ALGORITHMIC PATTERNS FOR FACADE DESIGN

Inês Caetano | PhD in Architecture
ines.caetano@tecnico.ulisboa.pt

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ALGORITHMIC DESIGN

Current architectural facades present complex shapes and patterns, a trend supported by recent digital technologies. Also, due to their aesthetical and environmental relevance, the design of facades has been combined with analysis and optimization processes, aiming at achieving better performing solutions. A new design approach has been promoting the development of complex facade designs, Algorithmic Design (AD), which promotes the description of shapes through algorithms. Nevertheless, architects still suffer limitations when using AD, mainly:

- the need for specialized expertise;
- the fragmentation resulting from the integration of analysis and optimization processes in an AD workflow, which involves using multiple models/tools, thus becoming error-prone, time-consuming, and hard-working;
- the limitations on the AD design freedom, derived from physical (structural performance and fabrication), time, and cost constraints.

DrAFT FRAMEWORK

To reduce the time spent in the programming task, we propose a theoretical framework to facilitate the mathematical description of algorithmic-based facade designs together with the implementation of the most used analysis and optimization processes, merging these in a continuous design workflow. The framework includes:

- a classification of facades based on different categorical dimensions;
- fundamental algorithms and strategies to address the needs of each dimension;
- guidelines to help architects select/combine the most useful algorithms for a design;
- algorithms for cost efficiency and assembly processes to ensure the obtained solutions can be manufactured.

Case Study 1

The DrAFT framework was used to develop a set of facades with a geometrical pattern composed of several parametric diamond-shaped elements of different apertures (Fig. 1), which varied according to:

- the need for natural light;
- the design's aesthetical criteria: a parabola curve shaped effect along the facades.

