

The DigiTile Project

Conceiving, Computing and Creating Contemporary Tiling Prototypes Using Computer Aided Modelling Techniques

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The influx of computer-based design and presentation platforms, particularly in conjunction with computer aided physical modelling and manufacturing techniques, has stimulated a renewed focus on imaginative, innovative architectural product design. Essentially, the ambition of the DigiTile exercise was to stimulate the development of individual proposals for new kinds of surface articulations on the basis of a tile-like unit, or set of units. Inspirations varied widely: from precedents ranging from history to nature, as well as from contemporary design practice and graphic imagery.

The prevailing freshness and technical inquisitiveness amongst the participants contributed to the generation and concretisation of distinctive tiling concepts, many of which have arguably not been seen before. The findings and conclusions are based upon the array of outcomes from the programme so far, as well from a very recent session. Furthermore, the paper highlights the kinds of opportunities for hands-on education-based compositional studies that we foresee in the near future.

Keywords: *Computer aided manufacturing and modelling; composition; prototyping; tiling; ornamatics; education-based research.*

Opportunities

In contemporary architectural practice, the introduction of new kinds of computer aided production methods has initiated a refreshingly 'post-industrial' attitude towards architectural materialisation and component design. Whereas Modernist approaches to architectural design and building tended to

involve the selection and combination of *standardised* elements, produced industrially in large numbers, the architectural landscape of today seems increasingly to be inhabited by *individually* designed, project-specific components and surface elements, produced in relatively small series.

As a result, there is a growing awareness amongst architectural practitioners – and indeed students – of

the expressive potentials of individually articulated building elements on the level of architectural composition and perception.

In this context, academic environments might be expected to respond to the challenge by offering groundbreaking study initiatives, which may be beneficial and stimulating as learning experiences, but also take on the role of *creative laboratories* on the level of technical innovation and a better understanding of aesthetic performance.

Study groups in an educational environment offer opportunities to connect the research ambitions and methodical discipline of academics on the one hand with the open-minded enthusiasm and computational dexterity of students on the other and may lead to novel solutions and rewarding insights. This contribution offers an overview and assessment of such an initiative: the DigiTile study project.

Procedures and Explorations

The DigiTile assignment formed part of the ongoing Ornamatics project in Delft. The basic requirement of this exercise was that one or more 'tileable' elements should be made combinable in such a way that visually appealing surface patterns would be the result. The perceptual impact might primarily be graphic, but issues such as plasticity and even transparency might also be expected to play an important role.

The challenge was to investigate and shift the boundaries of existing tiling concepts, but at the same time to come up with highly feasible, marketable DigiTile product proposals. The participating students and academics were stimulated to use any kind of design and presentation media that might seem appropriate. The visualisation platforms that were utilised varied considerably, from quickly executed sketches and collages to a variety of computer-based applications, ranging from 3D digital modelling to parameter-based geometric structuring. Presentations of intermediate study results involved several digital means, whereby individual proposals were projected via a beamer and discussed in the

group. The input was collected using a project database, intended for future referencing and research.

From the outset it was made clear that the outcomes of study should not just remain *virtual* propositions, but should take the form of *physical*, tangible elements. These might be scaled down if necessary, but should ideally be executed as prototypes manufactured in *real size*. In order to create such physical objects, three elementary CAM techniques were made available:

- 2D lasercutting facilities on the basis of CAD files;
- 2.5D CNC milling devices;
- 3D printing facilities with either monochrome or coloured output modes.

An important aspect – in anticipation of potential production procedures on a (semi-) industrial scale – was the generation of ideas not only as 'positive' objects, but particularly as 'negative to positive' forms, involving *casting techniques* which might potentially make use of different materials such as ceramics, concrete, composite materials, bronze or aluminium.

The Delft CAM-lab

CAM techniques, especially CNC milling and cutting techniques have been around for some time. Recent developments in 3D modelling software and the increased availability of rapid prototyping techniques have made CAM-based production platforms available to a steadily broadening range of professionals as well as educational institutions.

