

Future roofed

GenerativeComponents was used by BDP to help IKEA meet strict design and environmental constraints for the design of the complex roof structures for its new malls in China



IKEA in the Daxing District of Beijing



Central hub at Wuxi

The IKEA project at Wuxi



Wonder how the Chinese will get on with Swedish Meatballs. They are going to get the chance to try them as IKEA - the Swedish company Inter IKEA Center Group, to be exact - is planning to build two shopping centres in China, bringing the delights of flat-packed furniture to the Chinese masses, and, of course, the company's favourite dish in its restaurants!

One of the shopping centres will be based in the Daxing District of Beijing, and will open in 2014. The other is to be located in Wuxi, in East China's Jiangsu Province, opening in 2013. With business areas of 200,000sq.m and 140,000 sq.m respectively, and space for 13,000 cars between them, they will comprise more than just the iconic furniture retailer, with adjoining malls housing the usual fashion, food, home electronics and entertainment businesses.

The reason we are interested in the development is that the architects, BDP, have designed the two shopping centres, both of which feature a series of complex roofs, using Bentley's GenerativeComponents. The unique way in which they were able to optimise the complex roof designs earned them a place in the finals in the latest BE Inspired Awards Event in Amsterdam, in the category Innovation in Generative Design.

BDP is the foremost architectural practice in Europe. The Partnership started out in 1961 and now has upwards of a 1,000 employees in numerous offices in the UK, Europe, Abu Dhabi, India and China, working in all construction disciplines - architecture, design, engineering, urbanism, sustainability, lighting and acoustics. BDP has won over 600 awards for its work in all areas, and is currently top of the Architect's Journal 100 list.

Apart from overcoming the design challenges BDP faced in designing such complex roofs, the software also assisted the Partnership in meeting the environmental challenges that they were tasked with, namely to adopt an environmentally friendly approach to the



Mall walkways with complex roofing

design with a careful utilisation of resources. They were able to achieve this for each of the roof projects, each of which had a unique geometry, and BDP was even able to re-use the company's design strategies - modifying scripts, procedures, 3D details and panelling calculations to suit each project.

With its links to Bentley's STAAD.Pro, BDP was able to use GenerativeComponents to compare different construction geometries and materials to minimise steel use and simplify the panelling. Similarly, the use of environmental analysis tools, specifically Autodesk's Ecotect, enabled BDP to optimise daylight and minimise solar gain for the roof panels in each Mall. Overall, the process was able to achieve design and documentation savings of 20%.

WUXI

Following in the illustrious footsteps of Gaudi, and taking inspiration from nature, the design of the complex roof structure for the Mall at Wuxi followed the planispiral form of the ubiquitous ammonite fossil, of which each segment generated different envelope conditions - an expanding geometry that enabled BDP to adhere to the site constraints, but still allowed for the possibility of future expansion. The shell dictated the cladding envelope, the organic mall roof, and the large hub roof, the shapes of which were converted into the complex geometry for each section.

Using GenerativeComponents, different variations of cladding and panelling were generated and tested, not just as a design study but, in the case of the mall roof, to compare ETFE panels against glass panels for the large 75m spanning steel diaphragm

roof. Producing the complex geometry, with loading patterns that included large temperature effects as well as global stability and limiting deflections, were among some of the complex problems that had to be solved, as well as working to Chinese design codes. Refining the geometry by running it through GenerativeComponents enabled BDP to achieve a 50% saving in steel weight from the initial architectural concept.

BEIJING MALL

The Beijing Mall features glass panelled roofs spanning 20m over the mall walkways. GenerativeComponents was again used here for iterative testing of all of the complex roof sections. Parametric models were created, from which GC Scripts were prepared, enabling the data to be exported for structural analysis.

The point co-ordinates were exported to Microsoft Excel, and the data rearranged to prepare it for use with the STAAD.Pro Editor so that the analysis could be run, and the graphic results returned. An iterative process was set up which made adjustments to the parametric model, to compare the effects of different member sizes upon the shape and performance of the structure. Because GC was used to perform the iterations, successive analysis could be carried out purely on the basis of the member size changes without having to re-apply loading.

Similar studies were carried out to evaluate environmental performance, with facets, created after geometry evaluation, exported via Opensource and *.dll to evaluate daylight factors. From the parametric model, the GC scripts enabled

adjustments to the geometry to be made and evaluated before being exported to Autodesk's Ecotect for environmental analysis.

Commenting on both the projects, BDP's Chief Architect, Jeremy Sweet, said, "Intel IKEA shopping centers in the Beijing and Wuxi project group will maintain the Nordic ethic for being close to nature, their passion for fashion and their fresh architectural outlook; the way they use energy, their commitment to environmentally sustainable building materials, and the practicality of their approach are exemplified within the architectural features of the structures.

They are also used to meet the business interests of the shopping mall layout; utilising a measure of system planning to provide a comfortable, convenient and personalized new shopping experience for their Chinese customers.

Hardly of less importance, the presentation that BDP made to the Bentley BE Inspired judging panels, which are comprised of experts from all sectors of the industry, included a more local project; St James Quarter in Edinburgh. This also features complex roof sections covering a walkway, with a glass roof. Two competing shapes were compared using GenerativeComponents - a toroid, or a pulvinated, shape using different base lines, gridshells, trusses, radial beams and supports as starting points, modifying the geometry for different apex heights, and introducing a number of beam sections sizes and weights to optimise material usage.

BENTLEY SOFTWARE

Centred mainly around GenerativeComponents, the two projects used a number of Bentley software applications, besides STAAD.Pro. These included Bentley Structure, Bentley Architect, Microstation V8i, Luxology, Bentley's GC Script and Bentley's Opensource code - as well as Autodesk's Ecotect for environmental analysis.

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