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Tectonics of kinetic architecture: Moving envelope, changing space and the shades of the shed

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Buildings in our day are no more frozen pieces of music as ascribed by Johann Wolfgang von Goethe. They can move, rotate, flip and perform various physical gestures. This paper aims to explore the spatial, aesthetical, and technical characteristics of kinetic buildings within the framework of the theory of tectonics, which is still far away from covering the art form of movement. The study has been organized into two phases. The first phase sets up the theoretical framework of the topic by exploring the main dichotomy of the tectonic discourse on "ontological and representational parts of the building" and introduces the main concepts of kinetic architecture related to the characterization of architectural space. The second phase is a case study on The Shed as also known as Culture Shed in Hudson Yards in New York City. This part focuses on the interrelations between tectonics and the physical movement of architectural elements. The results indicate that the type of movement and the role of moving elements change not only the architectural space but also the tectonic character of the building. While some movements and moving parts are directly related to the representational aspects, some change the ontological character of the building. The impact of the movement on the tectonic character is a topic that hasn't been well investigated yet and has the potential to be developed through further research. As a result, the theoretical findings of this study can contribute to tectonic thinking during the design process of kinetic architectural products.

KEYWORDS

tectonics, kinetic architecture, adaptive structures, theory of architecture, taxonomy, the shed

1 Introduction

This paper is particularly interested in elaborating the theory of tectonics in parallel to the evolution of the structural needs for adaptability. Performance of this type of building that is already called kinetic cannot be easily explained in connection to the purposefulness but also as manifestations of technological advancement, novelty, and vanity. In contrast to the ever-changing timeless monuments of history, these buildings

are designed to change and move to commemorate the ephemeral. The interrelations between time, endurance, stability, and the art of fabricating in the theory of tectonics, which can be traced back to Semper (1989) and Bötticher (1992) in the 19th century, have no longer essentiality in kinetic buildings, which are designed to change shape, even to add or remove spaces. Although moveable buildings are not something entirely peculiar to the 21st century, it is important to understand how and why the theory of tectonics in history precluded the idea of ephemeral and adaptive.

Material qualities of architecture have always been evaluated as an outcome of knowledge, experience, and mastership and are located at the widest span of the pendulum, in between physics and phenomenology in the theory of architecture. Inevitably, the overall system that keeps pieces together provides a visual communication with the spectator; it is the logic of resistance to the forces and simultaneously a mediator of signs and symbols (Nilsson, 2013). Therefore, the assembly of architectural components and the multi-layered skin of the envelope is described as the tectonics of architecture and is expected to cover all the tasks mentioned above.

Although Vitruvian tradition is the source of the discussion of tectonics, the term did not come out until the mid-19th century, in the age of rationalism. Karl Bötticher (1806–1889) and Gottfried Semper (1803–1879) established the base of the tectonics theory by differentiating the dual character of the Kunstform (art-form) and Kernform (core-form) (Semper, 1989; Bötticher, 1992). Both approached tectonics from an ontological point of view, thus mostly dealt with revealing the essence of the phenomenon. Although Semper and Bötticher assumed that the Kunstform and Kernform were essential to tectonics, by definition, the Kernform was given a primary task. The superiority of structural essence over the representational one can also be found in other scholars, as well. For instance, Bötticher underlined that although art form is not a subsidiary category, art needs to return to its functional and logical roots (Schwarzer, 1993). A similar approach can be seen in Hartoonian, who believes that the artform is needed to elevate the structure, but artform without a structural purpose is excluded from the notion of tectonics (Hartoonian 1994).

The ontological perspective is critical in understanding the interdependency between structure, clothing, function, and materiality. Doubtlessly, classical antiquity was the first era that questioned the absence of structural utility. Although controversial opinions were formulated in the subsequent periods, it is notable that tectonics was always recognized as inseparable from spatial qualities, whereas the autonomy of space always remained. The interdependency between the built form, the rules of energy transmission, the space, the tools, materials, and knowledge became critical in the theory of tectonics.

