Reasons for Implementing Movement in Kinetic Architecture

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Abstract. The paper gives insights into different forms of movement in contemporary architecture and examines them based on the reasons for their implementation. The main objective of the paper is to determine: the degree to which the complexity of kinematic architecture results from functional and spatial needs and what other motivations there are. The method adopted to investigate these questions involves theoretical studies and comparative analyses of architectural objects with different forms of movement imbedded in their structure. Using both methods allowed delving into reasons that lie behind the implementation of movement in contemporary kinetic architecture. As research shows, there is a constantly growing range of applications with kinematic solutions inserted in buildings’ structures. The reasons for their implementation are manifold and encompass pursuits of functional qualities, environmental performance, spatial effects, social interactions and new aesthetics. In those early projects based on simple mechanisms, the main motives were focused on functional values and in later experiments – on improving buildings’ environmental performance. Additionally, in recent proposals, a significant quest could be detected toward kinematic solutions that are focused on factors related to alternative aesthetics and innovative spatial effects. Research reveals that the more complicated form of movement, the more often the reason for its implementation goes beyond the traditionally understood “function”. However, research also shows that the effects resulting from investigations on spatial qualities of architecture and new aesthetics often appear to provide creative insights into new functionalities in architecture.

1. Introduction
Nowadays, many new genres of kinematic architecture are appearing. Buildings are not only constructed as objects with moving parts of façades, mobile walls, or rotating components, but often are also equipped with different kinds of subtle responsive systems. A multitude of different forms of kinematic solutions in architecture provokes questions about prevailing reasons for their implementation. The answers are different, and many architects indicate that buildings with movable elements serve better utilitarian purposes. Some critics indicate the noticeable pursuit of spatial effects in architecture – others’ comments pertain to the accelerating pace of changes that the contemporary society is facing. Asefi Maziar argues, “The modern aim of transformability is to respond to the user’s requirements in an ever-changing world”, [1].

However, one may easily notice that the “ever-changing world” is not a novel construct, and it was equally intriguing to architects and philosophers at the threshold of the 20th century. Already in 1907 Bergson wrote: “What is real is the continual change of form: form is only a snapshot view of a transition”. [2] Those new emerging ideas, as Sanford Kwinter argues, have given creative impulses toward engaging in science and architecture new concepts, such as instability, adaptability, interactivity.
and most importantly – change. [3] Closed static systems as a context for architectural thinking were replaced by ones that are unpredictable, developing, organic and open.

In the mid-twentieth century, movement in architecture became one of the central issues investigated by both artists and architects who were performing many experiments on space. However in the built-world reality with but a few exceptions, buildings had remained stable. In the 1970s, Zuk and Clark wrote: “Whereas today buildings are typically designed to remain unchanged as static monuments, a building should be designed to be many different buildings through time. This will suggest a major change in the analytic stage of the design process.”, [4]. In the last decades, one can observe the increasing number of architectural objects with integrated kinematic solutions. Although, what the reasons are for their implementation remains a question. Many of them seem to be following modernistic investigations of efficiency, economy and utility. But a significant group of experiments appear to be unrelated to users’ needs and focused around another set of issues. Investigation of the incentives brings forth inspiring insights into contemporary architecture.

2. From pragmatics to aesthetics – in pursuit of new functionalities in architecture

There are numerous objects in which kinematic solutions are implemented for the sake of responding to pragmatic reasons. In most of such cases, the forms of movement are rather simple. Despite this fact, due to the mobility of one or two elements in the building, the interior space could be considerably restructured. One of the representative examples is the Sliding House project by the London-based architectural studio dRMM. The movement is pre-designed and uncomplicated, yet the achieved effects are very interesting. In its simple form, the building completed in Suffolk, UK refers to the vernacular traditions of the region. However, the whole form of the building could be covered by a sliding 20-ton solid structure that can change its position. This sliding action enables alterations in the building’s functions, where some of its parts can receive a roof or become open to the surrounding. Moreover, the project can be developed in any way, because the adopted system was assumed from the beginning for the possibility of future extensions. Space reconfiguration enables free adaptation of the object to the users’ requirements and a variety of weather conditions [5].

The possibility to adjust the interior space of an object to different types of activities became an important prerequisite for the building of the Shakespeare Theatre in Gdańsk, designed by Renato Rizzi. The object was built in accordance with the pattern and traditional form of a Shakespearean theatre, which assumed flexibility of stage arrangements. For greater adaptability, the building was equipped with a mechanically retractable and rotating roof that changes the spatial configuration of the object and its relation to the environment. When the roof is open the building offers a central, uncovered "yard" surrounded by arcades with the audience. The interior space and the stage itself gain daylight. Raised to a vertical position, the roof becomes a projection screen or backdrop for performances taking place on the roof. This change not only affects the object itself, but also has an impact on the panorama of the historic city centre. In this case, kinematic solutions let the architect creatively reconcile tradition with new demands for space reconfiguration [5].

