COLLABORATIVE DESIGN

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Abstract:

Design process and outcomes for two stadiums designed by Populous. The façade of Eden Park in Auckland, and the roof of Metricon Stadium on the Gold Coast are discussed as examples of how complex geometries were realised from concept through construction.

Collaborative design results in a more refined and economical outcome, it allows for more design time and for the testing of ideas and options. As designers continue to deal with the more complex geometry that is enabled by new computer tools, it is vital that information is shared in the early design stages between engineers, materials specialists, contactors and others involved in the project / building industry. For both Eden Park and Metricon Stadium, the highly collaborative process delivered some excellent results.

Keywords:

Collaborative Design, Architecture, Eden Park Stadium, Metricon Stadium, Populous, ETFE, BIPV, Photovoltaic Cells, Environmental Sustainability, BIM

Collaborative Design

Collaborative design in the context of this conference is mainly between the architect and engineer. However it involves most aspects of the design and construction process. For this talk I wish to discuss two recent projects completed by Populous. They are both stadiums, but for each one there are two distinct elements that are worth going into detail about. The projects are Eden Park in Auckland, about which I will discuss the facade, and Metricon Stadium on the Gold Coast, the roof of which provides a valuable point for discussion.

Firstly a quick background on the company I work for - Populous. Some of you might know our previous name, HOK Sport. We changed to Populous about 3 years ago. Populous is a global design practice specialising in creating environments that draw people and communities together for unforgettable experiences. For more than a quarter century we've made a difference through our design work that includes sports architecture, conference and exhibition centre architecture, interior design, environmental graphics and way-finding, events planning and overlay, master planning, sustainable design consulting and facilities operations analysis.

Around the world, Populous projects include an involvement in more than 1000 projects including sporting stadia and ballparks, entertainment arenas, racecourses, convention centres, motor racing circuits and the planning of major national and international events including an Olympic Games. We design buildings, venues and events that inspire athletes, performers, fans and the rest of the watching world.

EDEN PARK

Eden Park was redeveloped for the 2011 Rugby World Cup (RWC) in New Zealand. The project involved a new 22,000 seat south and 8,000 seat east stand, a western concourse and bus hub. Included in the work are 13,000 temporary seats that take the capacity for the stadium during the RWC to 60,000. After the RWC the seating capacity reduces down to 50,000.

The Facade

The facade was designed to dematerialise, visually minimise or ameliorate the mass of the building. Due to its residential context we believed that it was really important to devise a way of reducing the day to day visual impact of the building.

The idea was to design a facade, a veil that reflected the surrounding sky and context. The adoption of the veil surrounding the various functional requirements of the stadium creates a strong coherent form conceived to appear as that appears as a cloud hovering above the solid ground plane. The subtle reflectivity of the transparent cladding forming the veil reflects the natural surroundings and the changing moods of the day.

A number of materials where researched that could achieve this veil effect we were looking for. The choices that we settled on where, glass, polycarbonate and ETFE. ETFE was the obvious choice due to cost, ease of installation and importantly the architectural aesthetic.

The Geometry and ETFE

The facade geometry is a result of the optimal ETFE pillow size and the 'Fern' Structures in the corners. The straight section between the main cores has a simple geometry, with the ETFE panels running in horizontal bands. On the corners of the site the building follows the seating bowl and thus creates more space by curving away from Reimers Ave. These are the locations of the entry plazas. The entries are marked by a more complex geometry of the ETFE support structure, curving around the building and also "tucking in" underneath the Level 4, 5 and 6 concourses. The interface between the straight central part and the curved corner areas creates a fern shape, repeated several times above the entries.

There were two main factors determining the criteria for the facade geometry. One was the optimal economic size for the ETFE pillows and the other the maximum curvature of the pillows. Populous produced a number of models using Rhino software that where shared with Vector Foiltec (the ETFE subcontractor) in their London and Bremen offices. These models where essentially simple models just giving the centrelines of the steel members. The process enabled us to fine tune the design and gave us confidence that the geometry would suit the ETFE cladding. During this phase our model was also checked by Aurecon to ensure the steel curvature and spans were within the parameters of the steel CHS sections. Other than connection, extrusion and flashing details we produced no drawings for the facade set out of the ferns. The model was used for this purpose.