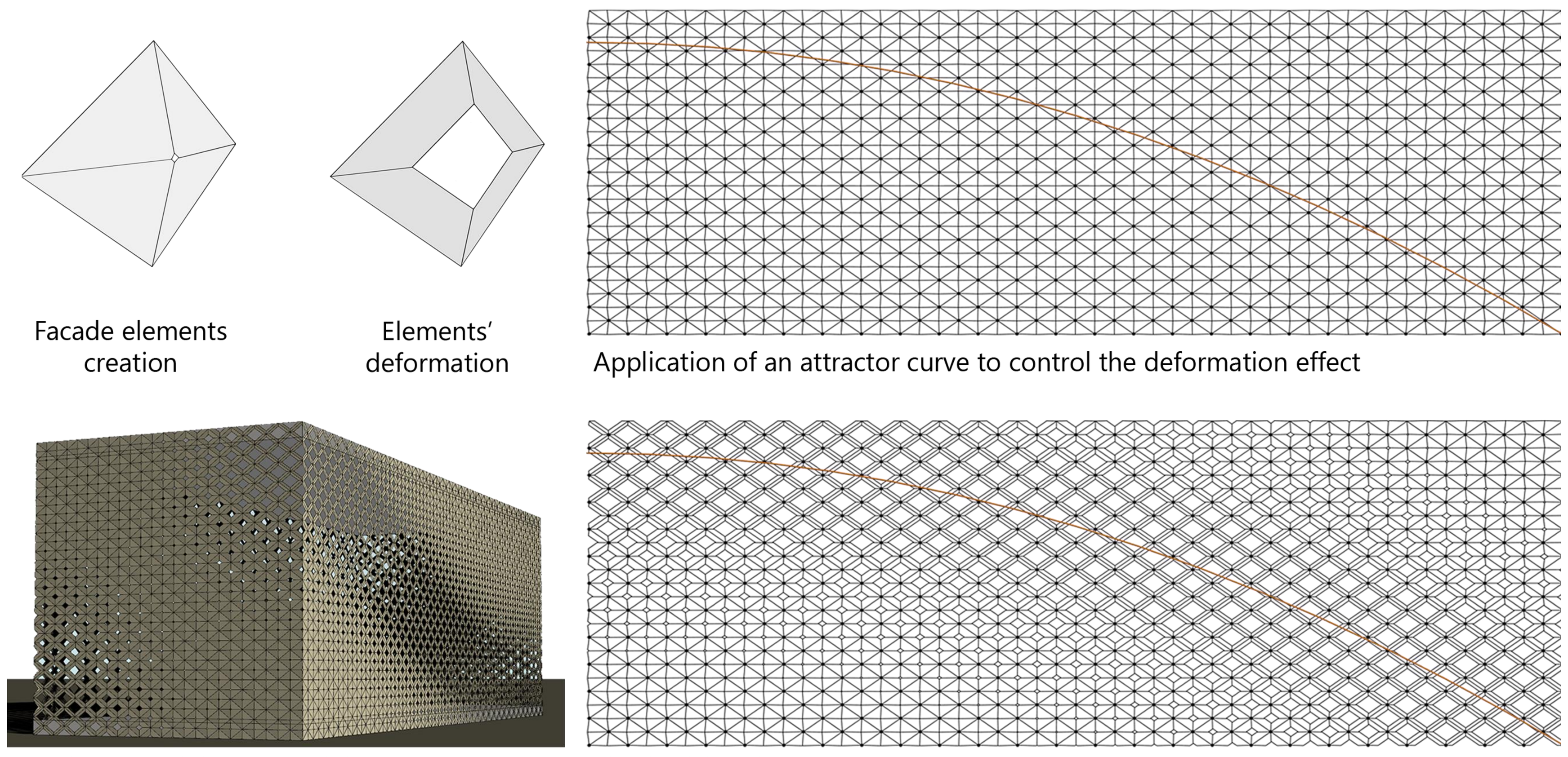

Figure 1. A case study developed using DrAFT framework.

The final design had 2424 different pieces in 6144 total, which required the creation of moulds, a clearly unsustainable scenario in terms of cost and material waste. DrAFT's rationalization algorithms were used to control the number of different pieces of each solution, enabling a trade-off between the production cost and the design concept.

In Figure 2 (top), each type of panel is represented by a different colour, which means, the more colours a solution has, the more expensive its fabrication will be (Fig. 2 down).

