

# Magnet-based Interactive Kinetic Bricks

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*Brick has been used in construction since ancient times and has been respected among other tectonic materials through out the history. Novel technologies recently have opened new horizons in using brick in architectural design. This paper investigates innovative implementation of bricks in kinetic architecture. Kinetic structures usually employ complex and high-cost mechanisms to come into force and their movements might be limited to some conditions. By the use of magnet in digital design, this research examines new methods for performing simple and affordable kinetic structures so as to create interactive relations between architecture and human being. Magnetic energy is applied in two ways to move a roof made of brick which is considered a heavy and masonry material. Consequently, it represents the hidden potentials of magnet as a renewable source of energy.*

**Keywords:** *kinetic architecture, interactive design, parametric design, Bricklaying, magnet energy*

## INTRODUCTION

Nowadays explosive growth of digital technology has affected the core of architectural design. Certainly, digital tools offer new possibilities that were inconceivable only a few years ago (Picon 2010). This research arises from a project in design studio of Tarbiat Modares University (TMU) defined as "Interactive Transforming Canopy with Particular Reference to Computational Design Thinking". The canopy seems to be a pavilion to exhibit cutting-edge technologies which developed by TMU students, understanding that, the canopy itself should show high level of interactivity. As a result, the design team were challenged

to examine their ideas and innovations through designing the canopy. The coherence between theoretical ideas and design to performance process was the main issue of this experience. The design team did their best to combine endogenous ideas as well as indigenous materials with digital technologies in order to find a way to design a kinetic structure with heavy and masonry materials like brick. It was an impressive task to bridge local materials (such as brick) to new shape of interactive atmosphere which was asked in the design terms of the canopy.

## INSPIRING BRICKWORKS

Brick construction counts with a long and rich tradition in architecture, which can be traced back to the origins of our civilization and reminds us of soil and nature. Because of accessibility and unique features, it has been employed widely in traditional architecture with variety of forms in each place. It was used in different parts of a building as structure or decoration in facade. Amazing samples of brick works around the world exemplifies our ancestors' progresses in producing and employing this material. As an example, among Iranian ancient buildings, Zambil Ziggurat, porch Ctesiphon, Isfahan and Yazd Grand Mosque and Rabat (Museum of brick work) can be mentioned.

Despite the long history of bricks and masonry in the built environment, they usually include limited possibilities to be applied in the design. For that reason, digital technologies can assist in developing proper methodologies for masonry (Al-Haddad et al. 2011) to meet contemporary design requirements and integrate new geometric possibilities. As noticed by Campbell (2005, 13), brick's evolution overtime has been grounded in two major areas: brickmaking technologies and brickwork techniques. While the first one sets the physical properties of the material (i.e. weight, dimensions, resistance, appearance), the second one defines the space for design creativity and efficiency of masonry constructions. The developments in brickwork techniques tend to be driven by structural and aesthetic goals, supporting the materialization of magnificent brick walls, arches or vaults, and also ornamental surface effects (Sousa et al. 2015, 362). By implementation of parametric design methods various forms can be created. This is what many contemporary designers are looking for. In recent years, some innovative brickworks have been created by designers which opens new horizons toward adoption of brick in contemporary architecture. It is important to highlight two magnificent monuments inspiring the design generators i.e. Cloaked in Bricks and Spris Café.

## *Cloaked in Bricks*

Cloaked in Bricks is a residential project designed by Admun Design & Construction Studio and located in Ekbatan, Tehran, Iran. It consisted of a façade design and lasted from 2013 to 2015. This project is an attempt to propose a prototype addressing the current issues of residential architecture in its region through bridging between old and new, proving how local materials and patterns can be used in new ways creating an architecture responding to both functional requirements and aesthetics.

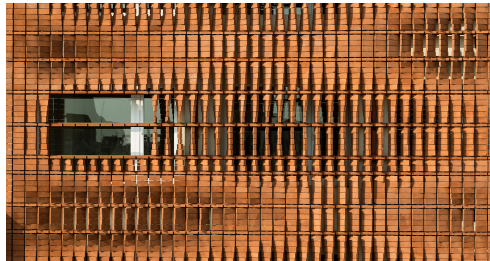


Figure 1  
The facade design  
of Cloaked in Bricks  
project.

