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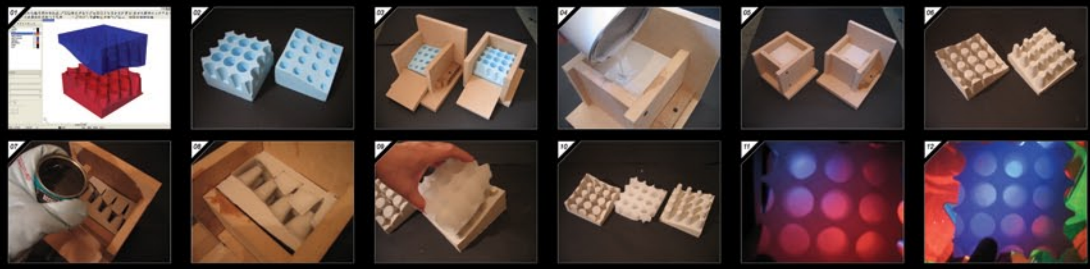
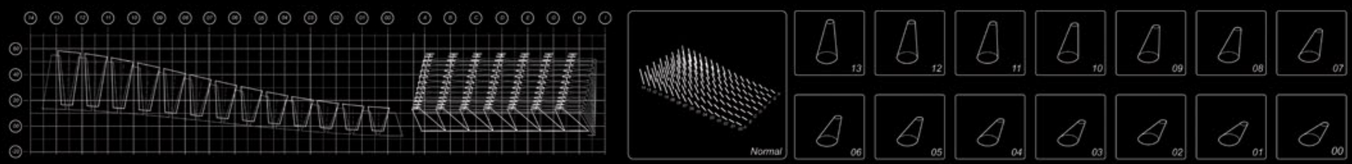
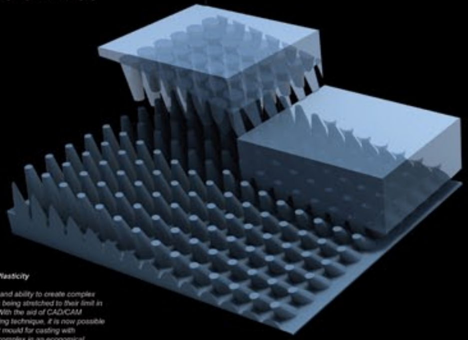
01	01-05-05	Mould was modelled in computer using the script
02	04-05-05	Positive set of casting moulds were fabricated using CNC machine on ploystrene
03	06-05-05	Casting box made for holding the mould in position during casting while containing liquid silicon rubber before it is set.
04	07-05-05	Liquid silicon rubber was poured into the casting box
05	07-05-05	Silicon rubber left to cure for 24 hours
06	08-05-05	Cured silicon rubber mould were removed from casting box
07	09-05-05	Molten wax (used for similating the effect and appearance of resin) was poured into the rubber moulds
08	09-05-05	Left to set for 10 hours
09	10-05-05	Set wax casting was removed from the silicon moulds
10	10-05-05	The mould could be used multiple times to fabricate casting of the performative material system
11&12	11-05-05	The performative material system was subjected to initial lighting test with back projection



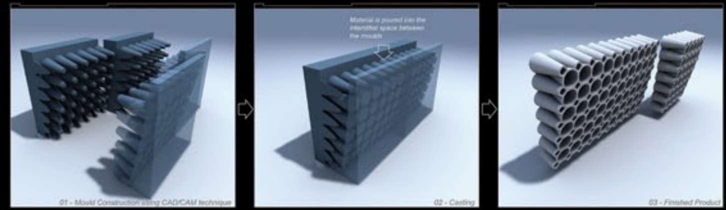


Mould Components Assembly
The drawing shows how several mould sets could be brought together for casting big objects



Concrete Plasticity

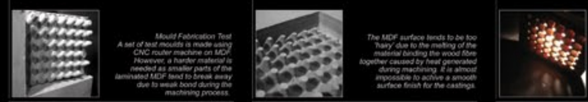
The fluidity and ability to create complex geometry is being stretched to their limit in this study. With the aid of CAD/CAM manufacturing technique, it is now possible to construct mould for casting with increasing complex in an economical fashion. The images on the right shows the concept of how the performative material system could be created using concrete with casting technique.



