Advances in Architectural Geometry Vienna 2008

Parameter to Production Alan Dempsey

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Introduction

Over the last fifteen years digital design technologies and stechniques have emerged as a primary focus of avant garde architectural design and research. Though it can be argued that contemporary avant garde production bears no apparent unity of aesthetic or formal logic, I propose there are three significant features common to digital parametric design that suggest we are in the early stages of a coherent movement that is at least as radical as the flourishing of modernism in the early 20 Century.

1. Contenporary form can be characterised by a high degree of internal surface or component variation.
2. Design variation is systematic and design parameters can be linked reciprocally to create constrined design models
3. Digital fabrication technologies are required to optimise production and coordinate complex assemblies.

Firstly, digitally generated geometric and organisational forms can be characterised by a high degree of internal variation. Such variation may consist of elements, assemblies or surface variation but in all cases the transformation tends to be coherent and highly relational.

Secondly, the use of design models means that relational values are genuinely reciprocal and establish a system that can coordinate and optimise multiple design and production constraints. In addition, parametric models become the medium through which contemporary design teams interact and communicate.

Finally, digital fabrication technology is leveraged to economically manufacture these highly differentiated elements or components, and coordinate the information required to arrange complex assemblies.
To illustrate these issues I will discuss three architectural projects in which I have been recently closely involved. The projects are at significantly different scales and at different design stages providing valuable insights into how these issues can be addressed in differing ways.

Case Studies

Spencer Dock Bridge with Future Systems Architects
The bridge is 40m span structure in Dublin City centre that carries road, rail and pedestrian traffic and explores the possible integration between urban infrastructure, public space and landscape. The bridge is a double curved curved asymmetric concrete structure and is being constructed from a combination of in-situ and precast reinforced concrete and all 1100m2 of formwork is manufactured directly from digital model files.

[C]space Pavilion with Alvin Huang & AADRL
This pavilion was commissioned by the Architectural Association School for the tenth anniversary of the Design Research Lab and was completed in March. The project was the winning entry in a competition open to 354 graduates which required a small temporary structure manufactured from fibre reinforced concrete.

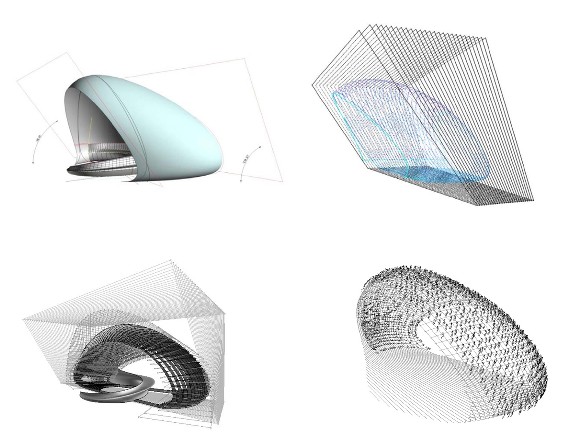
The project progressed from sketch design to construction documentation in ten weeks and required intense collaboration with the structural engineers to develop a range of parametric models and scripts to quickly optimise the form, evaluate structural solutions and manage the final digital fabrication of over 850 unique pieces of concrete and steel.