Similarly, adaptation to the user’s requirements was the reason for implementing movement in the project Living Room. Designed in 2005 by Seifert and Stoeckmann, the building envisions one of the possibilities of creating a more flexible layout of interior spaces. In this example, the living room could be extended due to the use of one large-scale retractable element that slides like a drawer, protruding from the form of the house. As a result of this movement, the volume of the living room extends, gaining also the space of the balcony. In the concept of Sharifi-ha House project (2013), designed by the Iranian Nextoffice Alireza Taghaboni, the interior space could be changed due to the rotation of whole modules that constitute the subsequent floors of the house. Rotating volumes allow for a complete change of the spatial arrangement in the interior and the manner of its exposure to the environment [6].
In Safe House, designed by Robert Konieczny and built in Warsaw, kinematic elements allow for opening and closing the interior space of the building. Several forms of movement have been imbedded into its structure. One of the prerequisites was to ensure maximum safety and intimacy for its users while maintaining spatial flexibility and openness to the environment. This was accomplished through kinematic solutions in the form of a retractable steel gate, huge shutters and folding balconies. When the house is open, its spaces relate freely to the surrounding landscape. When all the elements fold down, the house becomes a concrete massive block, or a purely geometrical cuboid.

In all the above-mentioned cases, the movement imbedded into the forms of buildings is clearly visible. Kinematic solutions are exposed and contribute to the characteristics of architectural objects. Sliding drawers protruding from the surface of the façade, rotating volumes, retractable roofs and walls become unquestionable elements of architectural form. In the late 1980s, when Robert McCarter and Neil Denari with a group of other architects became involved in the pursuit of time-related architecture their interest turned into building-machines. At that time, as McCarter argued, if there were any kinematic elements implemented in the forms of buildings they were hidden beyond static façades, “false” surfaces: “(...) machines in our time are enveloped in arbitrary shaped enclosures: “skins” that rather than revealing the forms of the mechanisms underneath, are determined by criteria related to fashion and market studies” [7].

In contemporary architecture experiments go much further so that not only the skin of the building reflects the changes, but also the whole object may change its spatial coordinates. This kind of space reconfiguration was achieved in the Prada Transformer 2008 designed by Rem Koolhaas. Prada Transformer was designed as a temporary structure that could be picked up by cranes and rotated to serve different kind of events. As an effect of the rotation, the floor plan and the height of the interior space may be completely altered. Flips of the pavilion enable a total transformation of the building’s function. It can become a cinema, theatre, or even a place for fashion shows or exhibition space. To adjust the pavilion to emerging needs, each flip will allow architects to redesign the scheme of the floor plan.
Despite the fact that the building was designed to move, it does not have its own system to execute the change. Independent cranes that are responsible for steering the rotation of the pavilion achieve the building’s turns.

Santiago Calatrava also used this kind of flexibility in architecture in the historical city of St. Gallen in Switzerland. The architect designed a kinematic form of entry into the multi-purpose hall of Pfalzkeller, located underneath the level of the square. The building hosts an auditorium, a music club and meeting place for locals. The entrance to the building was designed as a completely retractable form that can pop up literally in front of our eyes. When the entrance is closed, the panels form the roof above the building’s main corridor, which becomes part of a square. Therefore only during the opening of the entrance, can one see a beautiful geometric shape made of brushed steel. The movement used in the facility, apart from providing extraordinary functionality, also perfectly completes the traditional style of buildings in St. Gallen, serving as a manifestation of contemporary aesthetics harmoniously inserted into a historical location.

![Figure 2. Santiago Calatrava- Pfalzkeller entrance](image)

Similarly, new aesthetics of architectural machineries are introduced in the Split Waterfront Promenade. In the immediate proximity of the ancient walls of Diocletian's Palace, the Croatian studio 3LHD developed a kinematic canopy. As a result of rotation, the canopy opens or closes over the promenade. Revolving roofs made of a light membrane placed on steel frames protect against adverse weather conditions such as intense sun or rain. [8] In this case, as well, the reason for implementing was basically functional. But this functionality is not fully predictable and user-centred. Since the construction reacts to environmental conditions, the movement becomes undetermined. These kinds of constructions inserted in public spaces contribute to an ongoing shift in the conceptualisation of urban conditions. This shift, initiated by Bergsonian ideas, has developed into concepts of organic open systems, flows and events, which today could be perceived as the pursuit of moving “from structures to landscapes”.[9]

Environmental concerns were also one of the main reasons for implementing movement in the Torre Akbar building (2005) in Barcelona, designed by Jean Nouvel. Movable systems are integrated into the façade of this office building to control the access of light. The façade consists of mechanically operated glass panels that can rotate, thus protecting the building from excessive sunlight. The large unpredictability and complexity of movement makes the façade appear to be glowing with different colours, which creates a very characteristic component of Barcelona’s urban landscape.
As research shows, apart from kinematic solutions that are designed to respond to different user needs or impacts of the environment, architects are increasingly integrating additional movable elements. One of the concepts for the Expo 2015 Polish Pavilion, designed by Jacek Szczesny, Jan Cudzik, Milosz Szczesny, Paweł Kleczek and Anna Zawistowska, illustrates well this tendency. Architects made an attempt to create an object that integrates several different forms of movement. The main reason for implementing several kinematic systems was to achieve a desired aesthetic effect. In the concept proposal, the walls of the pavilion were formed by cascading water that provided privacy and muted the space underneath the roof. Sensors controlled artificial waterfalls, so when a user approached the object, the water cascade stopped automatically. The object was comprised of automatically sliding out poles responsible for the emission of fog and a holographic projection of meadows, fields and forests. The whole project was based on continuous deformation; therefore it never looked the same. The functioning of the pavilion was based on a responsive system controlled by the mapped movement of people in the building’s surroundings.