In Frampton's opinion, most recent architectural tendencies interpret the surface as wholly independent not only of its core form but also of other forms of expression (art-forms other than the surface), the process of construction, and the space that is bounded by this envelope (McCoy, 2009). Although Frampton's praise of tectonic culture suppresses the role of the surface, this element traditionally plays a part in tectonic expression within the traditional dialogue of core-form and artform. To move past the dominance of the surface in the postmodern sensibility, architects must once again realize it as part of a multitude of means to convey tectonic expression. The surface is thus a singular component working within a network of expressions, whose total to an architectural experience (McCoy, 2009). Table 1, originally prepared by McCoy (2009), summarizes different scholars' dual concepts in architectural theory.

According to this table, the difference between the load-transferring members and those only exist for representational aims are always differentiated and classified under different labels by different scholars. This difference creates the breakpoint in tectonic readings since such a division genuinely creates a binary hierarchical order which cannot be fully justified for kinetic buildings. Because this division is derived from a priori assumptions about the material, structure, space, and their performance of durability.

The concept of space is the undeniable essence of the architectonic character, as formulated by Frampton (1995); even when positioned as a craft, it still resembles the practical application of established knowledge. The tectonic and tactile character only transforms the intangible to tangible, the ideal to practical, or the ontological to representational. In this instance, the category of representational can only be understood according to its capacity to reveal the essential spatiality. Frampton (1995) prefers to differentiate the representational category from what he calls the 'scenographic' category. Scenography is seen as 'the design and painting of theatrical scenery' (Farrah, 2017). Actually, this stands as a counter-category in his approach and mostly represents a visual experience that simulates a constructional or technological logic. Additionally, Frampton also claims that scenographic aspects of a building are the ones that can hardly be associated with spatial manifestations. It is also interesting that scenography inevitably needs the existence of a spectator and forms within an acton of gaze.

The category of ontological, previously understood as core form/structure/ necessity, is directly linked with space, which was not seen as important as the tangible and visible essence of construction in the current literature. Even in the limited number of attempts to incorporate the changing definitions of space into tectonics, space was still understood as an essence physically defined by stable surfaces or linear members. Andrea Deplazes (2003) expands the historically defined dual categories to include space, yet he prefers to limit the understanding of space as an unchanging boundary.

The theory of tectonics kept evolving throughout history and had some significant breakpoints, such as the separation of the load-bearing and enclosure elements or the digitalization of the

TABLE 1 Dual nature of tectonic relationships and its terminology through time (Reproduced from McCoy, 2009).

Scholar	Dual components of tectonic expression	
Schopenhauer	Support (*Stutze*)	Load (*Last*)
Müller	"application" and "necessity"	"art" and "representation of deepest feelings"
Bötticher	Coreform (*Kernform*)	Artform (*Kunstform*)
Semper	Structural-technical	Structural symbolic (*Bekleidung*)
Loos	Underlying material	Cladding
Ford	Structure	The representation of structure
Sekler	Structure as intangible concept	Visual expression of structure
Frampton	Ontological	Representational
Hartoonian	Core-form as related to technology and science	Art-form as related to perception and tactile sensibilities

architectural meta/ product (Hürol, 2014, 2015). The changing conditions due to the technological advancements and materiality of the era left their marks in every epoch, not only on the architectural products but also on how we interpret the logos of construction beyond physicality. Despite these newly added layers of meaning and knowledge, two things remained the same: the issue of visibility of the rules of assemblage on the built form and its endurance (Ghelichkhani, 2020).

19th and 20th-century versions of the theory of tectonics all emphasized time and endurance, which are related to ontology and Vitruvian knowledge of architecture (Sekler, 1965). In ontology, the temporality of the entities is essential to their ontological presence, which is also closely linked with phenomenological presence. Endurance, one of the Vitruvian principles, is ascribed as the firmness of the assembled elements to resist the dead loads, the kinetic forces, and the erosion of the time. So, while, on the one hand, time is assumed as another physical force to resist, it also becomes one of the components of the system.