Geometric variation

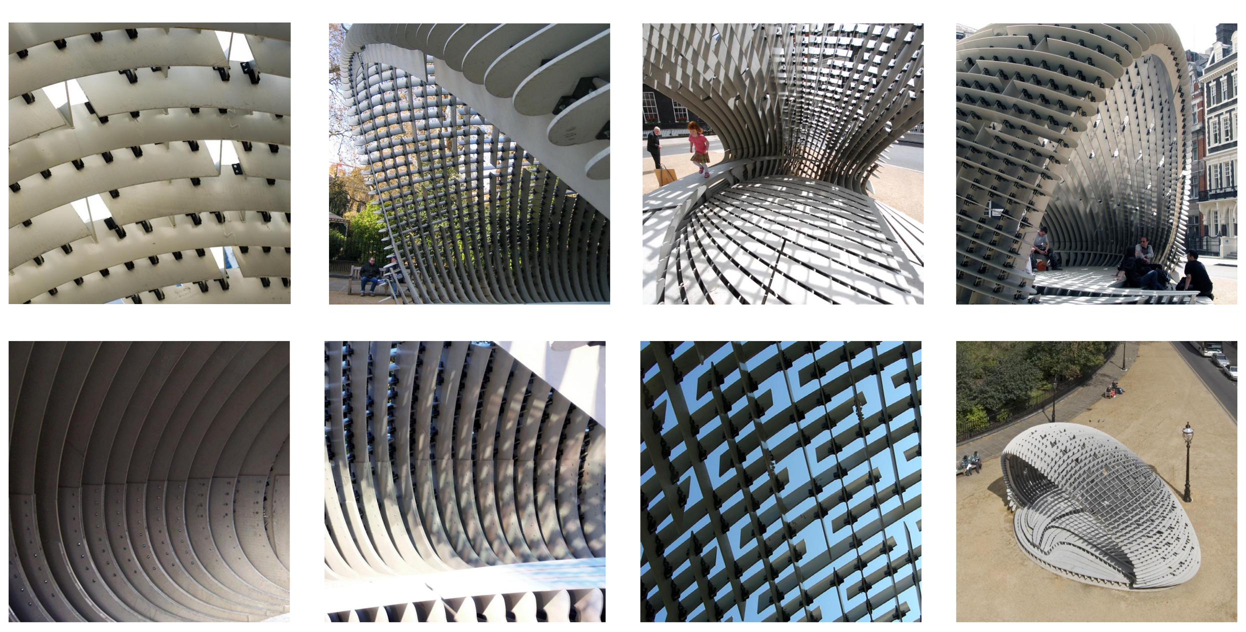
Constraints and relations

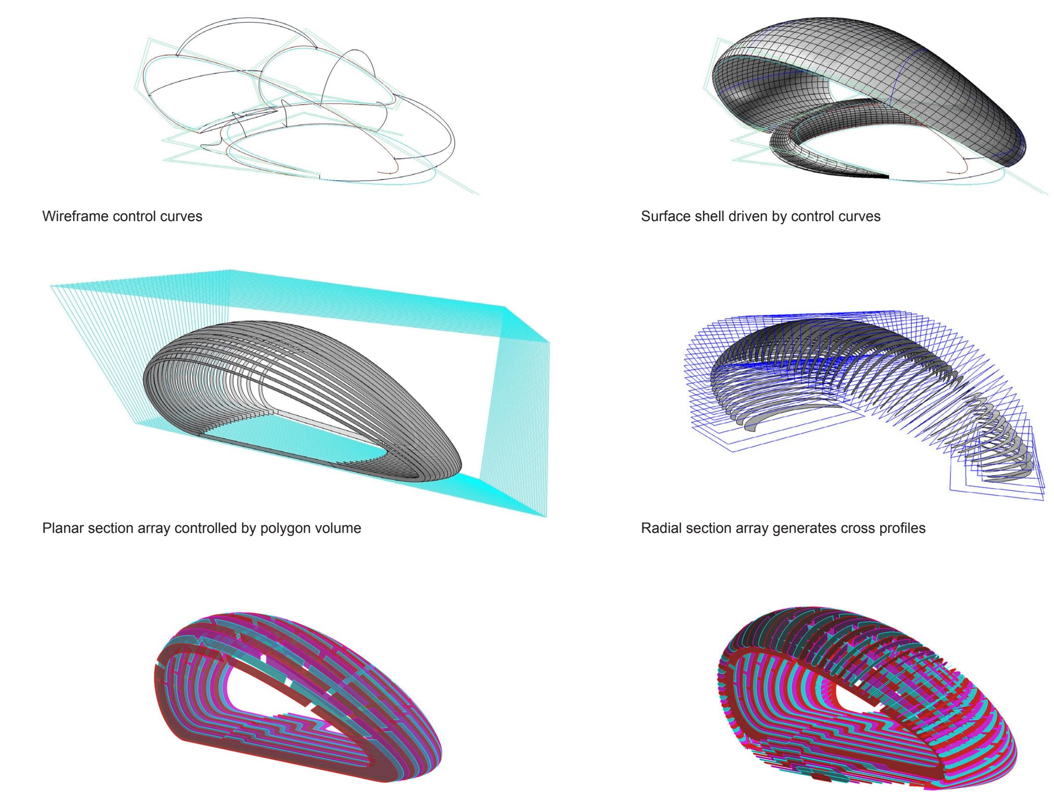
Digital manufacturing processses

[C]space DRL10 Pavilion, London with Alvin Huang



The pavilion was intially modelled as a skin or topological volumetric form, and is materialised through the sectioning of the skin with a series of fanning arrays of planar cuts which produce the fibreC lattice. This allows us to produce a geometry of continuous complex curves, while utilizing conventional flat panels.





