**MTRL 466: 2014**

**Flexible manufacturing of architectural panels**

There is a growing demand from architects for materials + processes that can allow them to break free from the constraints of “pre-fab” construction components (bricks, framing, drywall panels) so as to better meet the individual needs of buildings. The traditional “pre-fab” approach is assumed best from the perspective that it is low cost and easy to assemble.

The recent VarVac program undertaken by Houmin Architects has attempted to challenge this convention by seeking low cost ways of forming architectural panels, embracing rather than eschewing variability panel to panel. Embracing this panel-to-panel variability has the potential to provide optimal shape to a wall based on, for example, acoustic damping, natural light provision or thermal insulation.

 In this project we will continue with the same basic processing scheme as used in the VarVac program – thermoforming of thermoplastic polymer sheet. The aim here will be to work towards further simplifying the processing and, in doing so, reduce the cost and complexity associated with forming individual panels. This is to be done while retaining the maximum ability for the designer to easily and cheaply design panels separately.

Further, the concept of using either “point” or “linear” formed features will be explored. The idea would be to (eventually) construct complex shapes from a set of simple shapes formed by point loads or linear loading. For designers, points and lines serve as two of the simplest elements from which a variety of other shapes and forms can be designed.

One concept that we hope to explore in this is the how the intrinsic behaviour of the material itself can be used to aid in developing form. In particular, we wish to explore how the temperature dependence of the mechanical behaviour of the thermoplastic can be used to provide constraint in some areas (cold regions) while allowing for flow in others (hot regions). The particular question to be answered here is how to most efficiently heat (and control the heating) of the part so as to achieve desirable results.

In parallel, it is desired to survey the possible materials that could be used for this purpose. In the case of VarVac, polystyrene sheet was used but no attempt to find an “optimal” material was made. In this case an optimal material would 1) be easily formed at “low” temperatures 2) be resistant to degredation during use (interior use) 3) be environmentally friendly (considered in a full life cycle context).

Finally, with a preferable material and basic processing scheme in mind, it is desired to provide some guidance to the architects about the “processing window” available for forming. It may not be possible in the field to have a high degree of control over temperature, time and loading. In this case finding a material and forming conditions that allow maximal versatility would be optimal.

To summarize we wish to do the following:

* Use thermoforming of thermoplastic sheet to make either linear shapes or point like shapes.
* Look at methods for the controlled heating of the thermoplastic sheet rather than the conventional uniform heating
* Explore the possible range of materials available for this sort of processing and come to a conclusion on the best available material(s)
* Assess the best materials/process based on both an economic and an environmental (life cycle) analysis

Tools Required:

This project will have multiple aspects:

* The groups must become familiar with thermoplastic polymers, their physical, thermal and mechanical properties
* The groups must become familiar with thermoforming of thermoplastics, including (but not limited to) vacuum forming
* The groups must become familiar with the rationale for the design requirements arising from our colleagues in architecture
* The groups must be prepared to perform (simple) thermal and mechanical analyses in order to understand the behaviour of the materials under conditions of interest. These do not need to be detailed analyses; rather their aim should be to capture the basic physics.
* The groups should consider building “mockup” thermoforming systems which can allow them to empirically study and experiment with the thermoforming of thermoplastic components
* The groups must perform a life cycle analysis and (simplified) economic analysis in an attempt to justify the environmental and economic viability of these processes in comparison with other processes.