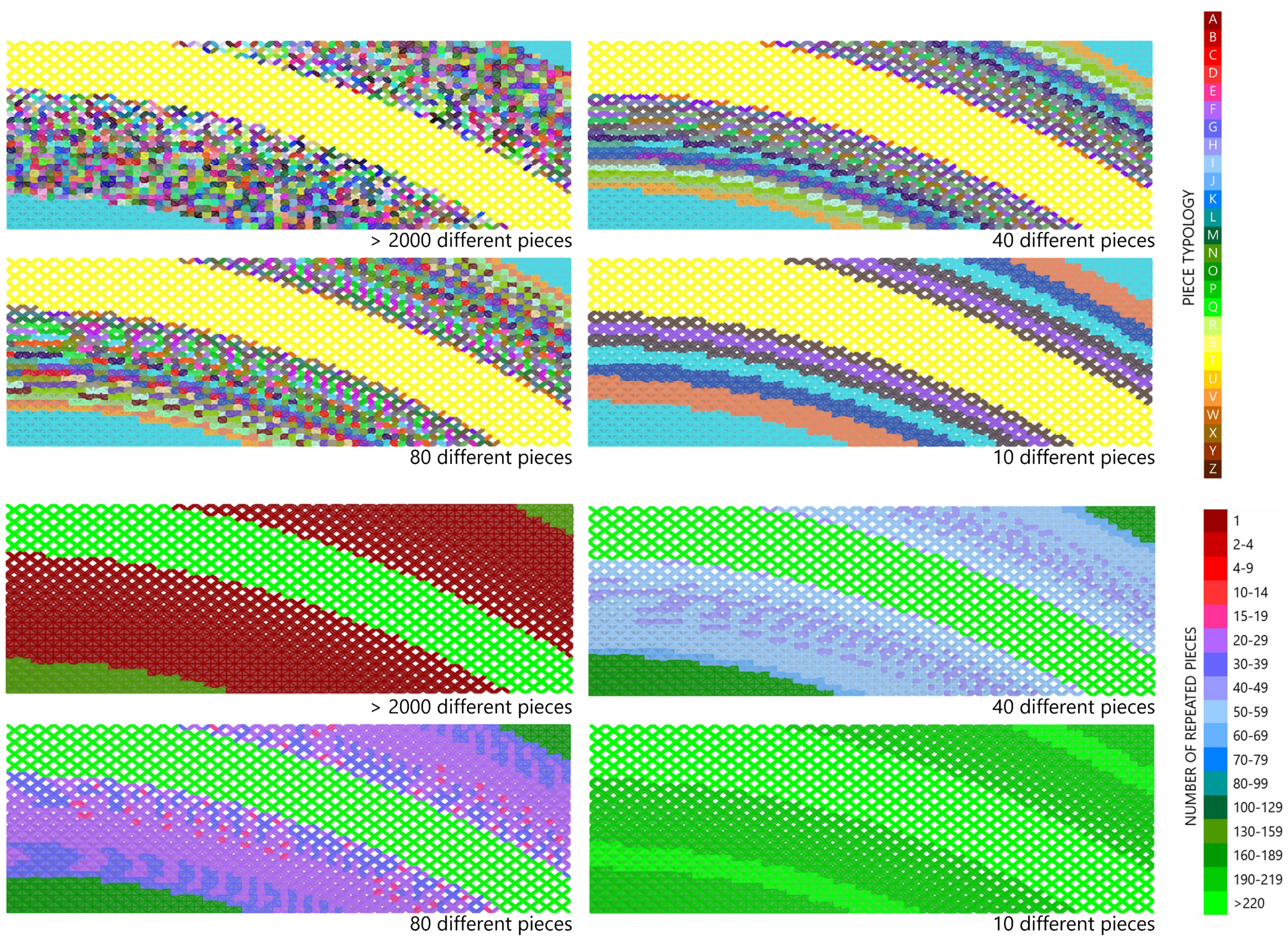

Figure 2. Facade rationalization process: the top-left solutions correspond to the pattern before the rationalization process, whereas the other three examples result from it. Top: the variety of existing typologies; Down: each typology repetition.