Wireframe control curves

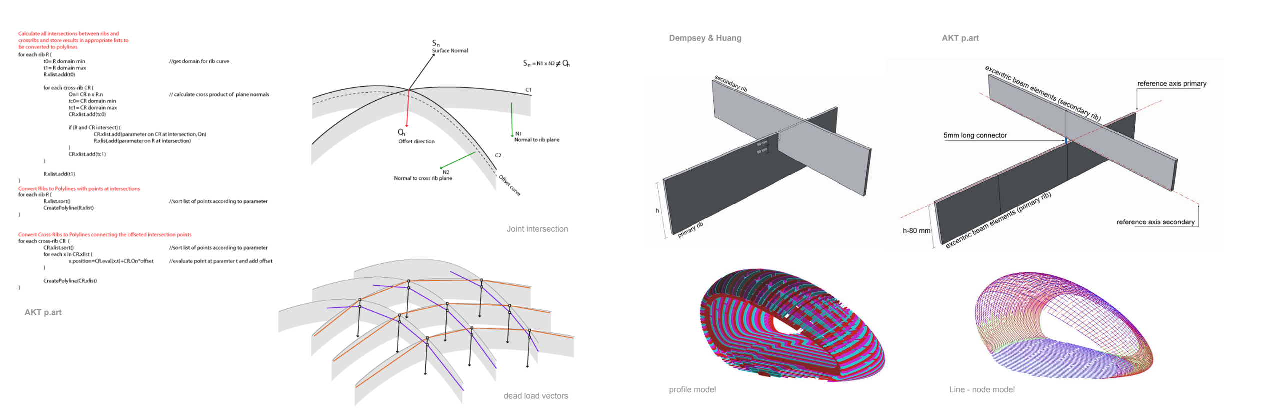
Surface shell driven by control curves

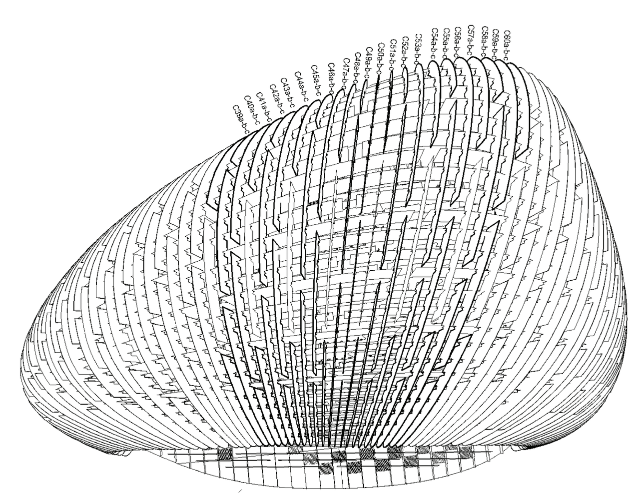
Planar section array controlled by polygon volume

Radial section array generates cross profiles

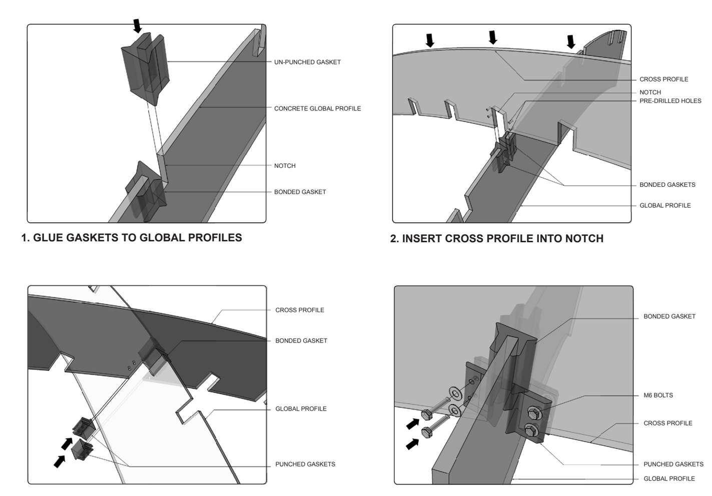
Tertiary section array panelises primary sections

Tertiary section array panelises cross sections





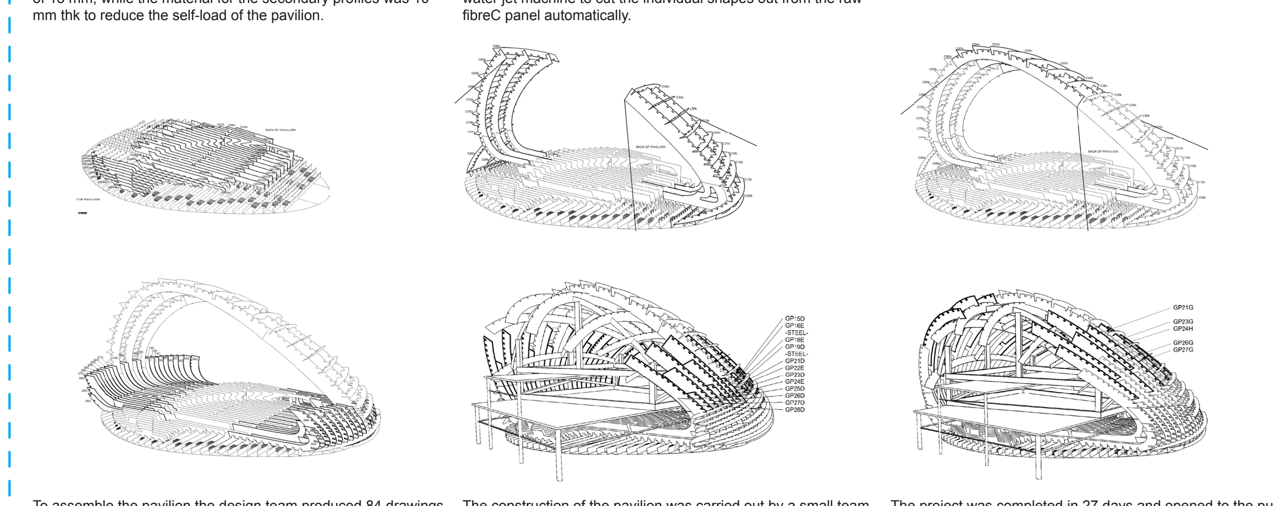
Roof Plan



Individual fibreC elements were manufactured off-site using water jet machine. The material for the primary ribs has a thickness of 13 mm, while the material for the secondary profiles was 10 mm thk to reduce the self-load of the pavilion.

A total of 840 different elements are exactly defined by a CAD programme. The defined measurements get imported by the water jet machine to cut the individual shapes out from the raw fibreC panel automatically.