Brick appeared to be a proper choice for the façade covering since it has always been used as a local building material in Iran meeting environmental needs while creating numerous aesthetically beautiful textures. The complex form of the façade, limited construction period and economical conditions of the project forced the project team to search for a new construction method for implementing the façade. The appropriate method seemed to be eliminating mortar by punching the bricks (Figure 1). Finally, parametric design software facilitated the texture design process. Despite the complex form of the facade the construction process was easily executable by workers through simple instructions prepared by employing a system of coding [1]. As a contemporary praised building, it focused on dancing brick to show flexibility of masonry materials.

### **Spris Cafe**

Spris Cafe with 28sqm space, designed by Hooba Design Group is located in Nejatollahi street in center of Tehran surrounded by Iranian handicrafts shops, neighboring the building of Iranian handicrafts Organization. The aim of the project was to renovate a gift shop and change it to a cafe, considering the small size of the project and its location the main idea inspired by the urban context to transform the traditional elements into an architectural interior space.

Figure 2  
The combination of bricks in Spris Café .

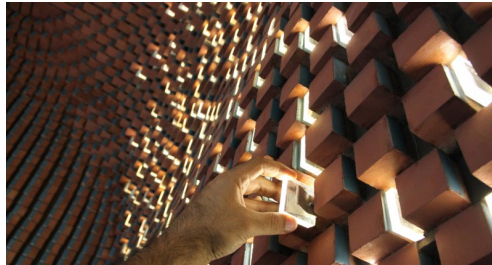
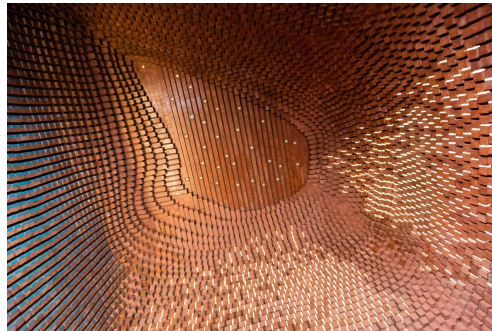


Figure 3  
The interior of Spris Café, facing the roof.



In designing the spatial diagram, the materiality concept is based on an integrated geometry continues from outside to inside. The neighboring building, Iranian handicrafts Organization with brick facade, was the inspiration to use the same material for the cafe. Concerning the small size of the project, a brick with 5\*10\*20 dimensions sliced into eight smaller pieces of 5\*5\*5 centimeters which one side of the bricks glazed in turquoise blue color. The terracotta bricks are also hygienic as they covered with antibacterial layer (Figure 2).

One of the main issues of design was creating a visual variation of the form in a small space. In this concept, the situation of visitors in relation to the project is significant in order to understand the form as they can differently perceive the composition of colors on the bricks regarding to their position (Figure 3). The turquoise blue glazed side of the bricks are facing south shaped with the monolithic geometry of brick laying that was modeled by the 3D diagram started from the pavement of the pedestrian and continues inside of the café [2]. In this case, zoomorphic and transitive character of brick, makes spiritual space which remind traditional architecture of Iran.

Case studies show that recent architectural projects focus on innovative understanding of brick while lack of movement made them conventional rather than cutting-edge architecture.

### **DESIGN TO PERFORMANCE**

It is believed that through implementation of parametric design, we can create movement and rhythm in brickworks making it much more dynamic. Therefore it was assumed that interactive approach toward adoption of brick in architectural design process might be pioneer answer to the design question. The design team had two challenges concerning the design process:

1. How to create movement in a number of objects simultaneously?
2. How to create movement in heavy and masonry materials like bricks?

