BIO-SHELL (BIODEGRADABLE VACUUM-FORMED MODULARIZED SHELTER)

SHINYA OKUDA
The National University of Singapore, Singapore

Keywords: *Digital Fabrication, Biodegradable, lightweight structure.*

1. Introduction: A new era of lightness in architecture

This poster demonstrates how digitally fabricated vacuum-formed components can provide a new type of lightweight construction applicable to architecture.

Surface-active systems such as a thin-shell concrete domes are some of the most material-efficient structures. Despite their efficiency few have been constructed recently due to necessary extensive labor cost. However, the growing concern for a worldwide shortage of natural resources and rising material costs, suggests that we reconsider the use of efficient structures, such as surface-active systems.

Vacuum formed plastics mainly used in industrial design have strong merit based on their fast and low-cost mass production. Together with the recent emergence of digital fabrication technologies, the vacuum forming process is becoming an attractive fabrication technique for new and innovative lightweight structures.

2. Key concept

Vacuum forming has the advantage of rapid mass-production capability of 3D curved forms. It can deform a thin sheet of plastic to increase its stiffness instantly. The result is an extremely lightweight structural component that can be prefabricated and stacked, thus it is easy to transport. Its major negative point is high cost of the initial mould although this is usually offset by the production quantity. Although most architectural production is one-off, the potential of large-scale production in quantity may justify the application of the industrial design method.

In addition, recent digital fabrication technologies, such as 3D CAD - CNC machining, have dramatically reduced the cost and time of making the mould. FEM (finite element method) also eases to simulate and optimize the shape of vacuum-formed components structurally prior to the mould making.

Since vacuum forming can work with almost any kind of thermoplastic material, recently developed biodegradable plastic, such as PLA (Poly Lactic Acid) made of biopolymer, could be one of the more sustainable applications. The outcome will be a biodegradable shelter, which is ideal for use as temporary disaster housings or exhibition booths, for example. The

T. Tidafi and T. Dorta (eds)
Joining Languages, Cultures and Visions: CAADFutures 2009

PLA is currently used for mainly disposable food containers.

The application of vacuum-formed modules at an architectural scale is primarily limited by the fabrication capability of existing vacuum-forming machines. One of the largest vacuum machines can form up to 1.2 x 2.4m size modules with a maximum 5 mm thickness of plastics sheet in one action, which is large enough for architectural component size.

3. Issues

The major challenge of this study is to find structurally stable geometry consists of only up to 5 mm thin components. Since thin shell is usually continuous surface, how to modularize the whole geometry into producible component size considering the size limitation of the vacuum-forming machines is also essential. In addition, it needs to develop 'surface joint' in order to transfer load evenly among the modularized thin shell components.

Other architectural requirements, such as waterproofing, weather resistance and heat and sound insulation properties are remained as future topics, which require further investigation.

Figure 1. One of the structural prototypes (Lattice grid), 1:2 scale mock-up.

References

Bechthold, M: 2008, Innovative Surface Structures - Technologies and Applications, Taylor & Francis, New York.

Sakamoto, T and Ferré, A (eds.) : 2008, From Control to Design: Parametric / Algorithmic Architecture, Actor A, Barcelona.

Schodck, D, et al.: 2005, Digital Design and Manufacturing: CAD/CAM Applications in Architecture and Design, John Wiley and Sons, Hoboken, New Jersey.

Staib, G, Dörrhöfer, A and Rosenthal, M: 2008, Components and Systems: Modular Construction - Design, Structure, New Technologies, Birkhäuser, Basel.

Thompson, R: 2007, Manufacturing Processes For Design Professionals, Thames & Hudson.