedestrian bridge is planned to both carry the "passing traffic" and to provide access to and within the station. The decision was made some time ago that this bridge should be "a landmark structure" and the design produced by architects Marks Barfield (designers of the London Eye) is simple but stunning. Its graceful arches might even be seen as bringing to mind the trajectory of a ball in flight - reflecting the nature of the adjacent stadium.

Similarly Wembley Central Station requires a new pedestrian bridge between the two platforms. Again an innovative design concept was created by the Halcrow architect, Nick Haseltine, including pentagonal and hexagonal frames for the ramps and span.

It was Halcrow's job to take these simple but innovative concepts and make the designs from which they could be manufactured and built. This task was taken up by Halcrow Project Manager, Billy Ahluwalia; Halcrow Engineers Krishna Ganasalingam, Pui Mei Chan and Trevor Gallyot and their respective teams supported by Doug in terms of the design technology to adopt. To quote Doug "innovation often equates to complexity in bridge design" and the process of going from concept to detailed design was recognised as a challenge from the start.

The Design Challenge

Halcrow have increasingly focused on the use of Architectural Desktop (ADT) as the preferred design tool for their projects but it was clear early on that ADT did not have the functionality to handle the complex geometry involved. The beauty and simplicity of one bridge with two sets of tapering and twisting arches with three curved pedestrian pathways with changing cross-sections is obvious.