In its original meaning, endurance was preoccupied with the building component that preserves its original position and form under the carried loads. In this context, the structure was predominantly recognized as a balance between force and counter-resistance. However, when referring to endurance as an ontological aspect rather than the physical, this situation leads us to the interaction between energy and support, which is meant to be legible through space and form. In almost all studies starting from Bötticher to Frampton, tectonic was seen as a "quality" when the transfer of the loads became apparent, and the total form reveals that truth to those occupying spaces. The relation between structural behavior and legibility formed an ethos attributed to the tectonics theory. Every other contrary position was left outside of the ethical realm: for instance, the use of components, mimicking to perform a particular structural duty despite not physically performing was evaluated as Apocrypha, or the unbuilt form, which has no physical borders, despite its spatial quality was classified as atectonic. So, in other words, the tectonic quality of a building was interpreted depending on the visibility of the assemblage, and it was problematized based on the true connection between the image and its structural performance in Western architectural theory (Hartoonian, 1994, 2006).

The delay in including mobility and transformability in the theory of tectonics is mainly related to the historically established norms. The reasons for this are summarized below:

1. Some of the buildings listed as kinetic have mobility capacity only through the cladding or shading devices, mostly seen as secondary elements of the tectonics.
2. When the transformation is only achieved through flexible or form-active materials, these constructional members tend to be understood as representational elements. Although Semper's view on textile materials played a significant role in the assemblage of the space and its construction, interest, and research on form-active materials did not continue in tectonic research.
3. The notion of durability in the theory of tectonics established a norm in architecture in which the kinetic buildings fall out of it. The energy transmission from one member to another was understood as the only goal of the structure, which made it difficult to conceive alternative structures such as moving or floating. The preconception of earthwork as the belly button of tectonics has created a priori categories.
4. Due to the significance of structural balance and endurance, the conventional theory of tectonics could only provide links between technology, space, and meaning for the buildings constructed on the ground and must be structurally balanced to resist the loads. Thus, it became bound with spaces that are not necessarily associated with the capacity for transformation, expansion, shrinkage, or rotation.
5. As put forward previously, the dual categories of ontological and representational were preoccupied with practicality by the scholars who studied tectonics. They mostly associated this realm with the place, climate materials, and energy transformation. In today's perspective, practicability and purposefulness also mean flexibility and adaptability, which the conventional theory of tectonics did not contain.

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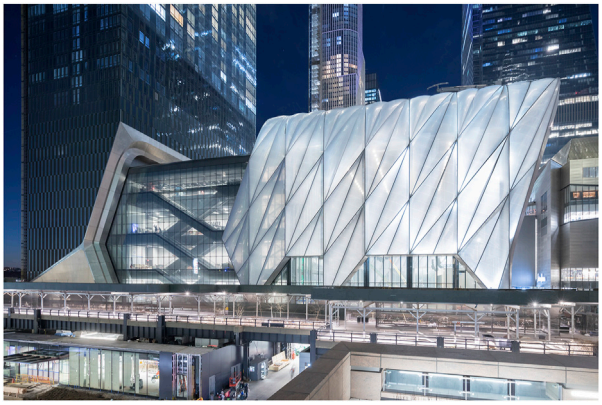

FIGURE 1
Night View of The Shed at Hudson Yards; Photography: Iwan Baan, reprinted with permission of The Shed/Diller Scofidio + Renfro.

Although the theory of tectonics was more revolutionarily modified after the rise of digital architecture to go beyond the physicality and tangibility of material, the idea of endurance and purposefulness still retained its vitality. In addition, discussions on 'ontological/representational' deficiently cover the contribution of the definition of space and its functionality. This paper revisits the theory of tectonics to incorporate the dynamic, moveable, and adjustable joints of structure that allow the adaptivity of spaces that replace classical architecture's timeless concept of endurance. In contrast to motionless joints, which have been well-read throughout history, the moveable structures need to be understood as a new paradigm between atectonic and tectonic as well as a new interpretation of interrelations between time and form.

