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FabPod: Designing with temporal flexibility & relationships to mass-customisation

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ABSTRACT

Digital workflows spanning from the design to the production of buildings and small installations have received significant recent attention in architectural research [1]. The structuring of these workflows is important for facilitating design collaboration. The successful delivery of 'non-standard' projects, with free-form geometries and novel fabrication material can be particularly dependent on such workflow. This paper reports on the workflow developed for the *FabPod*, an acoustic enclosure for meetings which could be located in an open knowledge work environment. For this project, a broad 'design system' was developed covering the project workflow from early stage design to completion of a fabricated prototype. This was implemented in order to defer design decisions, providing improved opportunities for testing detailed material and fabrication aspects of the project. It also facilitated collaboration between experts in different aspects of parametric workflow and in 'tuning' acoustic performance. A by-product of this approach is the possibility of using the system as the basis of further iterations and to consider the possibilities of developing the prototype into a product. A deferral of design decisions is a key strategy for mass-customisation. The system displays a number of characteristics and capabilities required for mass-customisation suggesting that a resulting product might hold value in its ability to be customised. In this paper we firstly evaluate the design system in its role for designing and fabricating the research prototype. We then consider the workflow in relation to key capabilities for mass-customisation.

1. Introduction

The *FabPod* is the second iteration in research which explores the acoustic properties of doubly ruled, hyperboloid surfaces and their potential use in developing a system of architectural panels (Fig. 1). The research stems from a hypothesis, based on anecdotal evidence from Antoni Gaudí's Sagrada Família church, that surface assemblies of hyperboloids provide good sound diffusion through scattering. This hypothesis was initially tested by constructing a prototype wall from hyperboloid shaped plaster bricks as part of the *Responsive Acoustic Surfaces* (RAS) cluster at SmartGeometry 2011 [2]. Building upon the promising outcomes of these experiments, in this iteration we explore whether hyperbolic surfaces can be employed to create a meeting room that satisfies auditory and acoustic criteria—the *FabPod*. Both the collaborative nature of the project and interdependencies between aspects of the project led to the conception of a generic "design system". This is underpinned by a holistic conception of workflow, from early schematic design stages through to the complete fabrication and assembly of the prototype. As such, it includes a series of digital tools to manage geometry and information as well as manual processes regarding material, assembly and quality control.

It has been well documented that digital workflows have a significant impact on both the richness of design potential and quality of the built outcome [1]. Through conceiving and implementing such a design system, it was possible to defer certain design decisions as late as possible in the process. This offers a number of benefits including the identification and resolution of issues arising in detailed design which affect earlier design phases, and more time for simulating and refining performance, in this case the acoustics and materiality.

This paper builds on previously published reporting on the project which focussed solely on the general arrangement of the design system [3] and the project's materialisation [4]. This is extended here and the project considered in terms of key capabilities required for mass-customisation.

2. Background

2.1. Previous research—responsive acoustic surfaces

The *Responsive Acoustic Surfaces* (RAS) cluster at *SmartGeometry 2011* demonstrated the potential for acoustically reflective surfaces to act as sound diffusors when they have a hyperboloid shape [2]. As part

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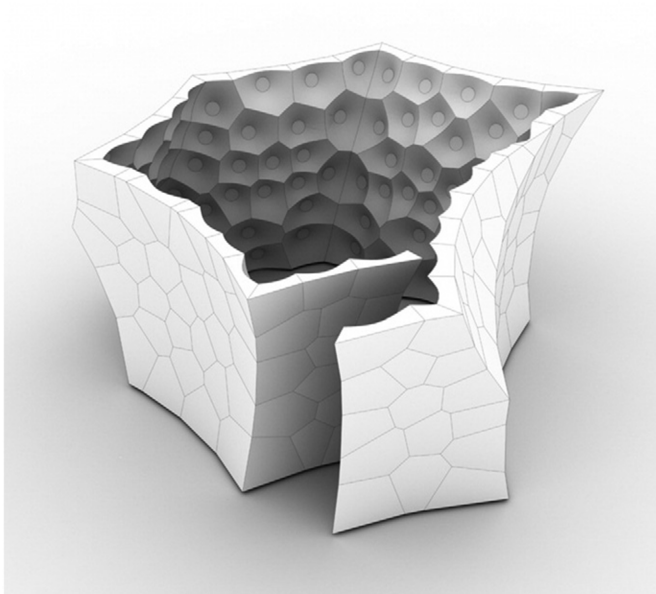

Fig. 1. A rendering of the FabPod prototype.

of this cluster a full scale wall prototype was developed from plaster hyperboloids, each supported by a plywood frame. The wall was semicircular in plan, a shape known to be acoustically challenging since all the reflected sound is concentrated at a central focus point. However, the wall with this surface articulation had a perceptible impact on the diffusion of sound when compared to a smooth wall of the same overall curved geometry. The hyperboloids were distributed in a regular pattern across the wall in order to simplify both the acoustic measurements and the construction of the plywood frame (by standardising the brick shape). Even though the wall shape and hyperboloid distribution were relatively straightforward, the researchers still encountered challenges both in calculating the intersections of the hyperboloids and designing a satisfactory construction paradigm (Fig. 2).

