Ukraine Health Protection Centre

Andrew Cornett, structural engineer, and Vladimir Masinsky, architectural assistant, BDP, explain how a hospital design relied on different types of software

This 250-bed children's hospital in Kiev, specialising in the care of infants and children with cancer, is the biggest charitable project in Ukraine's history. The hospital will provide, among other services, radiotherapy, oncology, neuro-oncology, haematology and pathological obstetrics. The project is a first in Ukraine both for its scale (53 000 m^2) and the programme of care provided.

Located in the heart of a wooded park the major challenge for the project was to provide a building form that integrates seamlessly into, and complements such an environmentally sensitive site. Part of this integration with the landscape was the creation of the complex 'organic' atrium which wraps around the main hospital building providing a spectacular focal point for the scheme.

The new building separates the treatment and diagnostic areas from the ward areas and buries the former block beneath a 'green' roof so that it merges with the forest floor. The building combines traditional construction principles (wood and oxidised copper for the ward fingers) with the hi-tech use of EFTE for the atrium roof. The weight of the ETFE pillows is a fraction of that of traditional glass and in addition it is a flexible material which responds well to settlements and deflections within the supporting structure when compared to glass cladding. These two characteristics have allowed us to design a much lighter steel frame for the atrium reducing material volume considerably. The atrium's ETFE pillows will consist of three or four layers into which air is pumped by a solar-powered heating system. Once inflated the pillows provide more insulation than glass could. This makes them particularly weather resistant too, in times of exceptionally cold weather they can be inflated further.

The main hospital treatment and diagnostic area is a five-storey building with basement that includes a service yard. The geometry of the ward blocks and main hospital building combine to create the form of a human hand with the main hospital treatment and diagnostic areas enclosed in the atrium, the surface area of which is around 6000m^2.

The atrium will provide a large spectacular open plan reception and meeting area within the hospital. The structure will sweep around the western, southern and eastern façades of the Technical platform with a geometry that curves in two planes with a free flowing complex geometrical arrangement. Two-storey link bridges between the wards and main building traverse through the atrium space and provide private access for medical staff and patients.

The complex geometry of the atrium structure is being solved through the use of Bentley's parametric design and associative modelling software, Generative Components, integrated with structural analysis software Staad Pro.

There were two primary challenges associated with the development of the atrium design. The first was creating a 3D model of the atrium's surface geometry which could quickly and easily be adapted and evolved to create the most visually striking and structurally efficient profile while being quickly adaptable to different forms and shapes of cladding panels. The various design options then needed to be presented in a 3D computer rendered format as well as physical models.

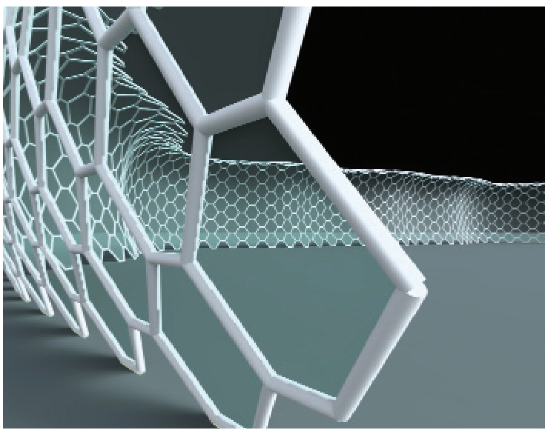
The second challenge was being able quickly and efficiently to determine the structural performance of the many different potential surface geometries and individual member lay outs and orientations to strike a balance between structural optimisation and visual aesthetics.

Neither of these two challenges could be met by using traditional design and CAD software so the Bentley software was chosen.

Numerous man hours normally spent on design feasibility studies for the atrium at various stages of the project were streamlined. The flexibility of the software allowed us quickly to determine the most efficient form for this type of structure thus assuring the client of optimum value for money. We were able to create complicated surface geometries and cladding patterns in a few minutes that would have taken days using traditional design software. An added time saving bonus was the use of Bentley Generative Components scripting language to automate further the creation of cladding geometries.

The scripting capabilities of this software allowed us to explore numerous design solutions with the click of a mouse. After the geometry of the atrium had been agreed we could experiment with a variety of different cladding panel shapes and sizes without any

1 GV Form study using hexagons
2 Cladding over parallelogram grid



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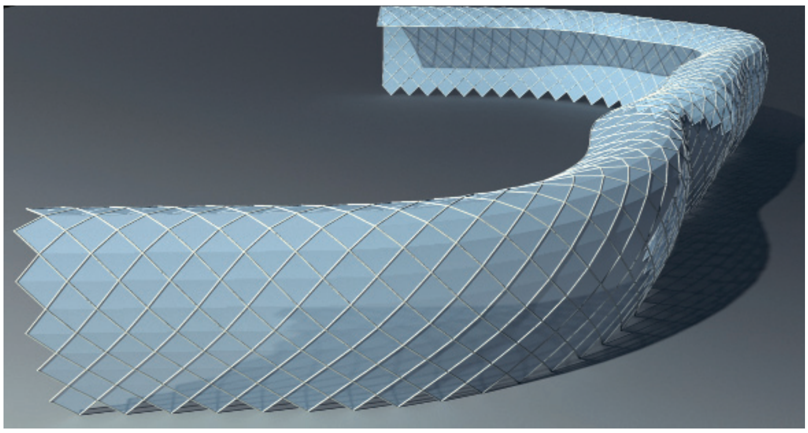