This study presents an elaboration of an already existing analytical method developed by Chad Schwartz (2017), who worked on a 6-step method to read the tectonics of the buildings and applies it to the case of The Culture Shed in Hudson Yards, New York, designed by Diller Scofidio + Renfro (DS + R) in 2015 (See Figure 1). The structure of the paper is based on five main parts: The first is the introduction which forms the basis of the discussion. The second part reflects a retrospective view of the conception and realization of kinetic buildings. The third part deals with the taxonomy of Chad Schwartz and explains how it was developed by the authors to understand the tectonics of kinetic architecture. The fourth part shows how the additional subdivisions discussed in the method chapter can be exemplified through a case, The Shed in Hudson Yards, one of the most notable and recent examples of kinetic buildings. The last part discusses both the appropriateness of taxonomy structure and how the theory of tectonics would become more crucial for understanding and conceptualizing the epistemological shifts driven by digital and kinetic architecture.

2 A retrospective look at kinetic architecture

Today, buildings or building components that are foldable, slidable, expandable, or transformable through pneumatic, chemical, magnetic, natural, or mechanical means are classified as kinetic in architecture (Megahed, 2017). Although architecture has traditionally been perceived as permanent/ stationary, kinetic architecture accepts motion as a design strategy. The advantages of this type of design can be significant: it lasts longer, serves its function better, accommodates users' experience and intervention, takes use of technology advancement more readily, and is more economically and environmentally feasible (Kronenburg, 2007).

The ability to incorporate the phenomenon of change is fundamental to kinetic architecture theory. Under current architectural approaches, the form is likely to become functionally obsolete long before it becomes structurally deficient and requires physical replacement. The physical form does not function as a straight jacket for the continuous shift in the set of stresses, resulting in an unstable relationship between pressure and form. Architecture, like natural form, should be adaptable, allowing the original set of pressures to grow, transform, and change (Zuk and Clark, 1970).

The concept of movement is not new in architecture and has come up with various systems during history. While Mongolian Yurt, which changes position without any change in its form, is an excellent example of a mobile/ portable building, Indian Tipi is a good example of an archetypal demountable building. The foldable textile roof of the Colosseum is also one of the earliest cases of convertible kinetic building components. All these examples fulfilled their users' specific demands by moving/ folding/ sliding their primary structures and/ or covering materials according to expected mobility, flexibility, and adaptability (Korkmaz, 2004).

The rising interest in living organisms during the Renaissance provided a new metaphoric and physical simulation between bodies and buildings. The general knowledge of anatomy in terms of joints, tissues, and organs taught architects to interpret the body of the building as the body of living organisms. In parallel, developments in portable war technologies and construction tools, which were sophisticated in the Roman period, inspired the idea of designing moveable objects. For these reasons, the design realm explored imitating motion both as a performance and representation in art and architecture. One of the well-known examples of this is the designs of Leonardo Da Vinci, who studied various types of movements and translated his research on nature into his designs, such as the Flying Machine, which had several versions circa 1488. His revolving set design also inspired many other followers, including his contemporaries and the future generation of architects (Richter, 1970).

While the Industrial Revolution opened up a new chapter for human and machine relations, it also added new dimensions to

human-building interactions. The concepts of motion and speed influenced art and architecture so profoundly that they almost formed urban and political space together with contemporary culture and reshaped the entire spirit of the 20th-century avant-garde movements. As an instance of the first group, the Streamline Movement of the 1930s was inspired by the vehicles of that era, representing technology, speed, and mobility (Markovskyi, 2021). Later in the 1960s, Eero Saarinen designed the well-known TWA Flight Center with inspiration from the Flying Machine of Leonardo da Vinci. Although the building is stationary, the form of the whole shell again represents a strong abstraction of motion.

The developments in the steel industry made it possible to manufacture moveable joints, which were first used in bridge constructions. The elaboration of this type of joint expedited the developments in portable, demountable structures. In the post-war era, the concepts of flexibility and adaptability of space became one of the essential concerns of architecture. The Metabolist Movement in the 1960s fused ideas about architectural megastructures with organic biological growth. In the same era, some other architects profoundly worked on the concept of mobility and ephemerality, such as Archigram, a neo-futuristic architectural group that designed various utopian mega structures like The Walking City (Sadler, 2005). In the late 1980s and 1990s, the high-tech movement strived to evoke an ever-dynamic sense of movement and change with the concepts of adaptability, flexibility, and openness (Meagher, 2014).