In order to find an energy efficient source of movement the design team decided to adopt Magnet as a source of energy. Electromagnetic energy is an extensive renewable resource that has been underestimated in many fields such as architecture. We believe that using magnet as a source of energy will open new approaches and causes huge effects in future buildings. Additionally, there is a new approach toward applying magnetic fields in architecture namely "Magnetic Architecture". The cur-



Figure 4  
The prototype  
representing the  
roof structure in  
scale 1:10.

rent focus of magnetic architecture explores the design opportunities of a new building process from phase one: simply using recycled iron-based material controlled with-in a magnetic field (Diaz and Dubor, 2013). Magnetic architecture might be seen as a potential to increase the flexibility of additive process to reach the architectural scale.

## MECHANISM OF USING MAGNETS THROUGH KINETIC BRICKS

The idea of moving bricks is based on the interaction between two energies: the electromagnetic energy of the magnet and the weight of the brick. In other word, magnet pulls the pieces of bricks upward, while the weight of bricks pulls them to the ground. Using this interaction between these energies made the design objective to be focused on the Roof of the pavilion. Therefore, a specific detail was needed to hang the pieces of brick from roof, so that

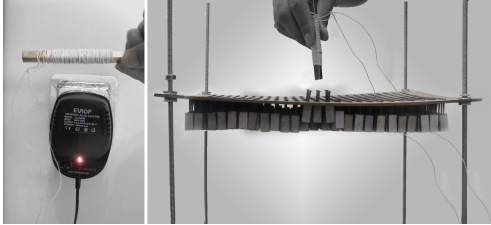
the magnet would absorb them. After all, punching the brick in minor section and reinforcing them with some iron-made bars seemed to be an appropriate solution.

The design was modeled in Rhinoceros ((C)McNeel) with the parametric design plugin Grasshopper ((C)David Rutten/McNeel). The surface was converted into a series of EPS bricks with 250x100x50mm, which is one of the standard dimensions of commercial bricks. In total, the model comprises 700 bricks placed vertically and ordered in one level. Firstly, each brick was punched from its minor section and then a bar inserted and fixed within it to suspend the brick from the roof. Additionally, a grid of holes was made within the roof as a base for bars. The holes were created in the square shape and also bars were rectangular in order to fit in the holes and avoid undesirable rotation while moving (Figure 4). The suspended structure of bricks enables them





2-axis X-Y) is needed to receive the commands from Grasshopper and move on the roof surface based on those commands. The commands are transferred to the robot by Arduino kits. As a result, the robot moves the magnet attached to it and enables the bricks to move in a special order (Figure 7).



Linking the robot with Grasshopper gives us the opportunity to draw various patterns and move the whole structure based on that to create those patterns on the bottom view of the roof. Also, we can equip the pavilion with some sensors to catch the presence of human in the space and transfer them to the robot to move based on human movement inside the pavilion. Consequently, the parametric design of pavilion leads to an space with which people could engage in interactive relations.

**2. Temporary Fixed Magnet (Electromagnetic Field).** The second idea is based on using an electromagnetic grid with fixed components which includes some temporary magnets located on a regular basis. Temporary magnet refers to a piece of steel with some cables turned around it. By exerting an electric current involving the pieces of steel, they would transform to magnets and produce electromagnetic field (Figure 8). As the position of magnets is fixed in this method, by altering the amount of electric current, the amount of voltage is changed and subsequently the power of electromagnetic field would be variable. If we place the magnets in a grid order, they cover the whole parts of the roof and variability of electromagnetic field causes the bricks to move vertically and create waves.

## CONCLUSION

The results of the project show that magnetic energy might play a crucial role in future of kinetic interactive architecture. This research opens a new horizon in computer-aided design while needs extensive researches and practices to be recognized as a design and construction method. Implementation of Magnet has the following benefits:

1. Magnetic energy is a renewable source of energy and is generated without damaging the environment.
2. It reduces the costs of a project during the design to construction process. As an example, to construct kinetic structures by using modern technologies high-cost systems is needed, but using magnets seems to be an affordable method for creating movement in space, because the energy generated for moving one object practically causes several objects to move.

Endless potential of brick makes it a flexible material for contemporary architecture. The results of the research emphasized on potential ability on combination between traditional material and kinetic character of contemporary interactive monuments.

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Figure 8  
Temporary magnet made of steel with cable around it carrying electrical current.