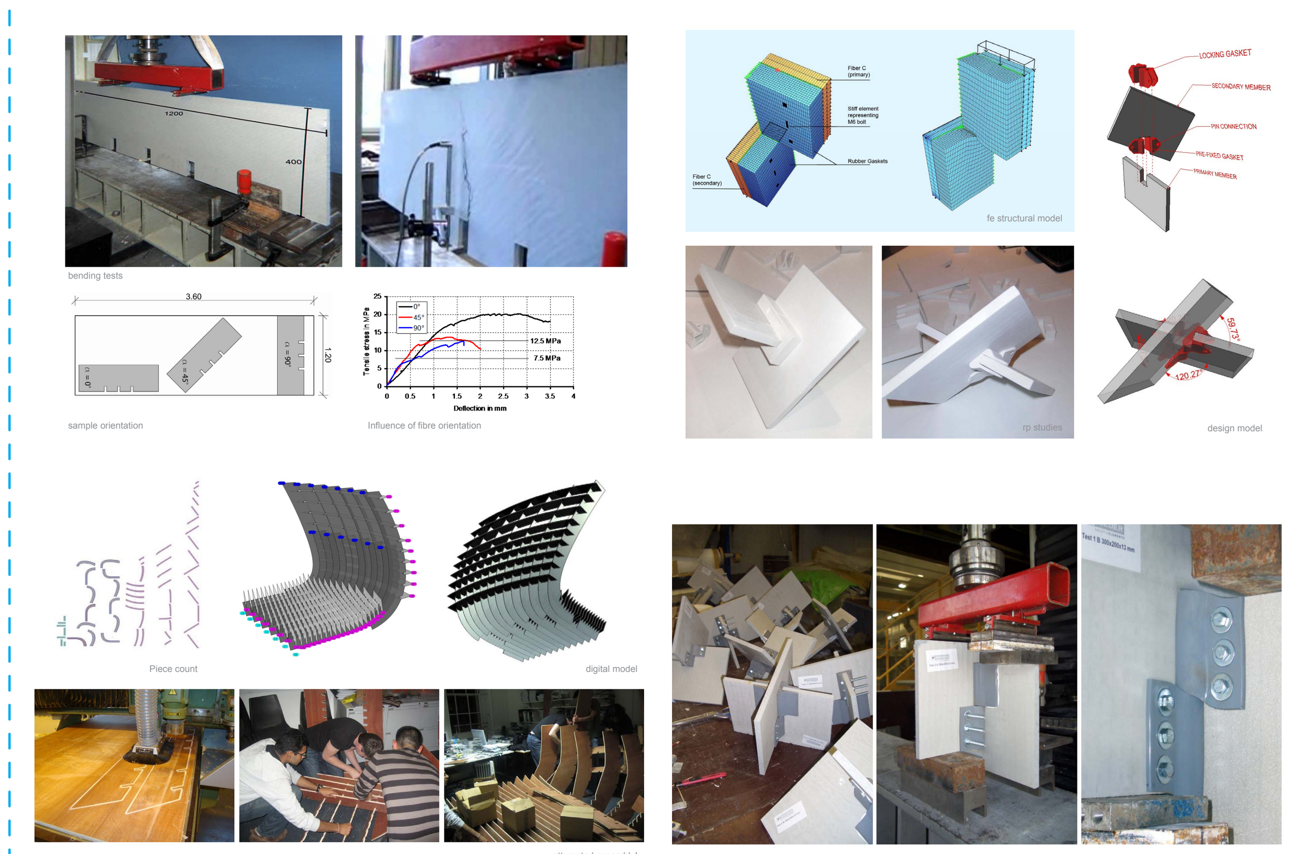
The panels indidually numbered and were packed in a predetermined order to make on site assembly more easy



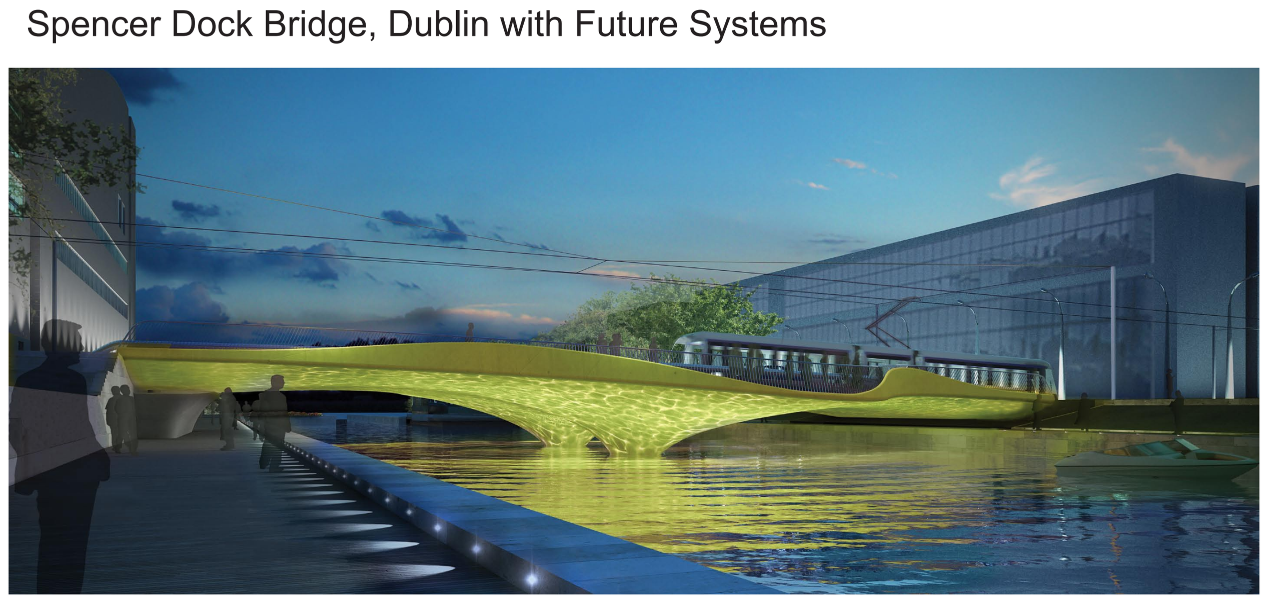
To assemble the pavilion the design team produced 84 drawings giving precise instrcutions on the construction sequence and locating each piece in the overall assembly

