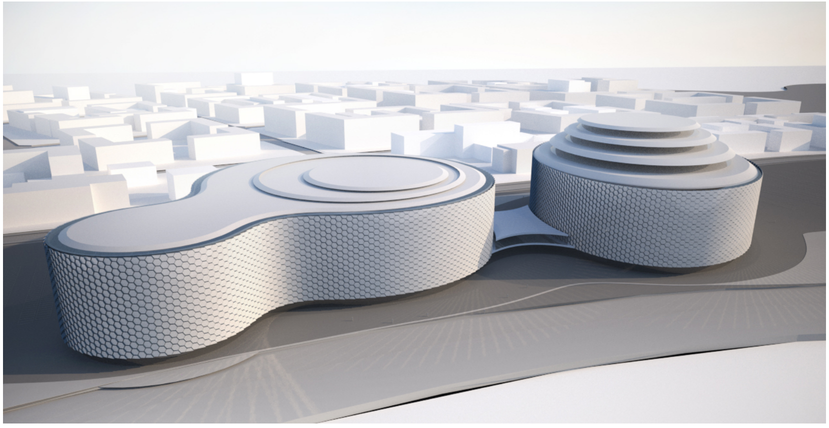

Figure 1: TODO Moritz: add caption and reference in text

1 Case Study: Hexagonal Surface panelization

Through conformal maps, the designer can explore alternative shapes with a high degree freedom to design under minimal constraints. Yet, important questions concerning panel layout, similarity and therewith constructability and cost can be addressed at early design stages such as competition entries. Furthermore, the topological modification of the mapped patterns open alternative design strategies to regular UV subdivision, as the density of the pattern can now be varied across the entire surface. This can be used for structural purposes, such as diagrid layouts, or design driven, such as window panel distribution. The option to optimize the panel layout toward single or multiple geometric criteria of each panel such as edge length similarity or planarization is consequential.

For a commissioned competition entry we tested and developed the method of conformal mapping. The project, which served as a case study, was highly constrained, as the architects were asked to propose an alternative facade design for an existing design proposal of a multifunctional exhibition center in Korea, see Figure 1. The massing was fixed, but there were 2 alternative massing options (1 single curved and 1 doubly-curved envelope) to be explored. Also, the client wanted a hexagonal tiling on the facade but only had a very limited budget of approximately 200 Euro / sqm for the entire facade including sub structure in mind.

These limitations, in combination with the very short timeframe of 2 weeks for the entire redevelopment of the facade including a feasibility study drove the development of the conformal mapping method. Especially, since existing solutions such as UV Mapping led to unsatisfactory results due to the high stretch of some regions in the master surfaces. Some specific questions that had to be addressed for each massing option were:

- How many (different) panels would we need?

Figure 2: TODO Moritz: add caption and reference in text

- If we can group the panels into different types (e.g. planar & non-planar), how many different groups would we need?
- Can we clad the entire surface with planar tiles?
- Can we equalize the edge lengths of each hexagon?
- Can we control the orientation of the panels?
- Can we achieve a regular pattern with a homogeneous visual appearance?

In the end, all the above questiones were answered / solved.

The first step of development focused on achieving periodicity across the surface seam / at the boundary. While the issue of periodicity directly addressed the last question, it strongly related to the others as they could be achieved by successive optimization steps.

Already during the design phase a fully periodic tiling was achieved. In a following step the panels were planarized, grouped by dimension and their edge lengths were equalized. Finally, a control for the panel orientation based on the tangents of the NURBS master surface was implemented. This hexagonal pattern served as a base for the facade engineering team. Due to the high cost demands, a simple component system that served as a sub-structure for each panel was developed (see Fig. 2).

Unfortunately the given massing for the building was not very challenging in terms of geometry. One massing option was a simple extrusion and the other had very little distortion. After the successful submission of the project, we decided to continue the development and test the method of conformal mapping on more challenging base geometries.

During these tests a Grasshopper Plugin for VARYLAB, see [**?**] has been developed and refined. We focused on tiling surfaces with a large distortion / stretch and double curvature. The main aim was to be able to tile these surfaces without

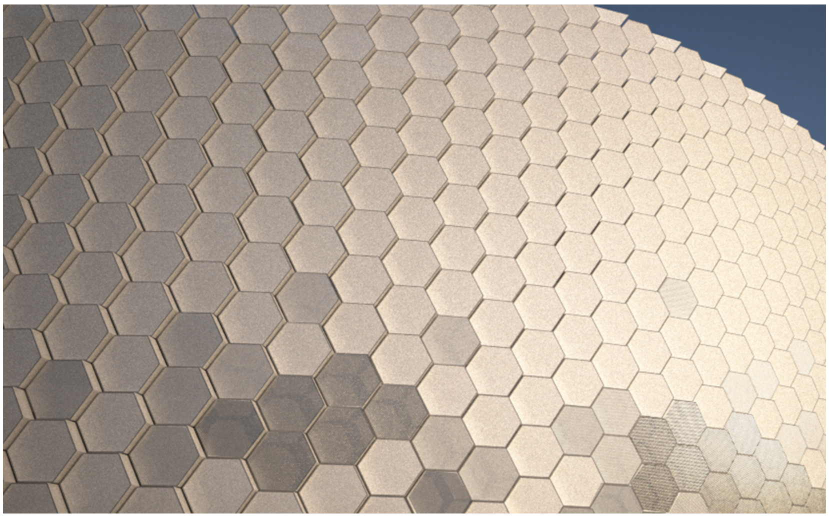

Figure 3: TODO: Choose graphic style and perspective

distorting the tiling. This led to focus on the boundary conditions. The designer is now able to choose between an "aligned-edge" mapping where each tile on the edge aligns with the underlyings surface edge. The trade-off being, that some of the panels will distort. Or one chooses a "homogenous tilling" mapping, where all the tiles are the same, but do not align with boundary. All of VARYLABs numerous optimization algorithms can be applied and combined with either of the two approaches. During the development, we realized that through singularities and special boundary conditions, one is able to control the density and distribution of the pattern on the surface and along its edges. We believe that there is potential in this approach especially for structural design, such as lattices and grids.

We also started to look into how patterns can be applied across multiple surface patches, such that the pattern aligns at the crease where the patches meet. This would necessitate to develop methods for non-/quasi-conformal mappings and the applications of multiple boundary conditions; A field that is yet to be developed.

The collaboration between architect and math department proved to be very satisfactory for both parties: The architects did provide specific questions related to real world projects whilst the mathematicians were able to translate these questions into mathematical formulas that provided meaningful results that could not have been achieved alternatively. The common design framework of Rhino and the basic knowledge of NURBS geometry and modelling techniques proved to be of essential importance for the successful collaboration between them teams.