After the emergence of digital technologies in the late 1980s, it became possible to create fluid forms and algorithmic designs that promoted new and closer collaborations between engineering and architecture. Santiago Calatrava, an important figure at the intersection of both realms, designed several buildings, bridges, and sculptures representing both abstractions of the movement and physical movement. The design conception of these examples is generally based on biomimicry and analogy of living creatures and aims to create the representation of movement with/without proposing a physical movement (Tzonis, 1999). The impulse created by the research on biomimicry and material technology gave way to smart building envelopes that move and change shape connected to BIM systems to provide better environmental performance.

Kinetic architecture has emerged as a developing idea in architectural design, owing to advancements in ubiquitous technology and the rising availability of novel materials, which enable the extension of buildings through information sensing, processing, and actuation (Jaśkiewicz, 2008). As an important difference from the former examples, by these developments, the products of kinetic architecture started to respond to the users' instant reactions and became more interactive. This interaction is not only between built components and people but also between the built components themselves (Oosterhuis, 2007). In this way of interaction, the building or building part changes according to the user; and the user behavior or perception changes according to the interaction of the building with the ever-changing situations.

The materiality and formal expression of the kinetic components may change the essential character of the building. In some cases, their contribution to the ontological presence is far more intricate than the cladding structure differentiation. For example, at Jean Nouvel's Institut du Monde Arabe, the moving parts are only the shading devices without affecting the main spatial hierarchy. It can be claimed that these moving façade elements are part of the representational part of this building. It can be called a kinetic ornament, unlike the Semperian understanding of ornament/Kleidung. However, the role of the kinetic elements is completely different in Seifert Stöckmann's Living Room Project and Next Office's Sharifi-ha Apartment. In Stöckmann's project, the master bedroom is designed as a drawer-like box, and when the bedroom slides out of the building, it transforms into an open-air bedroom, a kind of balcony. Similarly, when the kinetic boxes in the Sharifi-ha apartment move, not only the spatial setup inside the flats but also the total area of the balconies, and the open spaces, grows and shrinks. In these examples, the movement creates ontological changes for the host buildings (For more examples, please see Table 2).

3 Building a methodology

There are three important methodological traces in the theory of tectonics: Deductive approach, case-based research, and analytical categorization (See Figure 2). The first layer is rooted in the German thought school. The theory of tectonics, based on the Kantian philosophy of purposiveness, emerged predominantly as a rhetorical deduction (Kant, 1951). Kant and his followers, like Peirce, discussed concepts like beauty and function in relation to a complex system like aesthetics by following a path generally known as transcendental judgment (Kaag, 2005).

Based on the complexity and multi-faceted nature of the realm of aesthetics, the line of research in the discipline of architecture continued with case-based studies, like the works of Semper (1989) and Bötticher (1992), who studied archetypes, especially from the Egyptian and Classical periods (Herrmann, 1984; Frampton, 2002; Beim, 2004; Semper et al., 2004). This formed the second type of methodological approach. In contemporary architectural history and theory, this methodological approach more or less remained the same. Frampton (1998, 2002) and Hartoonian (1994, 2006, 2015) also studied tectonics through case-based research that became a well-established method in the studies on tectonics.

The third trace is setting out categories to understand the complexity of tectonics. Analytical categorization is very common in quantitative, qualitative, and mixed research in

TABLE 2 Some example kinetic buildings representing representational and ontological changes.

Building	Movement/ Transformation	Representational/ Ontological
Institut du Monde Arabe (Jean Nouvel)	Shading devices on the façade deploy/ fold according to sunlight.	Representational
Living Room (Seifert Stöckmann)	The master bedroom slides out of the building like a drawer	Ontological
Sharifi-ha Apartment (Next Office)	Some interior spaces rotate over the balconies	Ontological
Sliding House (dRMM)	The wooden building envelope slides over the masses and open spaces of the building	Ontological
The Bund Finance Center (Heatherwick Studio and Foster & Partners)	The three-layered bamboo-like kinetic elements slide over each other on the façade	Representational
Al Bahar Towers (Aedas Architects)	The origami structures on the façade deploy according to the sunlight	Representational
The roof of the Wimbledon Center Court (Grimshaw Architects)	The retractable roof of the court slides over the building according to the weather conditions	Ontological