From around 2000, the Rapid Prototyping potentials for architectural modelling have developed steadily (Klinger, 2001), (Breen, Nottrott and Stellingwerff, 2002), (Kvan et al., 2002). Several (technical) universities set up CAM laboratory facilities. But – perhaps more importantly – a growing number of trend-setting young architects and design groups have also started exploiting the creative opportunities of such instruments, translating their concepts into tangible structures by means of CAM techniques.

Their concepts and realised projects have been disseminated via the Web and influence the attitudes of students and teaching staff.

From 2002 onwards, the Delft Faculty of Architecture CAM-lab has been steadily evolving, developing new applications step by step. Having started with a small-scale milling machine, the facilities were expanded with the introduction of a first 3D-printer and subsequently a laser-cutting device. Due to the growing interest of students, researchers and professional designers from outside the faculty, the capacity has recently more than doubled and is still growing.

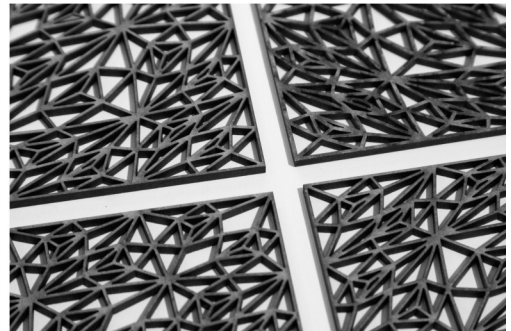
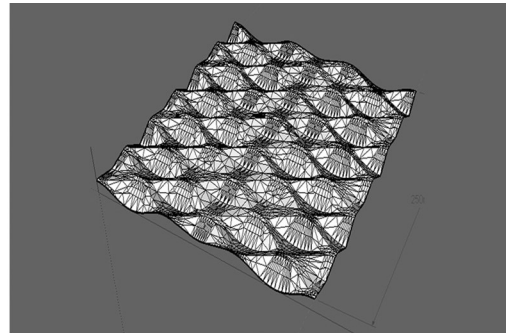
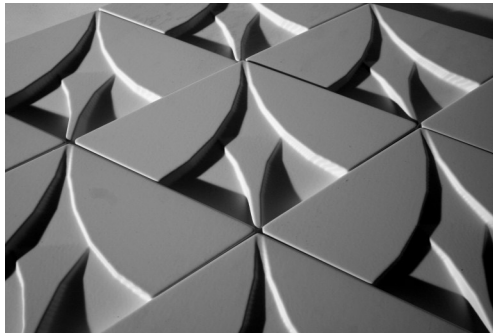
The Delft CAM-lab facilities are primarily used for the benefit of physical scale modelling and prototyping. Thereby an attempt is made to activate the available machines in order to bridge the gap with 'industrial' production procedures involving larger

machines that are used in full-scale commercial production. By using the different specific cutting, milling and printing techniques, students are stimulated to discover how designing and product development may be influenced by the opportunities – but also the limitations – of specific tools. Thereby they are able to acquire insights concerning the translation of a design idea into actual components. As such, working with a CAM-lab can potentially acquaint students with the kind of practice in which they might exert full control over uniquely composed and fabricated building elements.

The return of Ornamentation through new fabrication techniques

The DigiTile project formed part of an experimental, education-based study initiative entitled Ornamatics.

Figure 1
DigiTile variations 1: 3D
tiling in virtual, milled and
laser formats



The central hypothesis of this exercise was – and is – that the introduction of novel – computer driven – manufacturing and modeling techniques may stimulate a ‘new wave’ of ornamentation in architectural design, which was supposedly been wiped away by the influx of large-scale industrial production and modernist compositional modes.

The first thing the participating students are required to do in the Ornamatics course is to come up with a collection of reference material – and indeed inspirations – concerning ornamentation in architecture in the broadest sense: from history as well as from contemporary practice. The collages of samples they bring in trigger the awareness of other participants and generally lead to a lively discussion.

These inspirations tend to vary widely. Some students tend to be attracted by Celtic motifs or Islamic patterns. Frequently exemplars from ‘primitive’ societies or from nature (such as plant motifs, corals and sand dunes) pop up. Precedents from the Art Nouveau and the early modern movement also figure prominently, notably from the work of Labrouste, Horta and Lloyd Wright (particularly the concrete blocks of his Ennis house project) and Gaudi (the hexagonal, organic tiling patterns along the avenues of Barcelona).