The mechanization and automation of casting processes have substantially reduced the cost of high volume castings, while new and innovative techniques such as the use of styrofoam patterns and CAD/CAM pattern production have dramatically reduced both development times and costs for prototype and short-run castings, making it an ideal manufacturing method for this part of the museum.

Material is poured into the interstitial space between the moulds and left to cure at room temperature. The potential weight of these monocoque wall panels could be enormous due to their size, stiffening ribs maybe required to be cast into them to minimize deflection while increases its structural performance. Joining components such as steel rod could also be cast into material to minimize extra fitting during installation

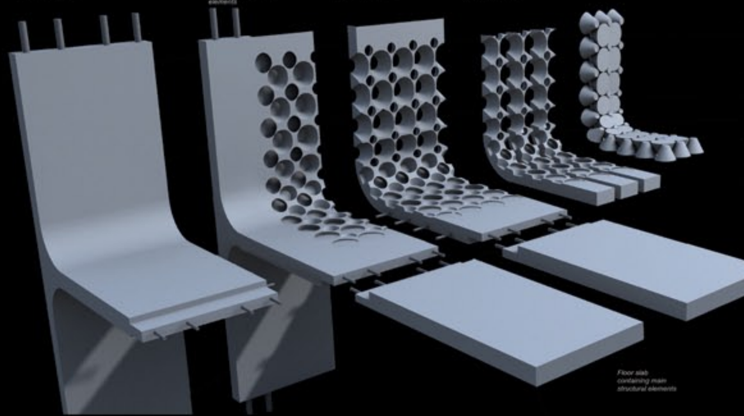
The major advantage casting techniques offer is that one could vary the materiality in a cost effective manner. The fluidity nature of concrete makes it an ideal material to be used in manufacturing the performative system.



Mould Fabrication Test
A set of test moulds is made using CNC router machine on MDF. However, a harder material is needed as smaller parts of the laminated MDF tend to break away due to weak bond during the machining process.

The MDF surface tends to be too 'hairy' due to the melting of the material binding the wood fibre together caused by heat generated during machining. It is almost impossible to achive a smooth surface finish for the castings.

Plywood was used in the next generation of mould (shown below) because it is much stronger than MDF and gives a better surface finish. However, owning to its stiffness, removing the cast without damage became a very difficult task. A strong and flexible material is needed and silicon rubber could be an ideal material for the task.



Surface Strategies

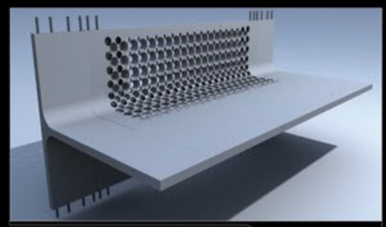
The explorations in constructability of geometrically complex envelopes in the projects of the digital avant-garde have led to a rethinking of surface tectonics. The building envelope is increasingly being explored for its potential to embed or subsume the structure into the skin, as in semi-monocoque and monocoque structures, in which the skin absorbs all or some of the stresses.

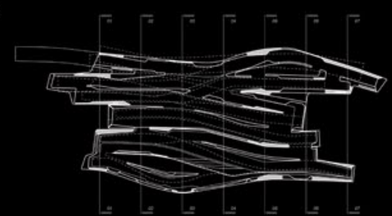
The performative material system is considered as a semi-monocoque cladding system that provides not only enclosure but also some structural support. To an extent, it is similar to the 'stressed skins' concept long used in automotive, aerospace, and shipbuilding production.

Structural System

Since 90% of the floors surface would be constructed out of reinforced concrete with minimum perforation, it forms a majority of the structural system along with a series of load-bearing wall throughout the building. The schematic plan below shows the distribution of structural wall elements (en-suite concrete with structural reinforcement) across the building. A new reinforcement product available in the market which takes the form of a series of flexible 3D mesh will also be used strengthen the finer elements such as the thin wall between cones.

The performative material system is pre-fabricated off-site and assembled to this super-structure (to structural wall/floor connections), aiming to provide extra strength and stability. (The illustration of the left shows a sketch of how the system connected to the main structural elements.