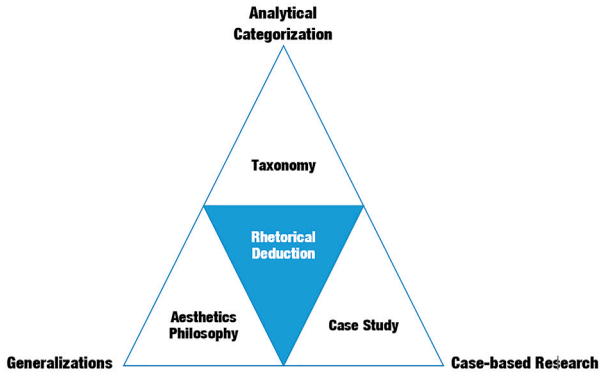

FIGURE 2
Methodology of the Paper.

social and natural sciences (Steinberg, 2015). The influence of Neo-Kantianism on the first genre of scholars in tectonic theory was evident in their consistency in finding out the essential aspects, which were generally framed within dual categories, like Kunstform and Kernform, that will be extensively discussed in Section 3.1.5. Contemporary scholars, who worked on tectonics theory, also presented categories that dealt with integrity through space, construction, and elevation. Their approach was clear and useful but also very rigid and cannot be expanded to evaluate kinetic architecture. This caused a delay in the development of a comprehensive theory of kinetic architectural tectonics. In the existing literature, the taxonomy developed by Schwartz is the only systematic approach available for expansion through the inclusion of kinetic systems that are drastically different from the immovable building in terms of representational and ontological essence.

In his book, Introducing Architectural Tectonics, Exploring the Intersection of Design and Construction, Schwartz (2017) developed a taxonomy to make the reading of a building parallel to the characteristics of the theory drawn from different lines of historical and contemporary thought. Schwartz's approach is a case-based, modifiable, open-ended taxonomy, which combines the second and the third type of methodological approaches as explained above.

This paper explores ways to understand and evaluate novel structural systems, which are the results of iterations of multiple types of joints that can change position. While doing this, it extends the taxonomy of Schwartz, which is presented more in detail below to include the movement's contribution. In this way, the newly added subcategories appreciate the moveable parts, the timely and scenic aspects of movement, and their contribution to the meaningful whole. Although case-based research allows the development of unique concepts, generalizable results are also given in Section 5.

3.1 Modified taxonomy of Schwartz

Before starting the tectonic analysis, Schwartz prefers to explore the background of the project and the brief. Precedent studies in architecture often reveal how a design theme changes over time as technology evolves. Similarly, Schwartz's precedent analysis captures the links between the former and later space and structure interdependence. Although this introductory part provides an almost standard base to start the analysis, he does not necessarily follow a strict order for the subdivisions. Instead, he modifies their order depending on the qualities of the case. This also provides a more open-ended and flexible taxonomy, which would allow to include the evaluation of kinetic buildings, which are mostly left outside in the more conventional tectonic reading approaches. The subdivisions in his taxonomy and the suggestions by the authors can be understood in the diagram in Figure 3.

As discussed in the Introduction Section, Frampton approached scenographic designs from a critical point of view when representational elements are disassociated from the

