Expanding Design Boundaries

Symmetry Experiments in Frank Lloyd Wright’s Textile Block Houses

Carlos Roberto Barrios¹, Christina Lemley²
¹The Catholic University of America, ²The Catholic University of America
http://architecture.cua.edu
¹barrios@cua.edu, ²23lemley@cua.edu

This paper presents a research in progress on the use of simple block units for exploratory design of complex patterns. The research explains how to use symmetry rules to expand the design language of Frank Lloyd Wright’s textile block houses. The paper shows a case study of how a single unit can be used to generate complex patterns and intricate arrangements.

Keywords: Design variations; symmetry; design boundaries; random design.

Introduction

During the period from 1923 to 1928 Frank Lloyd Wright (FLW) embarked on a new phase in his career in which he embraced the structural and aesthetic possibilities of modular block design, specifically in the form of pre-cast concrete blocks. Wright designed and built four houses in this method: The Millard House and the Storer House in 1923, the Freeman House in 1924, and the Ennis House in the same year. These four houses were later called Textile Block Houses due to the quilt-like appearance of the concrete blocks.

Using modular blocks presented an opportunity to explore patterns and symmetries to enhance design, however, Wright remained rather conservative in his arrangement of blocks, thus creating a simple design arrangement where more complex and intricate form could emerge.

Eighty years later, our research shows the possibilities for creating intricate designs and complex patterns using no more time or effort than Wright originally invested. This paper will present a computational framework that allows for the creation of alternatives to patterns used by Wright. Through the use of very simple computational rules, we are now able to take Wright’s designs and expand his limited language and boundaries to a large number of new designs.

Textile block system

The construction of the houses consisted of a system of pre-cast concrete blocks – often referred to as “textile blocks” – woven together with steel rods as support; creating a knitting of tensile strength for the concrete, a method designed specifically for these houses by Wright himself.

The blending of steel and pre-cast concrete gave Wright the opportunity to explore his ideas about plasticity, which he defined as “the expressive flesh-covering of the skeleton” (Wright 1977). Wright’s purpose in building out of concrete blocks was to experiment with a skin texture supported by a structural set of “bones,” creating a fabric with strength in tension as well as compression (Wright, 1977). Even though architects and engineers of the time understood the physical and structural
properties of reinforced concrete, FLW saw a void in understanding its aesthetic possibilities, writing that concrete's beauty had been "inadequately expressed" (Wright, 1928). For Wright, concrete presented an opportunity to mold, shape, and create something beautiful and fluid – but exactly how to achieve this goal was in question.

**Fabrication process of the textile block**

To make the blocks, FLW constructed wooden and metal molds in which he cast concrete and used the resulting blocks to build walls. This process proved to be highly efficient because the molds allowed for the production of blocks in mass quantities. However, working with square concrete blocks might have been less organic and fluid than Wright would have initially anticipated. He ultimately abandoned the idea of using textile blocks after only a few years.

We have not found any direct explanation as to why Wright stopped using the textile blocks in his designs. Some authors and researchers have speculated that the downturn in the economy, as a result of the Great Depression, made it difficult for Wright to continue building with this system (Storrer, 1994). Others suggest that there were limitations to the skilled labor needed which might have caused Wright to try something different. One limitation for Wright might have been the difficulty in creating fluid skins for buildings using rectangle parts (Blake, 1964). Wright stated, "here in a conglomerate named 'concrete' we find a plastic material that as yet had found no medium of expression that will allow it to take plastic form" (1928). After completing the last house, Wright abandoned the idea of the pre-cast concrete block, but continued to use concrete as a building material in a different way.

The four textile block houses remain unique in their structure, construction system and the designs of the patterns. While the minimal block variation might have been most cost-effective – requiring fewer unique molds – it did not allow for dynamic and varied building facades. He seemed to take little advantage of symmetry rules to create variations both in the individual blocks and the wall patterns.

**Analysis**

The first step in our investigation was to look at the blocks and determine which symmetries Wright used in each of the blocks and the houses. We used two different symmetry groups: one for the single block and one for the wall pattern. For the single blocks we used point symmetry, and for the symmetry of the walls we used wallpaper groups.

**The textile block**

In their book, *The Geometry of the Environment*, Lionel March and Phillip Steadman (1974) identified one of Wright's original blocks, the Millard house, as having $D_4$ symmetry. Using the symmetry rules they outlined, we determined Wright used $D_4$ symmetry again in another block, the Storer house, and $C_1$ symmetry in the two other homes, the Ennis house and the Freeman house. Figure 1 shows the symmetry of the blocks used in the aforementioned houses.

*Figure 1*

Original blocks from the Textile block houses and their symmetry: here shown in order: the Millard house ($D_4$) the Storer house ($D_4$), the Ennis house ($C_1$) and the Freeman house ($C_1$)
The textile façade

For the façade designs, Wright repeated each block to create the pattern for each house, thereby creating a wallpaper comprising all of the blocks woven together. We identified the façade of each of the Wright’s houses as primarily having W1 symmetry, although in some instances, there are little variations introduced in the corners. Using the wallpaper rules, we produced the possible arrangements that a square unit can generate. Out of the 17 wallpapers, we selected eight groups for possible designs with a square block - W1, W2/1, W3/1, W2/2, W3/2, W4/2, W4, W2/4. Figure 2 shows the different wallpaper arrangements that are created from a single block. The wallpaper groups take each block and apply multiple transformations within a specific set of rules to generate the resulting patterns.