Synopsis

Using a performative material system developed for the new Museum of the Moving Images (MOMI) in London as a case study, the goal of this investigation is to explore the boundary of buildability using concrete as a construction material to manipulate ones' perception of movement and spatial opacity with the assistance of various digital manufacturing techniques. In short, the performative material system is an optical filter created by endless variations of directionality, thickness and modular size that is capable of adopting to any surface condition. It is constructed with two layers of interlocking cones, designed to create different moments in spaces that simulates and impedes individual's reception of movement through manipulation of light intensity and views.

The investigation also focuses on researching digital prototyping and manufacturing techniques that allows for increased levels of repetition and difference in the context of mass customization. It discusses the possibility of fabricating cohesive heterogeneous components (elements that are similar in typology but all different) in an economically viable fashion through exploring different existing digital manufacturing techniques with a critical study on their possibilities and constraints.

Performative Material System
The nature of cinematic experience has always been related to creative manipulation of time, space and movement. Time calls for a system of references and the most immediate procedure by which man understands time is in relation to movement with the changes in his surroundings. In this way, the building is a surface of separation, more or less developed, between man and his set of references. The performative material system is envisaged to behave like a surface of differing thickness and differing degrees of permeability, which can in turn generate new measures for the perception of time and movement on the other side. Firstly, it challenges the idea of designing an architectural skin as a filter, which allows for an intriguing juxtaposition between the 'real' movement of visitors and the 'false' movement of projection with reference to Deleuze's idea of the Moving Image. Secondly, it is perceived as a device that creates highly individuated experience within the gallery (which relates back to the notion of creating differences within a system).

Geometry
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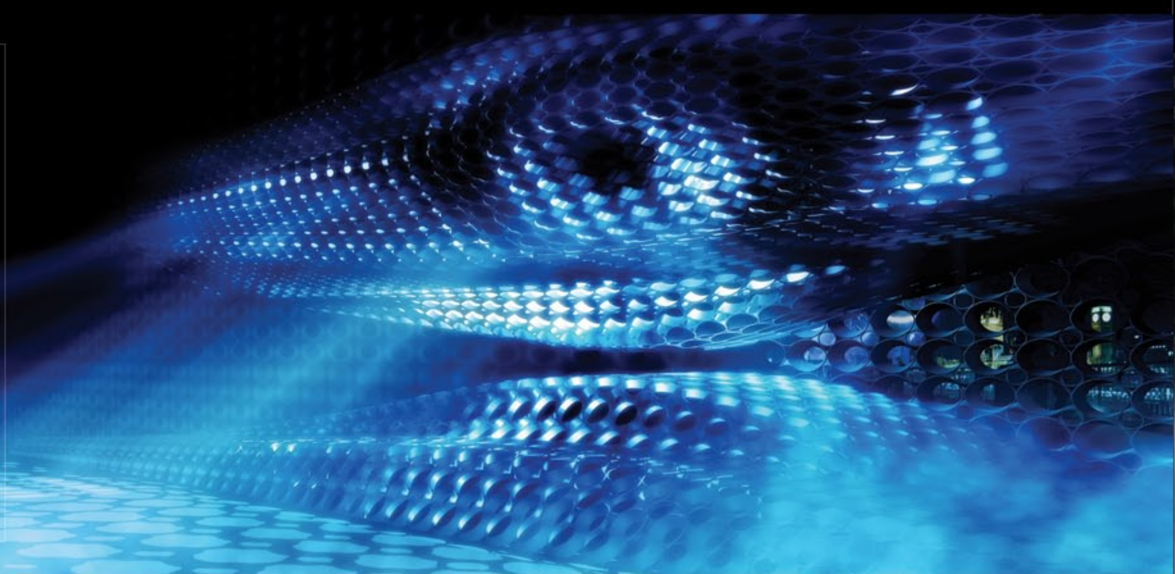

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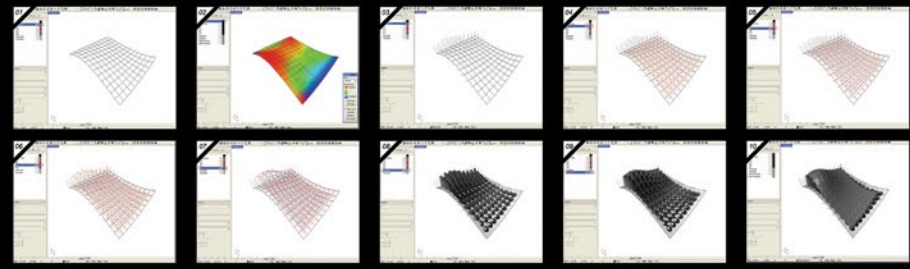