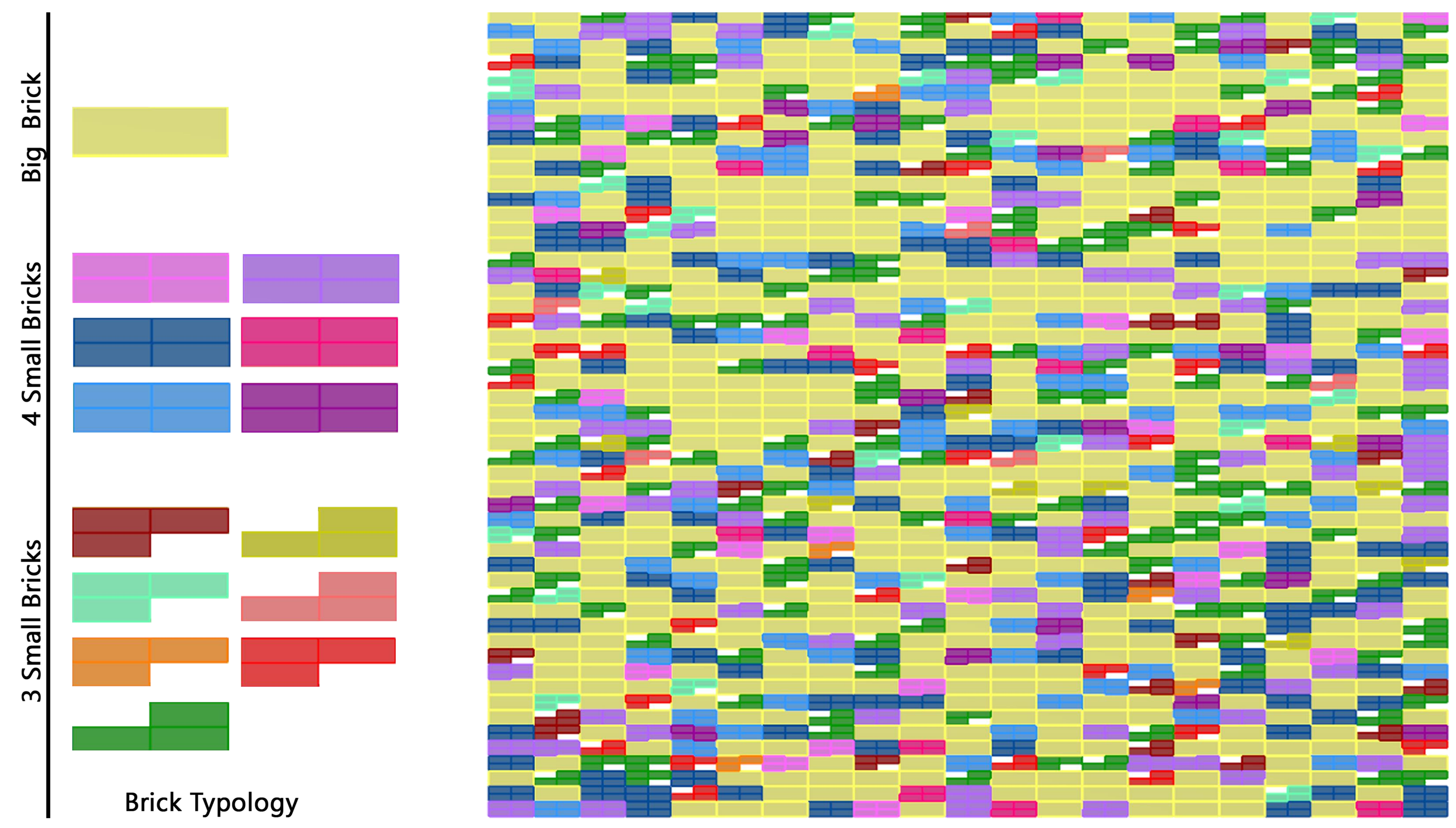

Figure 5. A scheme of the facade pattern with the location of each brick typology.

Case Study 2

The DrAFT framework was used to design a set of facades with bricks of two sizes that could be protruded or not. To create a certain permeability, allowing the entrance of natural light, some voids were created by punctually removing the small bricks (Fig. 3). The existing design constraints, like placing a big brick or 4 small bricks, creating facade voids, and protruding the bricks, were randomly controlled, while respecting the restrictions set by the architects: the percentages of big/small bricks, protruded bricks, and absent bricks.

Moreover, some constructional issues had to be solved, mainly the bricks non-conventional size. As the small bricks had to be fabricated in sets of 3-4 bricks, and the facade design was complex, the number of moulds for all the existing combinations of bricks had to be rationalized, allowing the same mould produce more than one type of configuration (Fig. 4).