The construction of the pavilion was carried out by a small team from Rieder and a group of students from the AADRL. The Construction was coordinated by DRL director Yusuke Obuchi

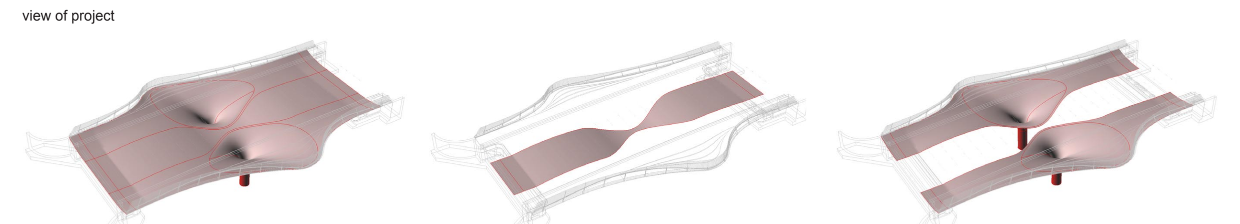
The project was completed in 27 days and opened to the public on 13 March. It will remain open until the begining of October 2008 after which it wiil be auctioned by Philips de Prury.



Spencer Dock Bridge, Dublin with Future Systems



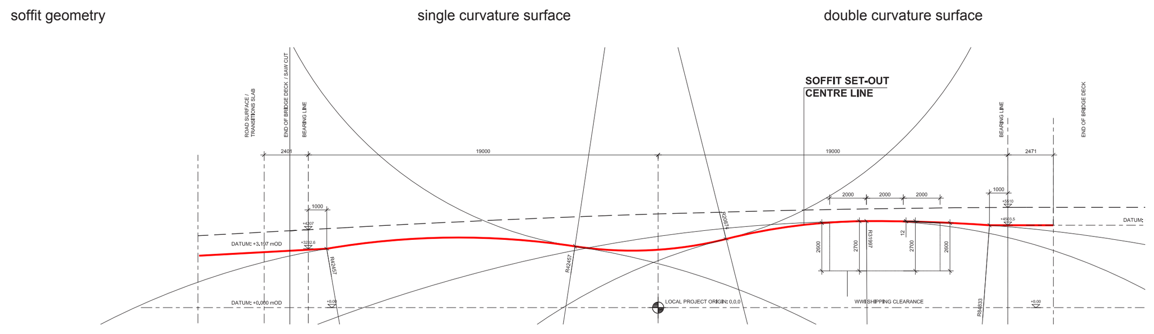
view of project



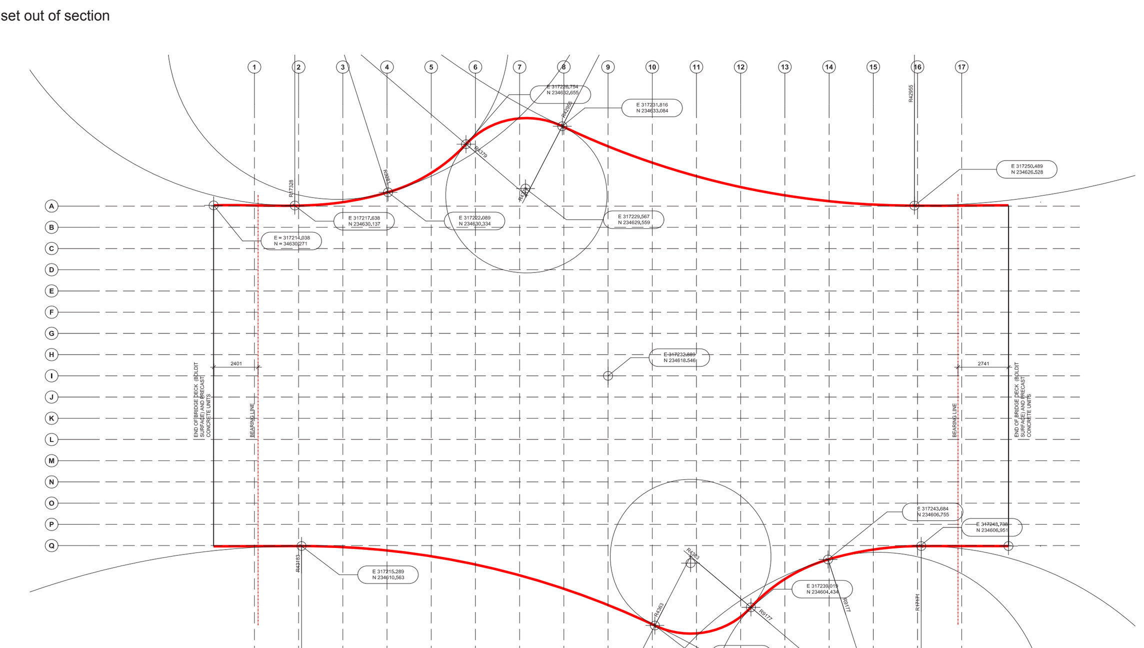