Expanding designs

To expand the possibilities of design we used parameterization of the original blocks. We created a variety of individual blocks based off slight changes to the FLW blocks. By only making minor changes – making certain parts wider or narrower, slightly changing proportions and lengths of block components – the symmetries were skewed so the individual blocks were not always as internally symmetrical as they were originally. Figure 3 shows a catalog of resulting blocks by parametric variations of the originals. Figure 3 also shows how the symmetry is changed by these variations.
We used the 3-D printer and the laser cutter to create panels of blocks generated from the wallpaper rules. We began with the most basic design, W1, and generated 10” x 6” panels. The 3-D printer files were extruded in CATIA to give them the proper dimensions and depths of the original blocks. Wallpapers were printed in a variety of scales. Using the laser cutter, we created two-dimensional panels which showed where voids were cut out. The limitation with this was that the laser cut panels do not show the depth of the original three-dimensional designs. However, 2-D laser-cut panels proved to be more efficiently produced than the 3-D print-outs.

We produced panels based off the sets of wallpapers for many of the less symmetrical designs we generated, not just the original FLW designs. Wallpapers of the same block started to appear very different in each transformation. The result is expanded design opportunities without actually changing the design of the individual blocks being used. March and Steadman point out that it is “the ambiguity of multiply readings that make pattern and symmetry so fascinating” (1974). Ultimately, the more varied the apparently randomized pattern appears, often the more interesting the design becomes.

**Design variations beyond Wright’s boundaries**

When the individual block is highly symmetrical, as is the case with the Wright’s $D_4$ blocks, the resulting wallpapers become identical. Mirroring, rotating, and repeating the blocks did very little to create dynamic wallpaper designs. When the block itself is not symmetrical the resulting wallpaper designs appear much more complex and dynamic. The lack of symmetry in the individual block meant that mirroring and rotating transformations of the wallpaper schemes became more apparent.

Since the new blocks do not have the $D_4$ symmetry of the Wright blocks, the wallpapers are much more dynamic and random-appearing. We then created the set of wallpapers by using some of the new designed blocks.
Designs and prototypes

We began to work with a block that was highly symmetrical – the Millard Block – and experimented with many wallpaper transformations. The Millard Blocks are placed on each of the wallpapers, for the most part, with the same orientation – FLW mirrors a handful of blocks throughout the design, but not with any extensive patterning. Since the Millard Block is a $D_4$, it presents little opportunities for complex wallpaper patterning. Figure 4 shows a wallpaper design with the single Millard house block. Figure 5 shows a variation of the Millard house block with the same wallpaper pattern. Due to the high symmetry of the block, both designs show little variation in the wallpaper. Figure 6 shows a close-up view of a small variation in the Millard house block as evidence of more dynamic wallpaper arrangement.

We continued our research by looking at one of FLW original blocks, the Ennis house, and used it in different wallpaper patterns. Since the Ennis house block has symmetry of $C_1$, the wallpapers had more variation. Figure 7 shows the Ennis house block with a $CM$ wallpaper pattern. Applying the wallpaper transformations creates a variety of new designs just from the one block Wright designed, in some cases looking more random and dynamic.

We also looked at design opportunities which occurred by randomizing the solids and voids in each wallpaper. Taking the very regular wallpaper block arrangement and randomizing the solids and voids created entirely different wallpaper design. This simple step increased the design possibilities, creating more options within each wallpaper design. Figure 8 shows a randomization of the Millard house block using $W1$ wallpaper symmetry.
Randomized patterns can also be created by following small variations to the original FLW rules for design. By using a limited number of blocks arranged in random patterns without following the wallpaper rules, numerous wallpaper designs are created. Figure 9 shows a wallpaper created by using different blocks with random arrangement. In this case the vocabulary of blocks is limited, but the possible combinations become extremely large.

Additional random combinations were produced with different degrees of block variations and different operations for the wallpaper designs. Figures 10 and 11 show in detail the results of this experiment.

**Conclusions**

In our trials it did not take any more time to produce a panel made from a regular arrangement of blocks and one made from an arrangement with randomized patterns. This is a good indication that mass customization would be possible at the same speed, whether it was a simple wallpaper pattern, the like W1 Wright used, or the more complex arrangements. Mass production cost would be dependent upon material and quantity being used, but for the purposes of this investigation, we suggest that Wright could have created more varied designs for the same cost, by simply using less symmetrical blocks and applying more detailed wallpaper transformations.

By applying simple transformations to the original design, new and complex designs are created which extend the current vocabulary of blocks. We did not find any evidence suggesting Wright attempted to play with and manipulate wallpaper symmetries. Experimenting with variations in the symmetry of the single block as well as with the wall patterns, we found a number of possible designs
were generated with just small changes to the original block. We discovered there are opportunities to build upon the concrete blocks used by FLW and develop them in ways he might not have been able to, or at least, in ways not reflected in his body of work. Aesthetically, this allows for a wider variety of design options; creating hundreds of new designs with just a few simple variations of an original.

Wright believed these textile block houses to be his first “Usonian” homes: homes that were designed to be affordable and accessible for middle class Americans (Wright, 1977). He kept costs low by mass producing one block design per house. His first client for a textile block house was Alice Millard. Millard wanted to keep costs as low as possible, and ended up spending $18,000 on her home (Wright, 1960); that is the equivalent of $217,000 in 2007 dollars, according to the U.S. Government’s Consumer Price Index Inflation Calculator. This is a very modest figure for a home built in California today. With the technology available today it does not matter if individual blocks are similar or different, production costs can be made the same, thereby allowing for an expanded number of designs all based off of one block.

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**References**