Scripting

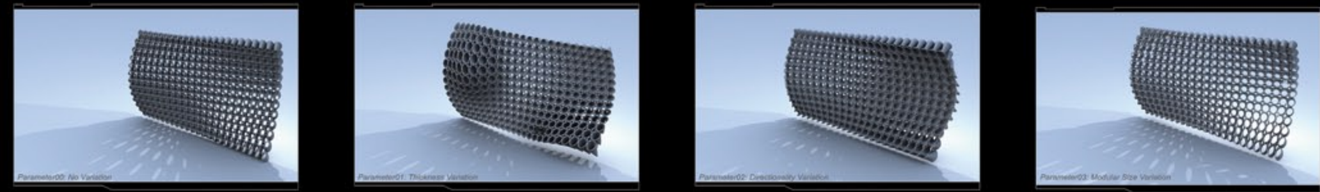
The performative material system has three basic parameters, which could be accurately controlled by the script, to manipulate different lighting and visual conditions at specific parts of the museum. The main variables are thickness, directionality, and modular size, which directly affect the visual opacity of the material system.

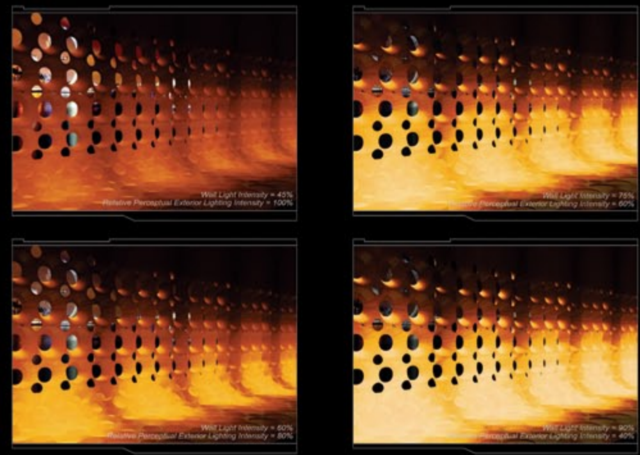
Thickness
The thickness of the system can be varied at any specific location on the surface. It works by varying the height dimension of the cones normal to the surface using a Gaussian distribution equation. The thickest part would be described by the centre coordinates of the distribution while its amplitude is dictated by the peak value in the same equation.

Directionality
Directionality is varied through skewing the geometry on the cones. The script describes this situation by tilting the normal of the cones which are originally perpendicular to the surface and thereby stretching the geometry to a particular direction. There are three basic variations in directionality which are discussed below:

Size Modulation
The ratio of radii between the larger and smaller circle at the extremity of an open cone could be varied in the same way as the aperture of a camera. A Gaussian distribution is used to describe the gradual change in radii ratio from the centre where it is most porous and cones becomes cylinders at that point.

Twisting
The idea is similar to altering the aperture of a camera lens. The geometry of individual cone could be deformed by twisting to alter the magnitude of perforation, which would in turn varies the visual and lighting porosity. The script also allows the user to manipulate twisting from 180 degree (0% porosity – full deformation) to 0 degree (100% porosity – no deformation).





3D Stereolithography Print showing how the three main parameters could be used to control visual porosity and light penetration

Concrete Opacity

Relative lighting level between interior and exterior of a building envelope could affect ones perception of its opacity. This phenomena is evident in building clad in curtain walling with reflective coating finish - the glass surface is relatively opaque and reflective during daytime when the interior is considerably darker whist opacity decreases dramatically at night when the interior is relatively bright. In the case of the perfomative system proposed in this study, one could also manipulate the material's apparent visual opacity with the same principle by varying the lighting level inside the building at night.

The effect would be more dramatic and interesting if the light provided by creating a glowing building envelope rather than merely lighting its interior surface. In theory it is achievable by either
a/. using optical fibres as reinforcement with a light sources embedded inside the concrete structure or
b/. including fine to medium size glass granules in the concrete aggregate to increase light penetration

The images above shows how the apparent visual opacity alters with the amount the building envelope glows at night.

