



## PLATO – Gridshell Design Method for Chadstone Shopping Mall Roof

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### Abstract

An extension of Chadstone Shopping Centre gave Atelier One the opportunity to create a new design method for Gridshell Roofs. The 7080 m<sup>2</sup> undulating form spans over 30m with a structural depth of only 220mm, and quadrilateral glass panels that conform to strict planarity limits.

**Keywords:** Gridshell roof; quadrilateral-grid; glass-panels; planarity; form-finding; computational geometry; design method; irregular boundary; commercial buildings.

### 1 Introduction – Key challenges

Atelier One were provided with a roof boundary by CallisonRTKL to match the programme of the shopping centre extension below. However, as the programme developed, so did the boundary - a non-planar orderless curve. This meant that the roof shape needed to be constantly updated as per the boundary line, and due to its uniqueness, a regular shape grid could not be used.

To reduce the weight of the supporting structure and improve efficiency of glass panel cutting, a quadrilateral grid was chosen, with triangular panels only needed at the boundary. The team were keen to avoid awkwardly cut edge panels.

The architectural brief from CallisonRTKL specified high points within the roof, requiring a large degree of double curvature. Quadrilateral glass panels could only be cold bent to a certain extent (1% of the shortest diagonal) whilst remaining within warranty.

All of these challenges gave Atelier One the impetus to develop a dynamic new bespoke software for generating a planar quadrilateral structural-grid to fit a non-regular double curved surface.

### 2 Planar panelisation of a double curved surface

A double curved surface made of flat quadrilateral panels was the target. A mesh of this kind is usually addressed using one of the following approaches:

- Directrix +Generatrix

In this method, a curve (generatrix) is translated along another curve (directrix). This results in opposing panel edges being parallel and thus planar panels. However, the boundary line is formed from the intersection of the surface with a plane, so matching an irregular pre-set boundary is not possible.

- Map a pattern on a surface

A pattern can be mapped onto a surface defined by its boundary and topology. This only gives planar panels for specific surface forms. The resulting form for Chadstone had many non-planar elements.

### 3 Planarity Tuned Orthogonal Grid (PLATO) method

Atelier One worked with Professor Chris Williams of Bath University to develop the Planarity Tuned