Further references include the work of Jean Nouvel (from his Institut du Monde Arabe ‘diaphragms’ to his Copenhagen concrete casting experiments), Will Alsop (the silk-screened windows of his Düsseldorf office complex) and especially Herzog & de Meuron (their entire, highly experimental, ingenious and elegant oeuvre so far).

There is also particular interest in the output of smaller offices, design teams that have been able to find a ‘niche’ in the domain where ornamentation and computer aided design and production come together, such as Hild und K, Ply Architecture, Edouard Francois and Maurice Nio.

Much of this reference material demonstrates a ‘balancing act’ between predominantly graphic approaches on the one hand and the exploitation of plasticity and materialization on the other.

The DigiTile assignment

After formulating our ambitions in the paper ‘Towards Ornamatics’, presented during the eCAADe conference in Lisbon (Breen and Stellingwerff, 2005), we started a pilot project with an international group of Masters students in the fall of 2005.

The ‘kick-start’ of this Ornamatics project was a ‘digital tiling’ exercise, whereby students were stimulated to come up with novel, spatial tiling concepts and to develop real-size prototypes using a variety of virtual and physical modelling techniques.

Different approaches included:

- Free-hand drawing and collage techniques;
- 3D modeling in using Maya and/or SketchUp formats;
- Combining of components in SketchUp and graphic programs for tiling effects;
- Applying mathematic graphing tools to produce and manipulate 3D patterns;
- Prototype realization using different molding and casting techniques.

Different material qualities were exploited for expressive effect: concrete for a certain robustness and mass in the realisation of the designs, MDF and plywood for a rougher finish; plastic moulds for smooth, even reflecting surfaces.

What soon became evident is that such a seemingly limited task can stimulate a diversity of approaches. The results demonstrated considerable diversity, on the level of elementary tiling shapes and sequencing approaches, as well as on the levels of surface layering, spatial geometries and material treatments that were addressed.

Although the DigiTile exercise was initially thought of as a short introduction, to let the students get acquainted with different techniques and concept in a relatively structured way, it proved to be extremely interesting on different levels: geometry, different types of symmetry and visual tension, moulding and casting using concrete and other composite materials, scaling up fabrication on the basis of one milled form, vacuum forming and particularly:

creating varied tiling compositions using a limited number of elements.

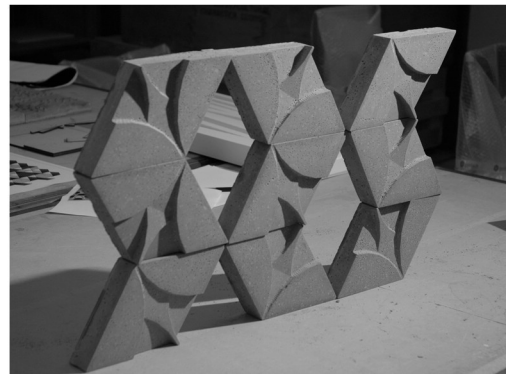
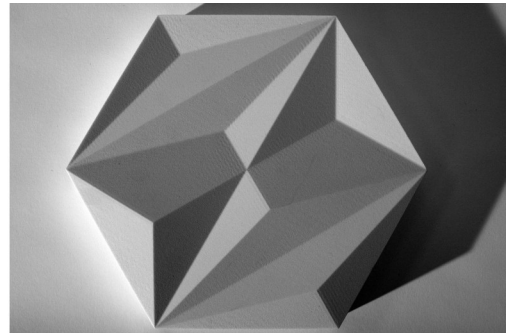
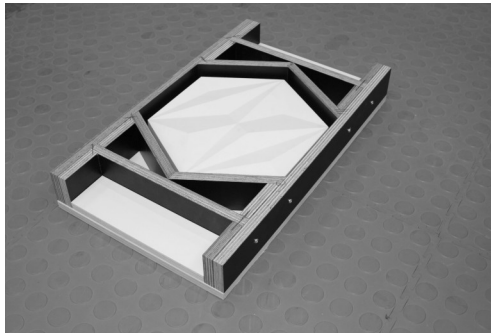
The DigiTile exercise proved so stimulating and successful that it became an essential and recurring feature of the Ornamatics course.