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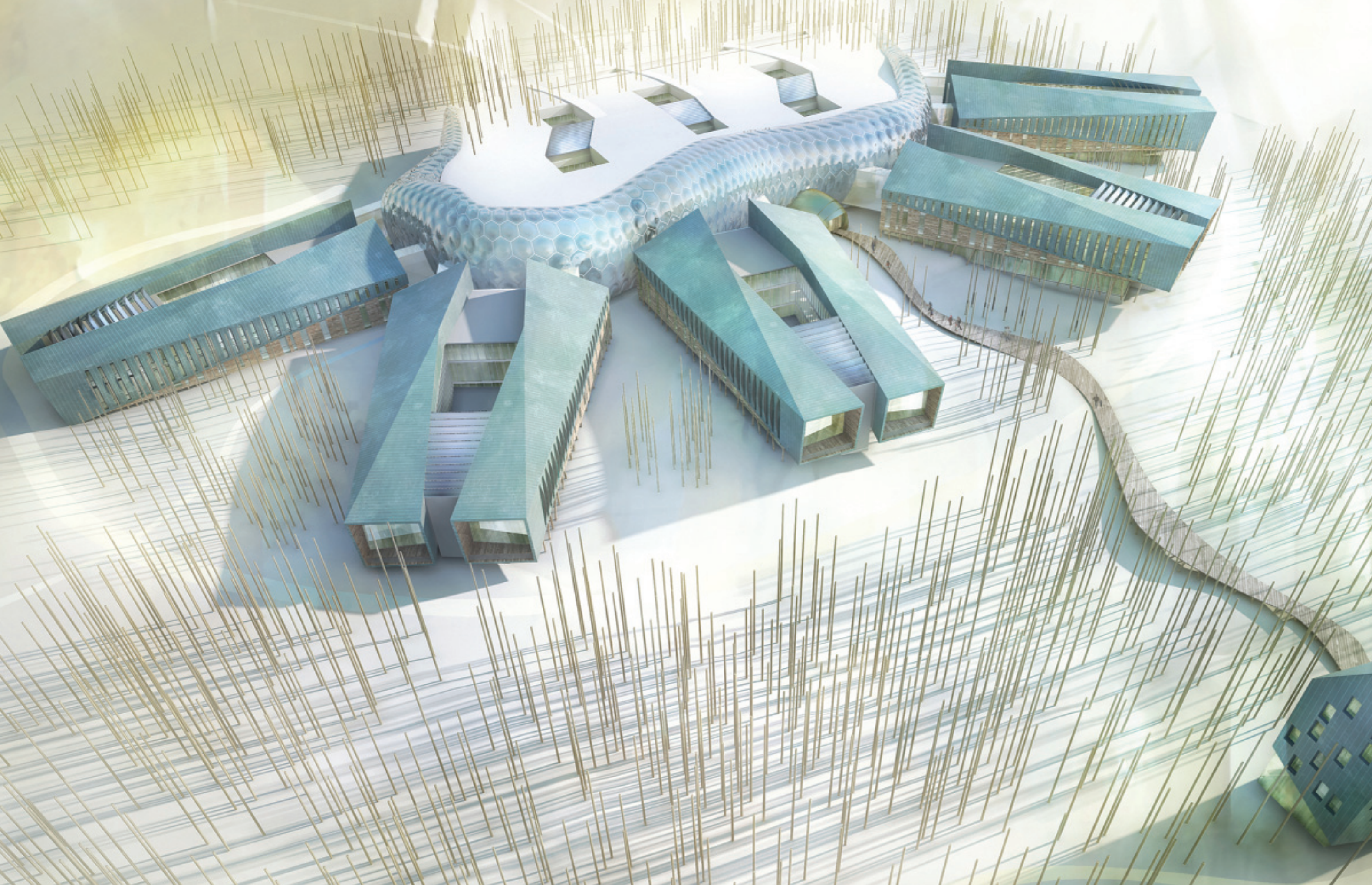

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3 **Aerial view of the proposed building showing the organic form of the atrium (*Courtesy bdpgroupe6*)**

re-drawing. This was particularly beneficial to the design programme as it allowed us to experiment rapidly with 'what if' scenarios with no time consuming re-drawing.

The visualisation provided by Microstation's 'built in' program, Luxology, was particularly useful in the early briefing stages of the project where we needed quickly to provide interactive images which could be viewed between the UK, Paris and Kiev. The images could then be used by the client to keep the population of the Ukraine informed about the development of the design.

