SOUTH HEDLAND PERFORMANCE SHELL.
South Hedland, Western Australia

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ABSTRACT: This paper gives a case history of the design and construction of a semi rigid timber gridshell designed with advanced computing methodologies and manufactured directly from CAD derived files. The structure is located in remote North Western Australia in a coastal zone within the Western Australian cyclone belt.

KEYWORDS: Gridshell; Prefabrication; Laminated Veneer Lumber; Architecture & Engineering design; CAD-Cam.

Extended Abstract

In this project of particular note is the close collaboration between the architectural design and engineering design teams which has resulted in a unique, ground-breaking project. The effective implementation of the design to manufacture sequence using CAD/CAM processes and CNC machining of elements enabled accurate and efficient prefabrication and rapid on site assembly in a remote location.

This project for a performance shell and outdoor theatre is located in the newly redeveloped urban centre of the West Australian town of South Hedland. South Hedland is a dormitory town to the Iron ore export hub of Port Hedland in the Pilbara region of Western Australia. The town has a tough reputation and lies in the tropical cyclonic region of the state. As a single industry town, Port Hedland has no skilled building industry and thus few resources on which to draw for conventional construction projects, thus an approach that required the minimum of onsite construction was required.

The Architectural Concept was initially conceived as an undifferentiated lattice, but evolved into the final form through extensive modelling using advanced generative computational design tools in an iterative process between the architectural design team and the engineering design team. With the design teams, the fabrication teams and the construction site all located in different states in Australia [Western Australia, Victoria, Queensland] the project was nevertheless delivered to the remote north west of Western Australia on time and on budget.

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The final form of the shell is structured as a segmented curvilinear lattice or ‘gridshell’ which is constructed from WA-grown and manufactured Laminated Veneer Lumber [LVL]. The LVL is produced from Pinasta Pine sourced from coastal plantations in the southern region of Western Australia. The structural design comprises a series of eight curvilinear segmented arch frames which are bound into a cellular ‘shell’ by a series of transverse members and crossed tension braces in each cell. The arch frames spring from buttress supports to a maximum height of over 6 metres and span over 15 metres. The frames, each differently shaped, lean outwards from their support points with the plane of the rearmost frame angled at 36 degrees to the horizontal. The engineering design involves splicing 2.5m sections of LVL in three layers to make up the segmented arches which are routed to a continuous curve on the top surface and left straight and interwoven on the undersides. The gridshell comprises 15cu.m. of LVL timber in 2.5m lengths making a total of 233 components. The design differs from recent European timber gridshell projects because it is a semi-rigid rather than a flexible structure. This structural configuration allows for the maximum amount of prefabrication and pre-assembly which facilitates an efficient construction process on site. Architectural concept models were developed by ATC [Patrick Beale, Tristan Morgan and Domenic Trimboli] with engineering load parameters and design participation from Bill Smalley of the Scott Smalley Partnership. The gridshell form was modelled in ‘Rhinoceros’ software through the application of computational design methods within the ‘Grasshopper’ scripting environment which allowed for material properties to be embedded within the design process at an early stage. The model was then exported to the fabricator [Timberbuilt Solutions] ‘Cadwork’ Swiss authored CAD/CAM software where the model was further refined to meet the structural and aesthetic parameters agreed for the project. The final step in the process was the preparation of machine files for export to the ‘Hundegger’ CNC carpentry centre for fabrication.
Finishing and partial pre-assembly of the main arch elements was also carried out in Melbourne. The pre-assembly included the mounting of each main frame in half segments including the steel end brackets being fixed to the feet of the arches ready for fixing directly to the concrete plinths on site. The remaining components – each element is repeated only twice as the structure is symmetrical – were loaded onto a flatbed in Melbourne and trucked to Port Hedland via Perth by road, a journey of over 5500kms.

The performance shell structure was erected on site in three days, with a further two days for the installation of the specialized PTFE - (polytetrafluoroethylene) coated opaque fiberglass membrane which is tensioned above the upper curvature of the shell form. The membrane protects potentially vulnerable horizontal surfaces of the timber and the stage area from sun and rain. The structure was erected primarily using rigging skills on site rather than the typical carpentry skills expected in a timber project of this kind and scale.

Other elements of the project [Change rooms, stage flats and ablution facilities/service areas] were similarly a mix of locally sourced material [rammed earth] and prefabrication.

This paper will examine in detail the design and manufacture/erection process of the building with consideration of improvements that should be implemented when undertaking a similar project. The paper will offer an evaluation of the performance of both the material and the overall structure after two years of service [project reached practical completion in December 2011] from both an engineering and architectural point of view. To date the structure has been subject to four cyclones and three severe tropical storms. Vandalism has been minimal and the performance shell appears to have been adopted willingly by the community where it serves as an informal gathering point for local youth as well as a performance venue.

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Construction: A T Brine and Sons; Tony Brine
Rigging: Denmac Pty. Ltd. Perth
Landscape: UDLA Pty. Fremantle, WA. Greg Grabash
Project Managers: Cossil & Webley. Perth
Client: Town of Port Hedland/Landcorp.

Figure 1: Front elevation of the completed shell

Figure 2: View from North West showing plinth form.

Figure 3: primary framing and steel braces and fixings

All Photographs: P. Beale, R Diggins, T Morgan