DigiTile variations

In the first DigiTile assignment, the emphasis was placed on surface articulation and casting. This led to a number of truly novel solutions, but also highlighted practical problems on the level of realisation, particularly in the 'second step' of casting. Positive objects were initially milled in soft foam and subsequently an attempt was made to make plastic counter-forms, which could serve as moulds for casting (in concrete or plaster, potentially ceramics or aluminium).

The second exercise followed a rather different approach. In this case the students were asked to work directly towards models produced as 3D prints. This had a number of consequences. On the one hand it offered a more direct link between concept and physical object (which approached the tangible qualities of a ceramic tile), which was enhanced by the fact that the process of production was relatively quick. The less positive side of this approach was that it tended to be more difficult to produce objects on a 1:1 scale. Instead, objects tended to be 'scaled down', which often meant that the output became extremely delicate and hard to handle. Nonetheless, this did mean that it was possible to produce series of objects, which stimulated studies on the level of repetition and variation. All in all, this approach brought forward some extremely clever, sometimes even stunning results.

*Figure 2
DigiTile variations 2: form-
work and casting experiments*



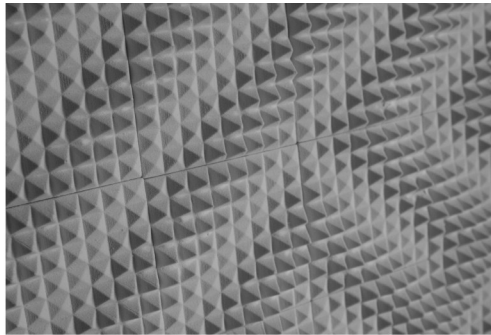
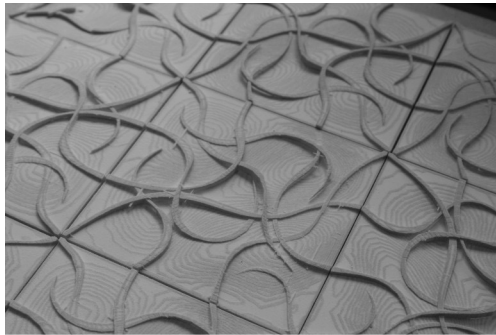
In the third Ornamatics group the emphasis changed once again. Rather than creating ‘free form’ tiles, a strict format (40 x 60 cm) was set and the technique was narrowed down even further: computer aided milling in plywood. This limitation proved to be both stimulating and difficult, the main problem being that it was relatively time consuming to generate physical results between group sessions. This indicated that it is important to be confronted with intermediate results that will trigger discussions and stimulate further developments.

Side track: collaboration with a professional ceramics artist

After the second course, we were approached by Dutch ceramics artist Babs Haenen with a request to assist her in the realisation of a unique DigiTile project.

This initiative also proved to be a valuable learning experience on different levels. Haenen had developed a WAD-tile, which referred to the typical waved patterns of sand on the Dutch Wadden sea coast. The tile had already been produced as a wall tile in blue ceramics. Based on the existing tile a new floor tile was to be developed. The same pattern should be scaled up and – in order to be safe and comfortable to walk on – the wave-surface had to be flattened and re-profiled.

The idea was to carry out the scaling and surface adaptations digitally and create the new tile using CNC milling techniques. A first attempt was made by means of a 3D scan, but the resulting ‘point-cloud’ proved cumbersome and eventually the whole pattern was 2D scanned from a drawing by the artist and the 3D pattern was modelled in SketchUp. The tiles were 3D printed and used as a mould for the