soffit geometry

single curvature surface

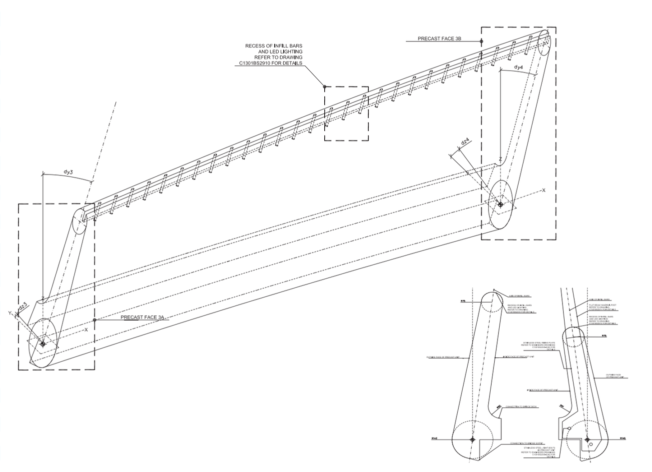
double curvature surface



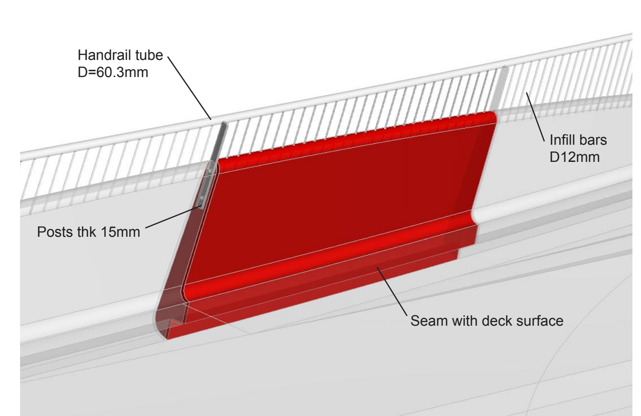
set out of section



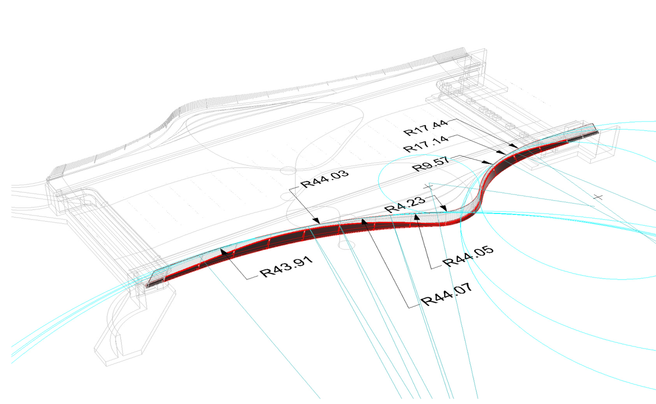
set out of plan edges



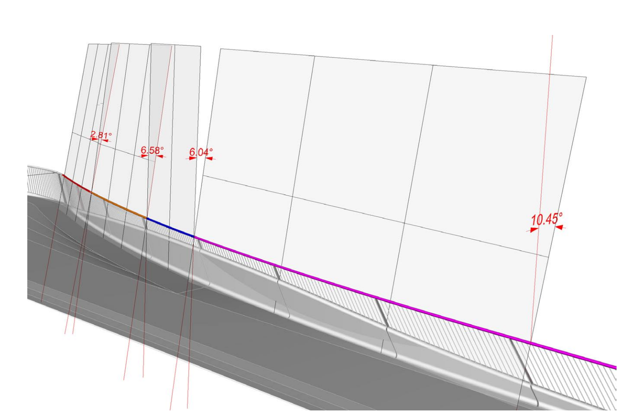
Geometric set out and constraint of parapet units was achieved by intersecting overall edge set out curves with planar sections that consisted of straight lines and arcs



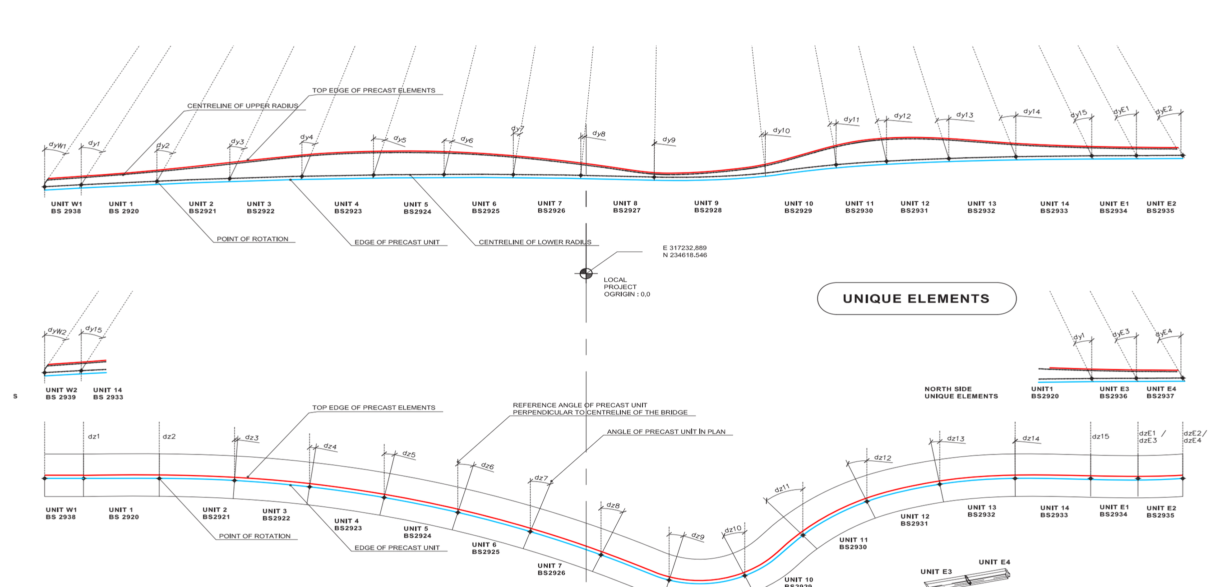
Component assembly of precast parapet unit