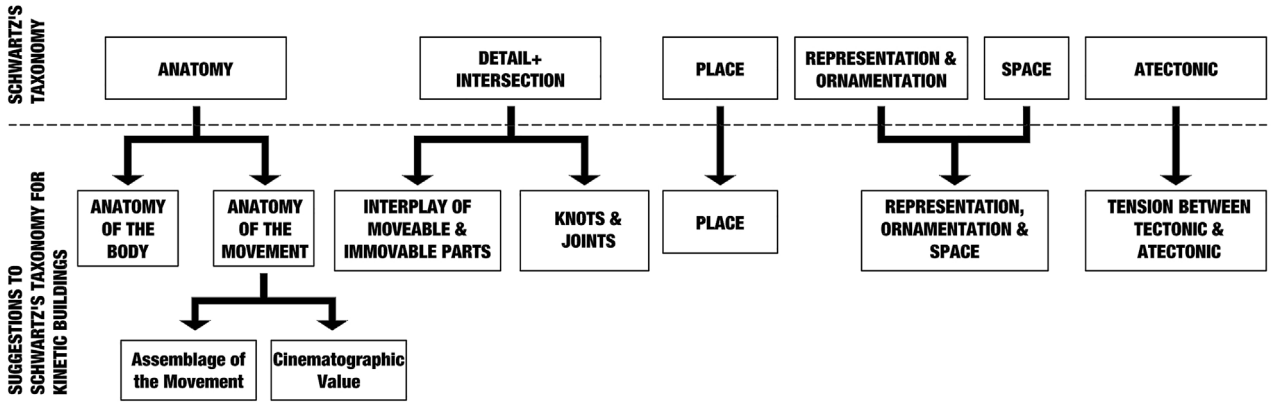

FIGURE 3
Suggestions to Schwartz's Taxonomy (Drawn by the Authors).

tectonic and spatial categories. However, movement in kinetic buildings is inevitably an action of spectating, regardless of its attribution to tectonic or spatial meanings. For this reason, the cinematographic values that capture the movement create a unique aesthetic category swing between representational and scenographic categories in kinetic buildings. During the analysis of kinetic buildings, it is essential to understand that these categories may easily converge or collide.

3.1.1 Anatomy

In this subdivision, Schwartz reevaluates the primary concepts of a building as drawn from Semper's theory, namely the earthwork, the heart, the roof and framework, and the cladding. He explores the framework (Schwartz prefers to use the term tectonic when discussing a structural frame system) or stereotomic systems. Although it is impossible to find both systems within the same example, in most of his analyses, Schwartz made that possible by comparing the substructure and superstructure when the former is generally a stereotomic system.

Schwartz dismantles the building into primary parts to explore how they serve to protect the heart (the crucial space). Through this category, it becomes possible to understand the main reason for assembling parts together in the first place. Although Schwartz analyzes space in an independent category, the other subdivisions help to reveal the interactions between material existence and practical needs. In kinetic buildings, this category needs to be expanded to understand the potential of the movement in terms of its legibility and the Spatio-temporal aspects. Therefore the subdivision of the anatomy of the movement is included.

Kinetic components have the potential to create almost a cinematographic image contrary to the photographic image of conventional structures. The legibility of the movement is crucial for kinetic tectonics, just as the legibility of the material is essential in classical tectonic theory. The kinesis of the building or the building part can be carried through the various movements or transformations on the whole mass of the building, its structural system, and envelope or separation elements. A horizontal or vertical component can either move only in between two predefined positions, such as a convertible roof, which is transformed between certain open and closed forms; or it may change position according to the various environmental, spatial, or functional inputs, such as the kinetic roof of the Sliding House designed by dRMM Architecture in Suffolk (Akgün, 2012). The perception of space and the tectonic character of the building shows a variety through these two different transformation strategies.

Conventional representation media for architectural products are orthographic drawings such as plans, sections, and elevations, physical or digital models, and the photographic images obtained from these media. Traditionally, architectural products are evaluated using these photographic images. A physical model is an exception, but it is again the representation of one single defining moment. However, is it possible to define a kinetic façade and its systematic geometric changes with an image representing one single moment?

The cinematographic experience of a kinetic building can be realized in two ways: continuous and discontinuous. In the continuous cinematographic experience, the transformation of the space, surface, or structure is visible and a part of daily life in or around the building. The process of the transformation and its cinematographic view is a part of the spatial experience. However, this is somehow different from the discontinuous cinematographic experience. Some parts of the buildings have some predefined active positions, but the users only perceive the fixed sequences but not the transformation process, just because

the period between two sequences is for the reformation of the body of the movable part.