*Figure 3
DigiTile variations 3: 3D
printed student projects*

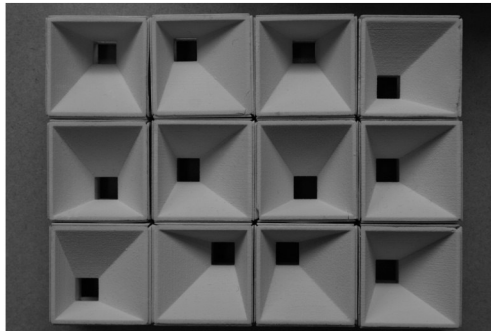
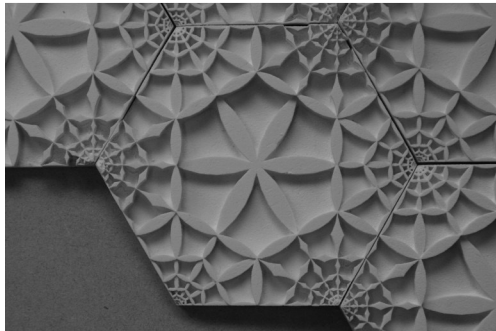


Figure 4
WAD-tile project: 3D scan
experiments and final tile
prototype on display



industrial production. Summer 2007 the first results were on display at Het Prinsessehof museum in Leeuwarden.

Findings, Conclusions and Perspectives

The DigiTile initiative has so far yielded a considerable number of stimulating, frequently even fascinating results.

The outcomes of this experimental project may shine a light on new sorts of product applications and production modes for tiled surface designs, using state-of-the-art computer technologies. The subject matter of the implicitly 'connective' building component has so far led to a renewed focus on the level of formal *grammars* and has kick-started other research and development initiatives based on CAM platforms.

The issue of 'new ornamentation' and the concept of digital tiling appear to be 'in the air'. Parallel to our initiatives, digital ornamentation has been explored and described by academics such as Strehlke and Loveridge (2005, 2006) and Elys (2006). Furthermore, since our previous concrete workshop collaboration with Michael Speaks, it appears that there are interesting new developments in this field at UCLA, notably in the courses of Heather Roberge, in which students apparently also work with "moulds and/or female and male tools" (Archinect 2007). The phenomenon of ornamentation and structure on

the level of the building's façade has been studied in an educational setting and illustrated convincingly by researchers Moussavi and Kubo from Harvard (2006).

The time seems right for an organised exchange of experiences – and potentially for more international collaboration – in this promising field.

But, more specifically, what are the insights the Delft DigiTile study has generated so far? What might we say about the instrumental and typological conditions that have surfaced and how ought we to progress?

Firstly, it seems justified – on the basis of the results – to draw the conclusion that the DigiTile exercises up to now have demonstrated that this subject matter clearly appeals to a young generation of designers that may be considered 'computer literate'. Although one might have assumed that the issue of tiling as such might come across as somewhat 'dry' to members of the young global community, the opposite seemed to be the case. Several students got seriously immersed in mathematical and geometrical studies, often being stimulated by 'classical' sources, which were frequently completely new to them. The prevailing freshness and technical inquisitiveness amongst the participants contributed to the generation and concretisation of distinctive tiling concepts, many of which have arguably not been seen before.

Secondly, precisely the *constraints* of the tiling format proved to be successful in introducing

a kind of typological discipline and rigour, not only into the body of work, but also into the discussions and evaluations. Characteristic decisions on the level of the basic tiling shape (square, rectangular, hexagonal, regular or (relatively) irregular proved to be decisive elements on the levels of composition and realisation. Furthermore, the computer-based ways of working seemed to free several students from the 'normal' constraints of tiling imagery. Besides relatively figurative or formally graphic modes being applied, this meant that a variety of layered, truly three-dimensional tiling options saw the light.

Thirdly, it once again appeared to be demonstrated that – to a very large extent at least – the Medium *is* indeed the *method*... We witnessed a marked difference in expression when the *output* medium changed from computer aided milling to 3D printing. The focus on casting as a method meant that students were less exclusively focused on the end product *as such*, but would be simultaneously thinking along the lines of the – negative – mould form and began to actively consider aspects of fabrication as a consequence of Form...

All in all, these experiences with a roughly similar task, but three different output formats (milling on the level of form/counter form, 3D object and milled panel) have only given further incentive to experimentation on the levels of Ornamatics as a binding concept and tiling as a theme. What proved to be particularly interesting in this context was that an experimental learning environment of this sort, with challenging tasks and clearly defined constraints, can function not only an education-based laboratory for technical applications, but can also be considered as a testing ground for new aesthetic paradigms.

To be continued...

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