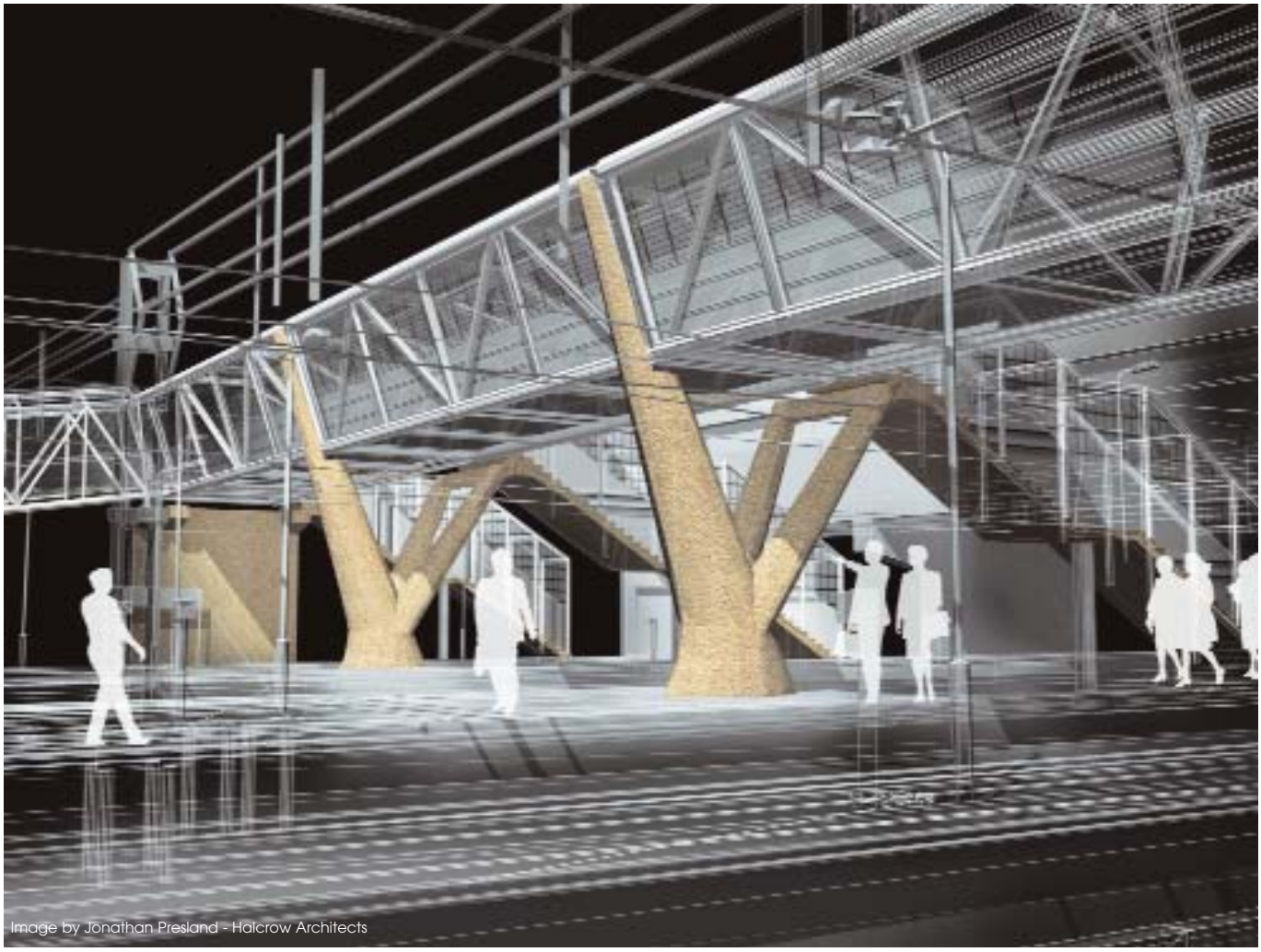


Image by Jonathan Presland - Halcrow Architects

However, Krishna recognized that using normal techniques such as a lattice of large numbers of nodes to define and analyse the structure was going to be extremely labour intensive. Furthermore the opportunities to iterate for changes as the design developed would be limited, timescales would be extended, risks of error would be greater and according to Doug there would be little opportunity for "value engineering". For the second bridge there were issues regarding how to design and analyse the stanchions where their complex shape made calculation of strengths, stresses and centres of gravity difficult.

Confronted by these challenges and looking for a "better way" Doug Bevan consulted Excitech to see if there was any new software available or under development which might help.

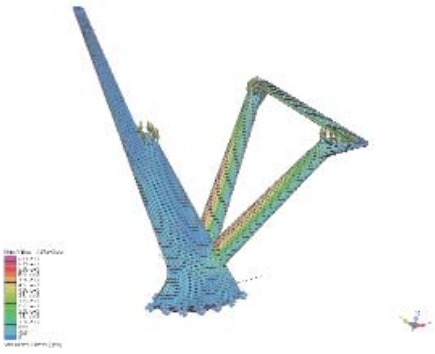
Interestingly, his query to Excitech arrived around the same time that a couple of other similar questions had arisen regarding the design and interaction of complex shapes within the construction sector on other projects. Excitech's consultants examined these and concluded that the most likely solution would be based on Autodesk Inventor. This is a sophisticated 3D modelling, design and analysis software package intended for the mechanical engineering and manufacturing sector. But its features very precisely mapped onto the requirements for Halcrow's projects due to its solid modelling techniques and handling of complex geometry. After some consideration it was also apparent that methods could be implemented such that design data in 3D could be transferred between Inventor and Architectural Desktop so the construction project tool of choice could still be used for the overall project. Inventor would be used to generate the geometry and either carry out design analysis or provide data for further analysis by other software, then the completed "components" could be transferred into Architectural Desktop.

Modelling In Practice

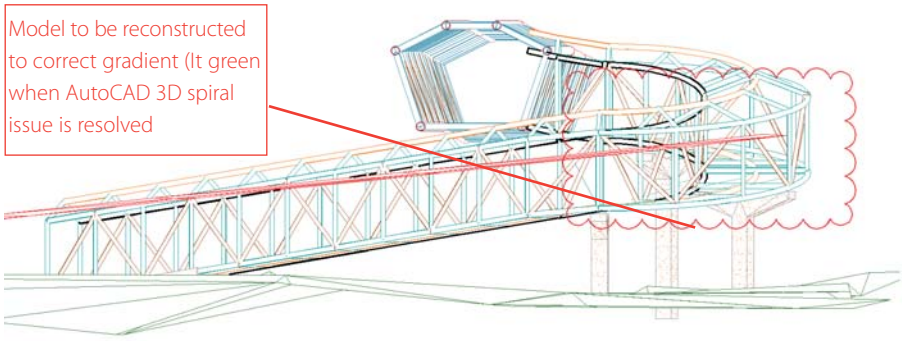
The challenge in the two bridge designs was to produce the necessary geometry, do basic analysis and then export for more detailed review such as Finite Element Analysis to determine stress points. With the tight timescales envisaged there was a concern that carrying this out with a software package that none of Halcrow's engineers or designers had any experience with could be a risk. They therefore asked Excitech to support them in this by the provision of further consultancy work. Lawrence Hooker, one of Excitech's Application Engineers for mechanical design products, was designated to the