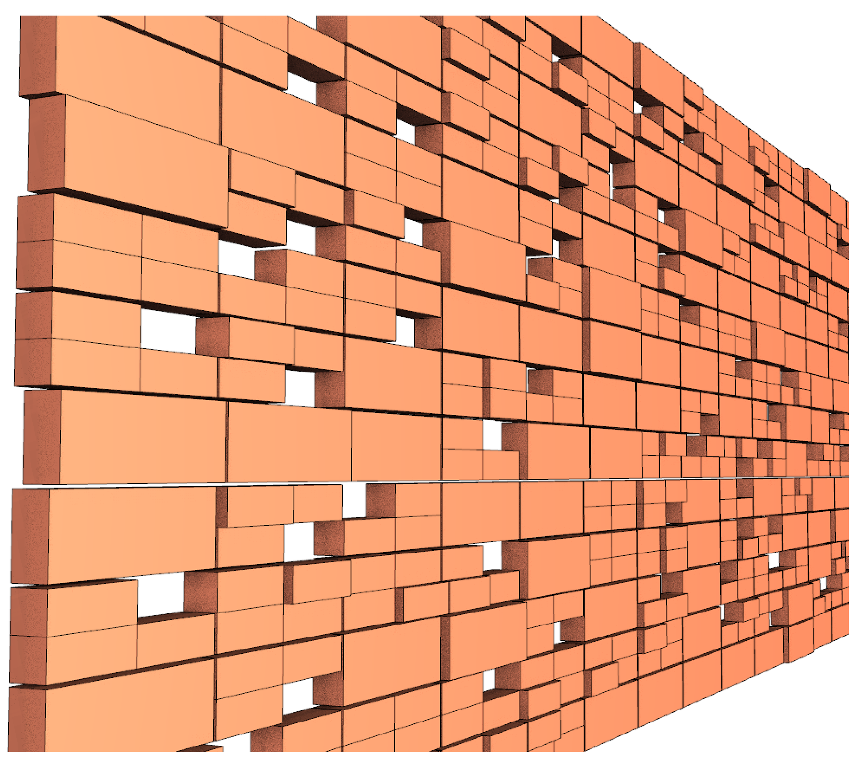

Figure 3. The 3D model of the facade pattern.

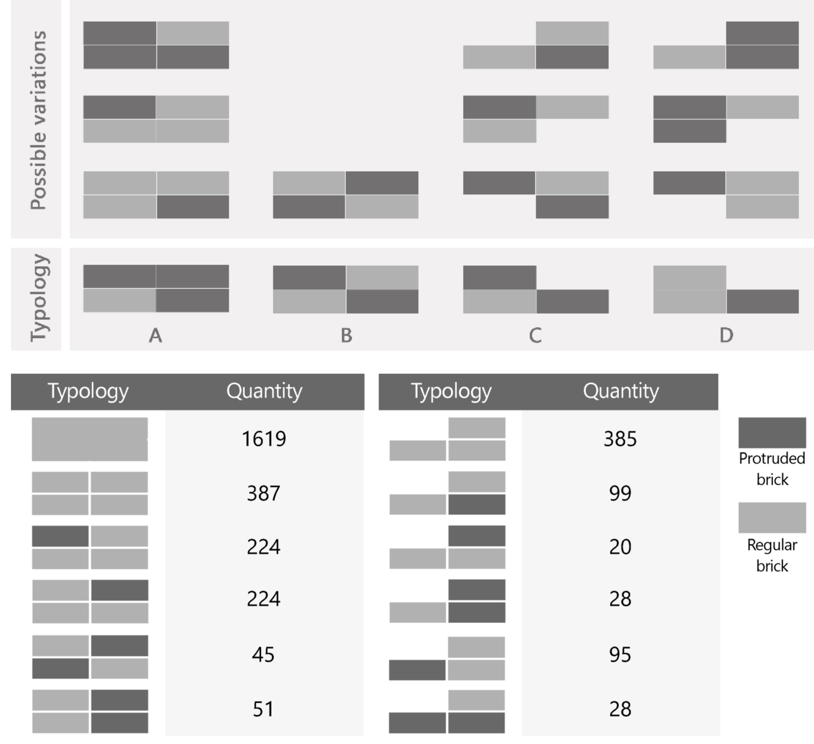

Figure 4. Top: mould typologies with the respective configurations. Down: typologies reusability.

As the model was algorithmic, it was easy to obtain a list with each configuration position and, then, create a scheme of the facade pattern with each brick typology represented by a different colour, so as to facilitate the bricks' accurate placement on site (Fig. 5).

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