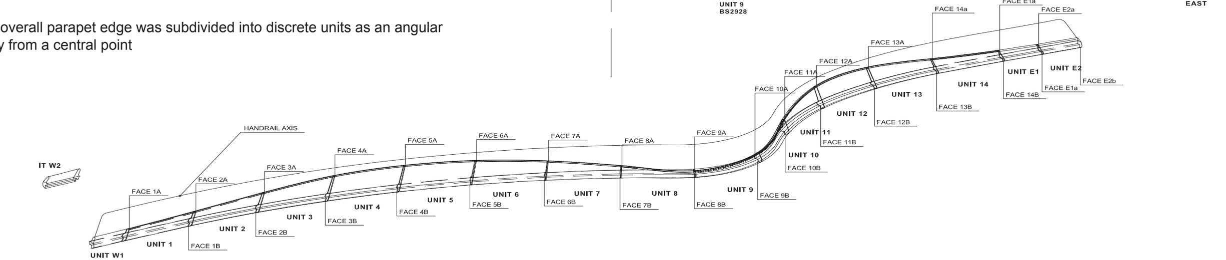
Geometric set out of overall edge in series of 3D true tangent arcs

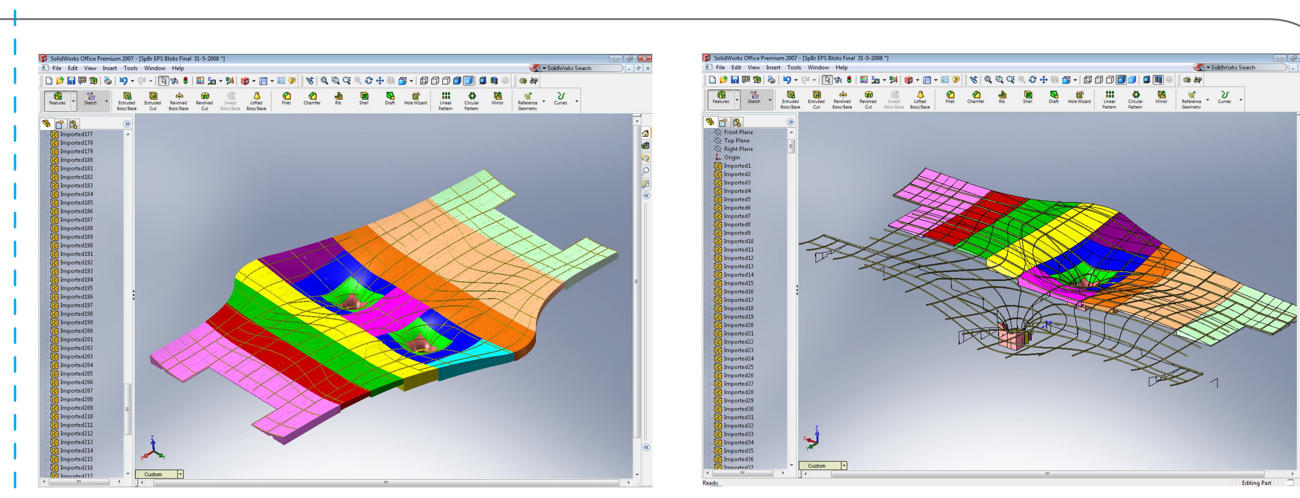


Steel handrail tube set out as true tangent arcs with rotation in z axis



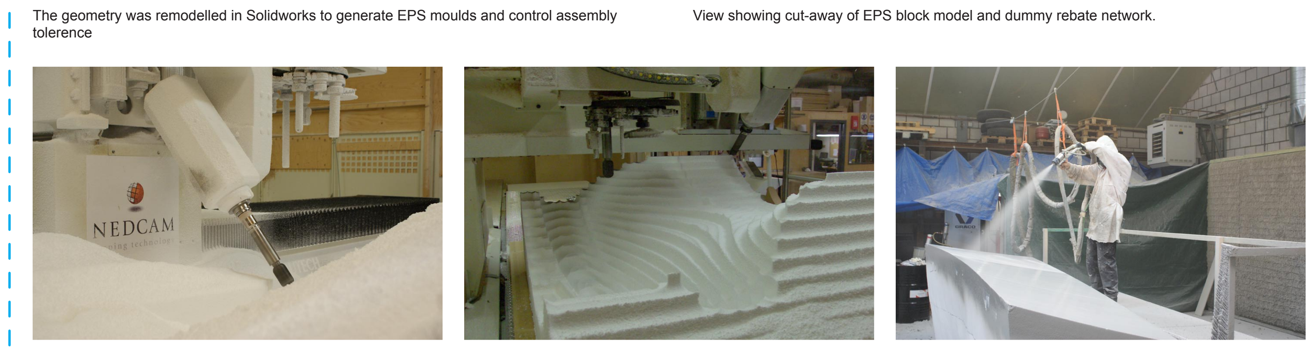
The overall parapet edge was subdivided into discrete units as an angular array from a central point