Manufacture

Once the geometry of the facade was resolved our model was then issued for shop drawing. This model showed just the centre lines of the steel from which the shop drawer, BDS (Brisbane Drafting Services) could add the steel sizes and work through the connections. Vector Foiltec provided a separate model for the location and set out of the aluminium extrusions for the ETFE.

Connections

The majority of the connections where firstly drawn by hand by Aurecon before being moved into CAD. We developed the connections based on the sketches and our mark ups as per a more traditional method of coordinating documentation between engineers and architects. However once the shop drawing model was produced all these connections where reviewed and approved in 3D using this model.

The Collaborative Design Process

The strength of this collaborative style of working is that the amount of rework is minimised as all the design disciplines are working concurrently, the design and documentation timeframes can be reduced and there is surety that the design will meet the requirements in terms of budget, programme and buildability.

As the design team was based in Auckland, Brisbane and Wellington this process is exceptional in working with remote design teams. As Populous has undertaken a large part of its work overseas and this is our normal way of working. We deal with this in a number of ways; from the traditional face to face meetings, video conferencing and sharing of models on our desktops.

METRICON STADIUM

Construction work on the new Metricon Stadium was completed on time, under budget, in 350 work days. Designed by Populous, the 25,000 capacity stadium is presently one of Australia's greenest stadium designs, and at a cost of $144million is also one of Australia's most cost effective.

Metricon Stadium, home to the Gold Coast SUNS AFL team, represents a unique development of the community stadium. The design focuses on the traditions of 'footy in the park', developed to encourage family and community participation.

Grouped food concessions are located in the park creating outdoor picnic and food court areas – a characteristic reminiscent of the old Carrara.

Inside the stadium, spectators are treated to the best sightlines of any AFL venue in Australia.

The new facility draws on the wealth of international expertise that Populous brings to the design of stadia, whilst providing a unique local solution.

New corporate hospitality options replace the traditional banquet tables providing a whole new dimension to the live game experience. Stylish and contemporary suites and lounges, with informal seating and coffee tables, create an atmosphere of 'watching from home' at the live match experience. Open corporate barbecue terraces offer a more relaxed corporate environment and reflect the Gold Coast lifestyle.

The Coaches Field Club offers a completely new concept in fan experience in Australia. Members are fully immersed in the game. They have direct viewing access into the Club's warm-up areas, and can even high-five the players as they run out onto the pitch.

Environmental Sustainability

In another Australia-first, a 'solar halo' comprising the integration of photo-voltaic cells in the stadium roof design provides the stadium with 20% of its power usage. This 20% is in line with the government's requirement of achieving a 20% renewable energy target by 2020.

In addition, extensive water harvesting and a new public transport system creates a new benchmark for environmentally sustainable stadia.

Roof

The stadium's roof design references its unique Gold Coast identity, with its undulating wave form reminiscent of the swell of the Broadbeach Surf and the undulating backdrop of the hinterland. "The new stadium is a significant landmark on the Coast; the architecture's colour and form generates a sense of fun and excitement". This undulating wave form floats above the East and South Stands supported on delicately designed steel 'legs'. Wrapping the steel structure is a PTFE fabric membrane creating shade and shelter from the rain. This material is commonly used throughout the Gold Coast region and thus reinforces intent of the roof to create an identity that is uniquely 'Gold Coast'.

The wave form of the roof was developed between Arup and Populous. A number of options were investigated during the initial design and form finding exercises between Arup and Populous.

The roof form follows the geometry of the seating bowl for the east stand, but as it transitions through the south stand the roof starts to move forward towards the field. This was done to ensure the fully serviced west stand had as much covered seating as possible. The overlay of the bowl grid and roof grid created some unique geometry clashes that where resolved elegantly through the use of 3D models.

In working through the form making of the roof, we found the process a bit frustrating from an architectural point of view due to having limited software capabilities to understand the optimum curvature for the roof. The design process could have been simpler with true BIM model sharing.

Shop drawings

The shop drawing team where brought into the project at the early stages of the design process. While there was a bit of rework due to unresolved design, the tight design and construction programme was managed due to this early introduction.