task and worked closely with Halcrow engineer, Pui Mei Chan and the design team. Lawrence used his experience both of the Inventor application and modelling complex shapes to support their skills in construction design.

The primary focus on the second bridge were the stanchions where the overall geometry, sizes and shapes of joins needed to be designed while taking into account the centre of gravity of each major component and analysis of the structural engineering and stress factors were assessed. Components, once designed, could then be exported from Inventor in Autodesk's ShapeManager data format. These could be imported into Architectural Desktop as mass elements which could then be handled as other ADT objects such that further detail and interaction with other components could be added.



The design of the arches by Halcrow on the other bridge produced a different set of challenges but again Inventor was found to be the ideal tool. The design vision was for arches which "burst out of the platforms" to form an elegant curving, tapering and twisting structure with a triangular cross-section. Defining this was intricate but Inventor's geometric tools handled the heavy mathematics and made adjustments easy. As with the other bridge, structural integrity work was necessary but there were particular concerns over ensuring that the right clearances were there at every point for both the trains and pedestrians going through. The precision of the shape in the design - no large lattices of nodes with straight lines - ensured tolerances could be relied on as being accurate. Again design data could then be transferred into Architectural Desktop.



Thus the project was using the most appropriate design tools at each and every stage; Land Desktop for the infrastructure, Inventor for "mechanical/structural" components and Architectural Desktop for the complete construction model. To quote Krishna " Inventor gave absolute confidence in the design and its integrity" by dramatically improving the process of design, modelling and analysis - and doing it much faster than they imagined. And according to Doug it is not just the design process which is improved, "this should also compress the manufacturing stage and the actual construction time" he says, "producing a more value engineered product". Indeed it is expected that when the design is approved the fabricator will extract the manufacturing data directly from the 3D design file.

Design Review and Publication

Not satisfied with just using the latest software tools and techniques for design, Halcrow also wish to manage design review and publication as efficiently as possible. To this end they use NavisWorks for design review including clash detection and walk-through visualisation, building on and combining their original 3D survey data (which was obtained by laser scanning) with their design proposals.

They have also recently started using Autodesk's DWF file format for design publication and review. Previously there would be a significant amount of time spent after a drawing had been completed on screen in the printing, copying and distribution stages. This usually meant that they would get no feedback for at least two days and even that might just be verbal comments. Now with DWF they send the drawing files to the print-shop electronically - so eliminating the first print stage. And increasingly they are finding recipients are quite happy to receive just the electronic copy i.e. the DWF file - for review either on screen or for them to print themselves. Thus they can now start to get feedback within as little as 1 ½ hours and that can be red-lined and annotated drawings in electronic DWF format. While most red-lining is at present still on hard copy drawings, there is a definite movement to pure electronic mark-up as people see the speed and have discovered they can also determine extra data from the DWF files such as making their own measurement checks.

Conclusion

Halcrow have demonstrated to themselves and to their clients how rapidly and effectively project design processes can be undertaken by using the right tools. And in this case the right tools were not those that were immediately apparent or, as far as they were concerned, intended for the purpose they had in mind. Doug Bevan acknowledges that "had we used conventional technology and not sought Excitech's advice it just wouldn't have been possible - certainly not within the timescales and certainly not with the level of confidence we have in the results". Halcrow have now leapt over a major hurdle in the design stage of the project and can see that the future stages will contain less risk. Furthermore they have a new design tool, as well as new design techniques and methodologies they can bring out when needed for future projects.

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