"Translucent" Concrete
Translucent concrete, in theory, could be made by adding small lumps of plastic or glass of various sizes into the normal concrete aggregate. It offers an extra dimension to materiality by allowing one to alter its opacity through adjusting the amount transparent material being added. However, there will be a size restriction to the glass granules depending on the wall thickness between the cones to ensure that the aggregate can be filled into the moulds.

Resin
Translucent resin is an more expensive alternative to translucent concrete but it gives much more flexibility and control in colour and the level of opacity.

Design Concept

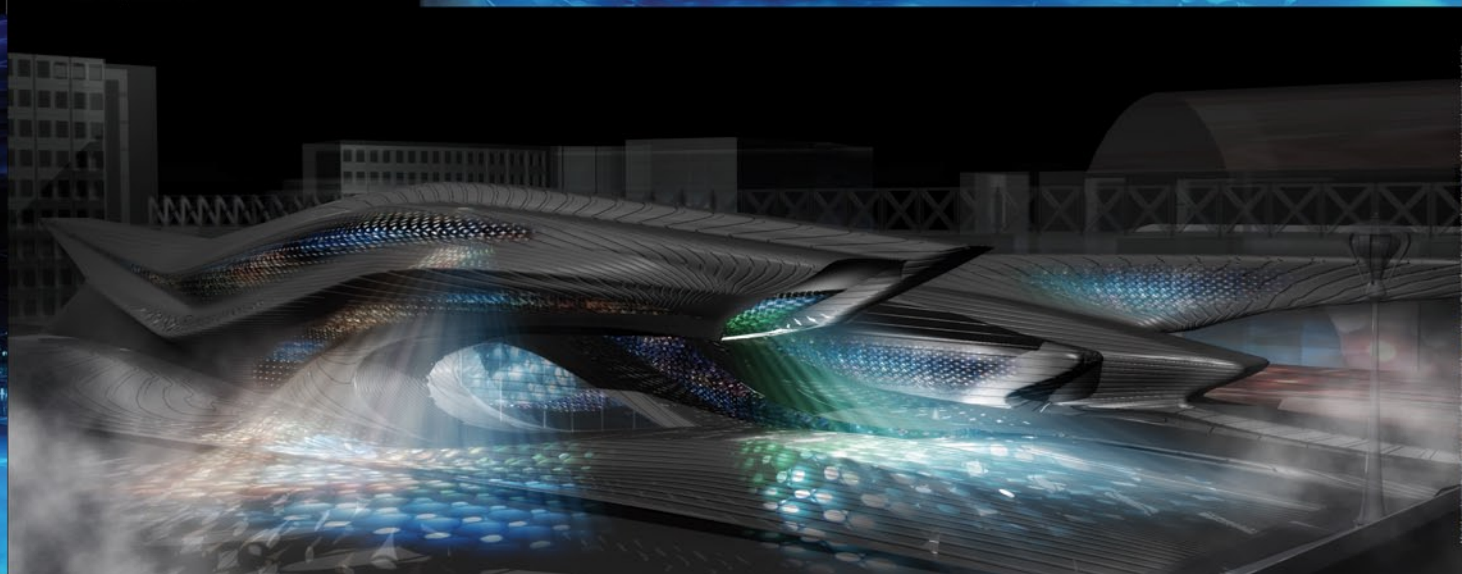
Deleuzian Notion of Movement
Both Gilles Deleuze and Henri Bergson were, to extremely varying degrees, philosophers interested in cinema who used cinema to suit their particular intellectual needs. Deleuze derives his thesis from the philosopher Bergson who opposed real movement and concrete duration (durée), with immobile sections and abstract time.

Real Movement
Real movement in everyday life is indivisible, unstoppable, and thus in no way can it be reconstituted. Regardless of how much space is divided, movement will always occur in a concrete duration (indivisible time).

False Movement
False movement occurs when abstract time is added to immobile sections. In fact Bergson used the 'cinematographical process' as an example of false movement: immobile sections [individual still frames] plus abstract time [the projector].

Juxtaposition of Real and False Movement
The performative material system is conceived as a platform on which the boundary between 'real' and 'false' movement is blurred. It is designed to simulate and impede one's reception of movement through manipulation of light intensity and views.

'Real movement' of visitors on the other side of the concrete wall system is perceived through the punctuations whilst 'false movement' of movie images is projected and overlaid onto its conical surface, blurring the boundary between these the two types of movements.



PANEL02