Populous produced diagrams and centre line models of the roof for Online Drafting, Arup, Tensys, Beenleigh Steel and MakMax to work on and refine to ensure all the fabric curvature and steel fabrication requirements were met. As per Eden Park there were no set out drawings (in the traditional sense) produced. The model was used for the basis of all further analysis and shop drawings. Prior to shop drawings being issued, Populous would review the model created by Online Drafting. This would give the design team a chance to review the connections in 3D and also give us time to make comments before the drawings were issued for steel fabrication.

Details

Originally for the sump Populous had designed a steel fabricated sump that was proving to be difficult to fabricate and was a dominant feature in terms of the aesthetics of the roof. When Tensys got involved in the project they proposed a fabric sump and steel rainwater head. The fabric sump was clever and simple. It used the PTFE fabric to its full potential and minimised the amount of steel used. Once the sump was finalised in terms of its form a prototype was built to check some of the minor detailing and to sign off on the form. The steel rainwater head is fabricated from the steel CHS used for the main roof and grandstand column.

The gutter was developed in a similar manner with Tensys, Arup and MakMax. A simple substitution of the Populous designed steel gutter with an elegant PTFE gutter enabled the material properties of the PTFE to be used and limited the need for other materials. It enabled the roof to have a very ‘clean’ soffit and ensured that the installation was made easier.

Photovoltaic Cells – ‘Halo’ Roof

The leading edge of the roof is made up of an undulating 5m wide section of building integrated photovoltaic cells (BIPV). These panels are designed to produce a minimum of 20% of the stadiums annual power usage. There is no storage on site with the power being feed straight into the grid.

The PV panels were introduced into the project near to the end of design development. In order for there to be no delay in the construction programme, the design team needed to maintain/ progress/ develop two different designs for the roof until the budget was resolved and the roof morphology and panels could be confirmed. This resulted in a design that allowed us to swap in the BIPV for PTFE fabric depending on the budget outcomes.

By producing a model for this 'halo' roof a number of different design processes were able to occur concurrently. These were:

- The solar orientation of the panels could be modelled to ensure the best efficiency for each panel and how to wire them together
- The structural team could run their analysis on the steel and glass
- The architectural team could review the geometry and ensure that there was standardisation of the panels. This was achieved by ensuring each PV panel was identical (2700x1250) and using clear glass infill as the device that allows the changes in geometry to be accommodated
- The shop drawing process could proceed

Additional Details

Other than the features discussed so far the design team also made use of a 3D model for the reticulation of services in the eastern and southern stands. Populous provided 3D models to show how the services could be reticulated from the roof.

As there was nowhere to hide them and they formed part of the facade it was important that the routes and locations where carefully detailed. This was done in Rhino and issued as 3D PDF drawings and a model to the shop drawing team to incorporate into the steel.

Populous produced a typical bay model that proposed routes and conduits for the following:

- Syphonic pipes
- Cabling for the following:
    - Sports Lights
    - Speakers
    - House lighting
    - PV Cells

Through the production of this model we were able to work through the service routes, lighting mounts, and integrate the required conduits into the project with relative ease. Once the conduit route was agreed with the services subcontractor we released it to the steel shop drawing team to add to the steel fabrication and ensure they where coordinated with the roof structure

CONCLUSION

Collaborative design brings a more refined and economical result, it allows for more design time and for testing ideas. As we deal with more complex geometry as designers enabled by new computer tools, it is vital that input is received in the early stages of design from engineers, materials specialists, contactors and others involved in the project / building industry. For both Eden Park and Metricon Stadium, the highly collaborative process delivered some excellent results, and with each project there has been a progression in the right direction towards a complete and fully integrated collaborative design process.

As this way of working continues to develop there are a number of issues that need to be addressed and opportunities seized so that that the process can be streamlined further. These are:

- The use of parametric software that allows the designer to work within the boundaries of the materials and geometry. This is particularly useful for *form-finding* when using membranes.
- Really understanding how much information is needed in the different models. At times too much information is added into a model that has to be redone as the design changes and adapts. This can be dealt with at an early stage of a project by agreeing with the different disciplines on the boundaries of each party's scope of work. While it is important as the lead consultant to ensure everything is coordinated, all disciplines have to contribute to the BIM model for the process to be a success.
- Ensuring that there is greater compatibility between the different software used by the various consultants and service providers, and making this a priority at the beginning of a project
- Understanding when to get the different construction professional and manufacturers involved in the design process; and acknowledging the value of their contributions
- Undertaking post project evaluation to learn from the project and apply these lessons to future work.