Figure 3. Movable poles in polish Pavilion for Expo 2015

In a whole new group of buildings movement seems to be implemented in effect of purely aesthetic investigations. Movement implemented because of aesthetic reasons - in a pursuit of unknown functionalities. One of them is Expo 2010 Pavilion in Shanghai commissioned by United Kingdom. The aim of architects from Heatherwick Studio was to create an impression that the contours of the building blur. The object comprised 60,000 translucent, flexible fiberglass tubes that were provided at their ends with seeds enclosed in a sealed capsule, which enhanced the organic metaphor of the building. Elastic elements were moved by the wind. While bending they let the light pass to the interior space, at night small numerous moving lighting elements defined unstable form of the building [5].

In search of new aesthetics in architecture Barkow Leibinger designed Kinetic Wall, which can change the imagination of how a building façade appears. Kinetic Wall is made of fabric that can be stretched by cylinders located in the inner part of the. The effect is such that the visitor does not see the mechanism, but only the reacting surface of the building that approaches the passer-by like an unknown kind of living organism. Hiding the actuators behind the façade and using lightweight materials, the architects proposed a new kind of aesthetics based on the combination of dynamism and lightness. Since the fabric covering the structure is made of recycled translucent synthetic fibres, the object transmits light and can as well be creatively illuminated at night. Kinetic Wall could be considered as a prototype
that can be adopted to create vaults, niches, as well as walls and façades. With a variety of patterns and textures that may be embedded, it could be the surface of future architecture.

![Elastic elements in United Kingdom 2010 Expo Pavilion](image)

**Figure 4.** Elastic elements in United Kingdom 2010 Expo Pavilion

Lighting control and a change in the perception of a building is also a feature of the One Oceans project by Soma, executed in 2012. Movement of the entire façade that imitates breathing was the main idea in the project. Panels made of flexible plastic were meant to bend in one direction so that the thickness of the slots was changing according to the rhythm inspired by the movement of fish gills. Inspiration based on biological forms was also a response to the main theme of Expo 2012 in Yeosu. The object is organic in appearance; it refers to fluidity and dynamism. The movement of building parts is further intensified during night by the use of LED lighting, which emphasizes the formal dynamism. The larger the opening in the panel is, the more intensive the light is being emitted by the object.

3. **Results and discussions**
As research studies reveal, most of the kinematic systems applied in architecture are focused on functional purposes, where the needs of the user are considered as the central issue. In such cases, implemented forms of movement are usually simple. In another group of objects, the introduction of dynamic mechanisms is fostered by specific contextual requirements, like in the case of Pfalzkeller by Calatrava. There is also noticeable growth in the number of buildings where kinematic systems are used as a response to environmental concerns.

Additionally, there is an emerging group of kinematic solutions that seem to be implemented only because of aesthetic reasons. They could be considered as pure experiments, or pursuits of generative and responsive qualities in architecture. In such cases, kinematic systems are usually complex and unique. Great examples are conceptual facades such as Kinetic Wall created by Barkow Leibinger, or Fluid UK Pavilion by Heatherwick. Many go beyond the practicalities of everyday life and could rather be perceived as creative investigations into new qualities of urban landscape and new aesthetics in
architecture. As Tatarkiewicz writes: “For thousands of years to create and deliver beauty was one of the tasks of architecture. [10] So it could be supposed that today architects are undertaking kinematic design experiments to achieve previously unknown spatial effects and to create new forms of beauty.

On the other hand, research studies reveal a noticeable evolution in thinking about kinematic architecture. It ranges from objects responding to users’ requirements to buildings with active systems reacting to the impulses from the environment. A recent group of experiments that focused on alternative aesthetics could in fact be offering creative insights into newly emerging functionalities in architecture. What the kinematic architecture of the future will look like and what its future functionalities will be still remains an open question. It has already been proved that interactive objects may stimulate human involvement, support participation and generate social encounters in public spaces. [11] Maybe they will play an important role in developing creative cities, re-constructing nature through culture, and providing inspiration and education.

4. Conclusions
Generally, it may be noticed that reasons for implementing movement have changed in the last decade from user-centred, simple functionalism to environment-centred responses to different kinds of stimuli. The characteristics of movement have been changed as well: from simply controlled reconfigurations to less predictable reactions.

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