While the hyperboloid wall from the RAS cluster was ideal for demonstrating sound diffusion, research by Peters [5] suggests sound diffusion can be improved further in practice by minimising periodic tessellation of the surface pattern. This was tested through the 1:10 scale modelling in the workshop to test scattering coefficients. One ambition of the *FabPod* research was to apply and test this at full scale.

2.2. The fabpod brief

The physical context for the *FabPod* prototype is an open knowledge work environment within a new faculty building in the University. The architectural brief called for a space that could comfortably seat a minimum of 8 people. Complete acoustic privacy within the enclosure was not required. Rather, the brief was to provide a significant barrier to sound transmission into and out of the meeting area and an internal acoustic that was conducive to small meetings. The research team proposed that a design that combined partial acoustic absorption with a degree of sound scattering would be an appropriate response to this brief. It should provide some sound reduction close to the source, good speech intelligibility without loud and quiet spots and a space that would remain bright and lively rather than suffering the deadening effect of excessive sound absorption [6]. By deploying absorbing materials and forms for sound scattering on the outside of the structure, it should improve the auditory experience of the surrounding workspace [7].

Importantly, the brief included the potential for the project to be extended to develop a series of similar structures. The brief was in some regards highly generic, situated within a common context. It was clear that a design system was required that was sufficiently flexible and open to be applied to range of scenarios, a system that could be used to design customised structures varying in size, form and material. As the research developed, understanding developed regarding the potential market for such a product. Through this, a further level of project evaluation was added to the team's research evaluation: how might this relate to the potential for developing a product which utilised strategies of mass-customisation?

2.3. Research in digital design & fabrication

This project is an example of a growing field of design-make research which utilise digital design and fabrication tools. These projects include pavilions and installations as architectural experiments to facilitate design research which is evaluated through material outcomes and qualities including aesthetic effects [8]. A number of these projects also focus on performance driven design and measurements on the built result [9].

Less well understood are the relationships of these projects to manufacturing and an understanding of how they might be developed into products. Postponing of the point of differentiation within a supply chain is a strategy common to mass-customisation [10]. In this case, while the *FabPod* is not immediately intended as a commercial proposition, we consider overlaps in the capabilities between this design-led prototyping project and strategies for mass customisation of a product.

3. Temporal flexibility for prototyping

3.1. Postponing decisions for the prototyping process

Fundamental to architectural projects is a requirement for the clear and consistent flow of information in a 'downstream' direction. This follows a chronological project sequence from early design proposals,

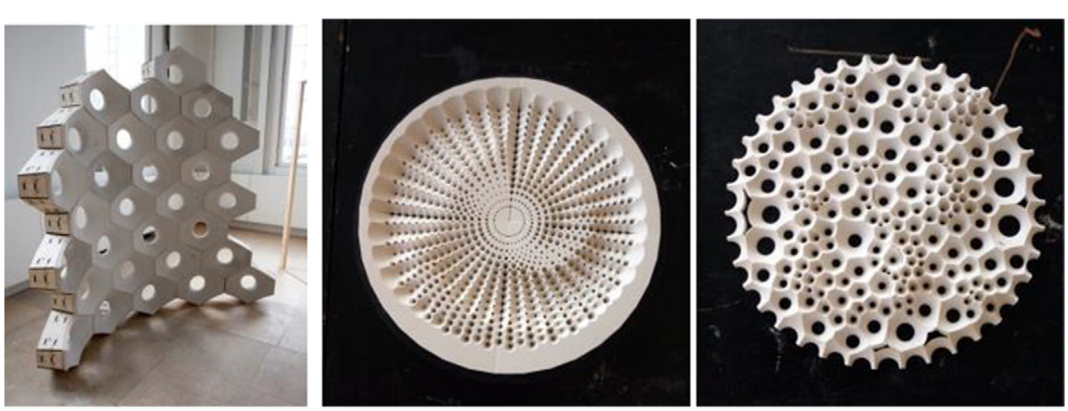

Fig. 2. The full scale prototype wall (left) and 3D printed test panels at 1:10 (right) from *Responsive Acoustic Surfaces* at Smart geometry 2011.