The geometry was remodelled in Solidworks to generate EPS moulds and control assembly tolerence

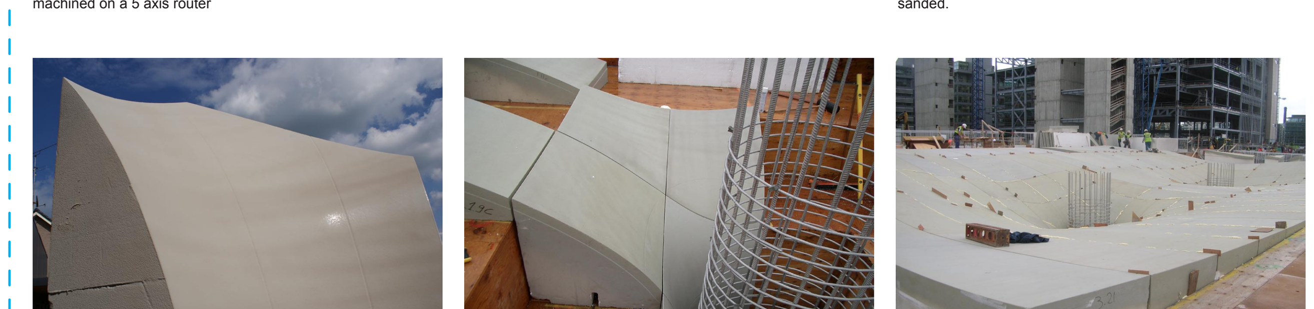
View showing cut-away of EPS block model and dummy rebate network.



The formwork was manufactured in high density EPS foam machined on a 5 axis router

The foam was milled in increments of greater surface resolution

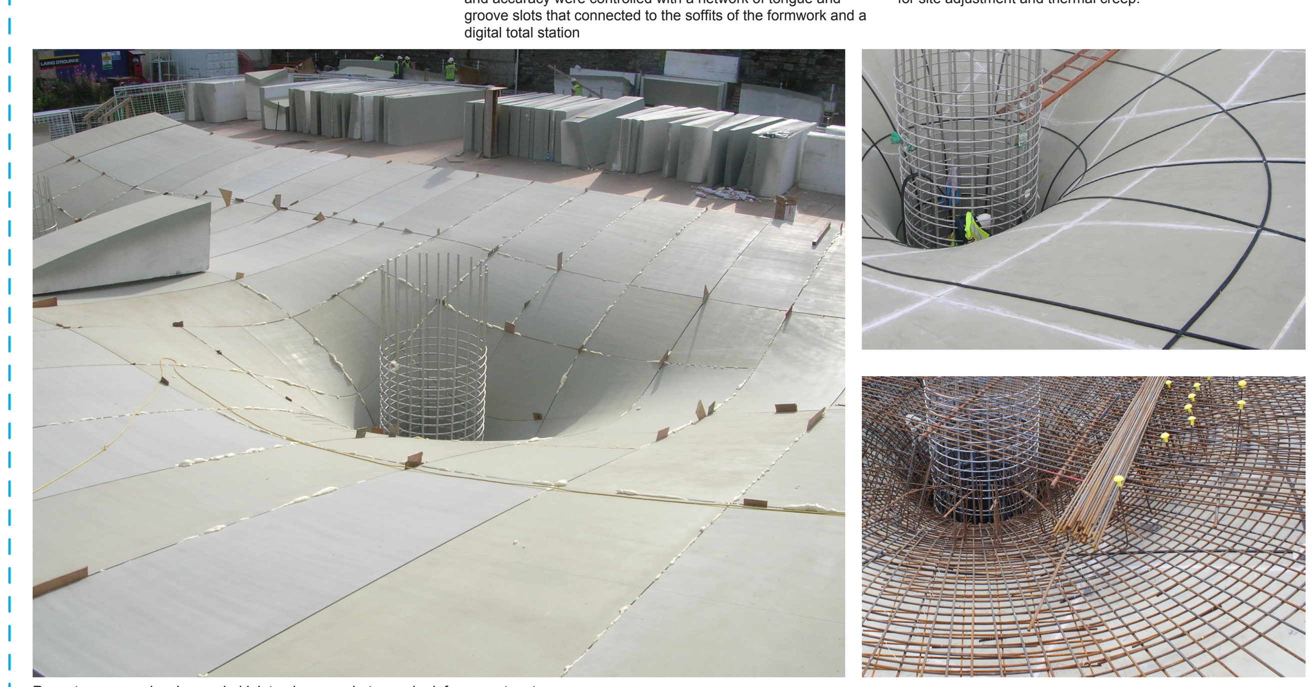
The formed face was then sprayed with 3 coats of polyurea and sanded.



The finished 3mx1.25m blocks were shipped to site

The blocks were assembled of a ply falsework deck. Position and accuracy were controlled with a network of tongue and groove slots that connected to the soffits of the formwork and a digital total station

10mm spacers were left between the formwork blocks to allow for site adjustment and thermal creep.



Recent progress showing sealed joints, dummy rebates and reinforcement mat