The architects for the project were based in Grenoble while the engineering team was located in Ireland. Collaborative technology allowed us to pick up and deposit live CAD drawings from a remote server to optimise the flow of design data between various disciplines. Architectural concept drawings indicating the preferred geometry for the atrium were quickly used to create a 3D model in Bentley Generative Components. The scripting language was used to generate a number of different surface cladding shapes. The flexibility of the scripting language within Bentley allowed us to go beyond generating geometries which followed traditional definable rules and allowed us to explore complex forms providing more visually stunning design options. As an example of this, we were able to create a scripting loop which could infill any chosen surface shape with a hexagon pattern. The script then allowed us instantly to change the size of the hexagons. The same process was developed for squares, rhombi, parallelograms and triangles.

We looked at a variety of different shapes to form the surface of the atrium. Our initial solution was to use hexagons. Although the hexagons created a visually stunning aesthetic they did not perform particularly well structurally due to the geometry of the atrium in section which curves in on itself toward the base creating large stresses in the members.

To resist these large forces we found that the members were becoming much too large and heavy which distracted from the lightness of the design. The alternative was to use a double skinned hexagonal structure, like a space frame, with the hexagonal member on the top stiffened by tie chords underneath separated by discrete struts. Although this solved the problem of bulky steel sections the complicated free form shape in two planes make the aesthetics look cluttered from the inside i.e. there could be no symmetry to the location and order of the tie chords internally.

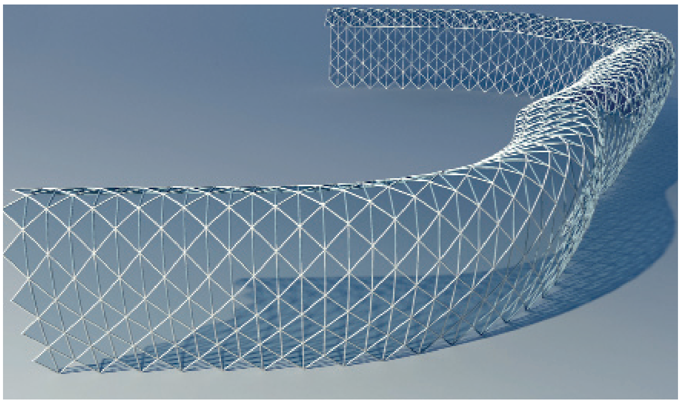
In addition, hexagons are not an ideal shape to form a surface which is curved in two planes. The double curvature of the atrium's shape means that all the hexagons would have been non-planar which in conjunction with some of the tight surface radii created problems with trying to infill the shapes with ETFE pillows.

The natural design evolution then brought us to triangulated panels which are much stiffer than hexagons, could form the surface geometry as planar elements and could create a much lighter single skinned structure.

Once we had created a design option for the atrium we could easily determine its structural performance by exporting the model to Staad Pro where we could quickly determine section sizes and shapes. The resulting model could then be transferred back to the 3D visualisation software to produce rendered images and solid models which allowed the design team and client to evolve the most efficient and aesthetic solution. Confidence was generated amongst the whole team that the given solution to a complex design challenge was proved to be buildable and demonstrated in a virtual world prior to construction.

Background to the project

Following a competition win at the end of 2007, against a strong field of seven competitors from Germany, Holland, Italy, UK, Ukraine, and USA, bdpgroupe6 was appointed to design the 250-



4 **Parallelogram grid with bracing and cladding** 4

bed children's hospital in Kiev, Ukraine.

The All Ukrainian Health Protection Centre for Mothers and Children (The Children's Hospital of the Future) was to be a multipurpose child treatment and prevention institution with highly specialised and technologically advanced departments.

The client's intention is that the building of this modern healthcare institution to a European standard, will help to focus human and material resources, implement highly efficient technology and ensure high level of treatment and diagnostics. The new hospital combines all the necessary components of a children's hospital: general paediatrics and surgery, oncology, oncohematology, and a peritoneal centre. It is also intended to set up a research and training centre for paediatric doctors which will help to integrate Ukraine into the world medical community.

The economic, social, environmental and other difficulties faced by Ukraine in recent years have badly affected the health of the young, particularly evident in the number of newborn children with serious chronic pathologies. In the country the level of oncohematological and oncological diseases and child disability is, in the view of the Charitable Foundation, unacceptably high; indeed child mortality in Ukraine has increased in the last 2 years.

The Foundation considers that the health of children and teenagers should be the focus of attention of society today and in the future. In the field of motherhood and childhood, healthcare authorities and institutions should apply effective know-how in health care management and the best of clinical knowledge and skill to address the problems children face, giving newborns in particular a healthy start in their lives.

The purpose of the hospital is therefore to provide highly qualified in-patient and outpatient diagnostics and treatment to children from all over the country by using the best knowledge in the field. Ultimately the project's goal is to improve the health of children and mothers as an important component of Ukraine's social and economic potential.

Credits:
Client: Ukraine 3000 International Charitable Foundation
Architect: bdpgroupe6
Civil & structural engineer: BDP
Building services engineer: BDP
Health planner, quantity surveyor and equipment adviser: EC Harris
Architect, engineer and quantity surveyor in Kiev: Budova Center 1