This discussion can affect both the representational and ontological legibility of the buildings. Because of this interaction and motion, the architectural space and the tectonic character of a kinetic building should be evaluated with a cinematic view. Immobile sections or plans are insufficient to analyze and perceive the kinetic buildings because these media can only represent a single moment of the design's form, space, and material. To understand the contribution of movement to the tectonic expression, the below subcategories under the subdivision of the anatomy of the movement are included:

- The assemblage of the movement.
- Cinematographic value

3.1.2 Detail + intersection

In this subdivision, the analysis is directed to find the smallest detail in the project that best represents the idea and forms a connection between the parts and the whole.

The subdivision of joints in Schwartz's taxonomy refers to the typical detail, which is iterated multiple times. However, in kinetic buildings, the joints generally have multiple forms. Some joints, whether repeated or not, can be treated as typical when the movement depends on its existence and location. For this reason, the discussion of the joints needs to be expanded to understand the interrelations between the static and dynamic parts. In this paper, joints are analyzed as below to expose the configuration better.

- Knots and Joints- the invisibility of the knots and their language
- The interplay of moveable and immovable parts- interconnectedness or autonomy

3.1.3 Place

This subdivision covers the possibilities and potentials of materials and their availability, specific to the geographic location. According to Schwartz, material choice is all about understanding the landscape and climate. Since this is a relatively narrow understanding of place, he concentrates only on the envelope's performance. However, place in architectural theory and urban geography is understood as a space that creates emotions and attachment. The material choice is also a matter of a phenomenological extension of the landscape, the genius loci, that was crystallized in the work of Christian-Norberg-Schulz, 1979; such a broad definition cannot be found in his approach.

3.1.4 Representation, ornamentation, and space

In the original taxonomy of Schwartz, space is taken as an independent category. This subdivision concentrates on the mutual relations between the creation of space and the construction, as well as the representational qualities of a building. Schwartz describes this category based on the theory of Bötticher, who understood the interrelations between space and structure in the context of causation. The truthness of the structure and façade in a Kantian manner provides a good relationship between space-structure-space, as mentioned by Schwartz.

On the other hand, Schwartz created another category for representation and ornamentation, mostly on the surface qualities of the buildings. He expanded the Bekleidung category, created by Semper, that became a central part of his writings and, ultimately, his legacy to architectural discourse. In this notion, the dressing of a building could be understood by this harmony of the outer layer in relationship to its inner structural component. Semper emphasizes that these two elements are closely linked, remarking that "the mask is no good if what it is concealing is false" (Semper, 1989).

According to Semper, the cover and the core, in many cases throughout history, did not have a direct relationship since the core was generated out of necessity. In terms of kinetic architecture, this relationship varies due to the existence of movable parts, which also change the spatial form. However, the core and the cover may still be two different entities when a change in the position of the cover also drastically changes the definition of the core. The Shed is a typical example of the direct relationship between the core and the cover. On the other hand, these two may be unrelated (like in the instance of Bund Finance Centre (2022) designed by Heatherwick Studio and Foster and Partners), in which transformation does not change the definition of the space, thus only creating a representational movement.

For this reason, the subdivision of representation and ornamentation in Schwartz's taxonomy should be rethought from this perspective. It is suggested in the paper that in kinetic buildings, representation and ornamentation categories are closely linked with the spatial essence of the buildings. The space and representation can be analyzed together in the analysis of kinetic buildings.

3.1.5 The tension between atectonic and tectonic

One of the most exciting categories created by Schwartz is atectonic, which refers only to the examples in which the tectonic expression is voluntarily distorted as a design strategy. With this category, he leaves the original expression of the term atectonic in the Semperian view derived from the Vitruvian roots to connotate the unbuilt form. According to Schwartz, the distinction between representational and ontological can only be understood through a level of normality, described as the juxtaposition of these two. Otherwise, all types of architectural ideas fall out of his span of normality.

Back in the 19th century, the term atectonic was used to indicate the unbuilt, even if it was preconceived as an idea or

proposal which can be verbally or diagrammatically exposed. The theory of the tectonics of digital architecture problematizes this issue by proposing that construction in any medium should be understood as a tectonic form (Liu and Lim, 2006). On the other hand, kinetic architecture takes place at a peculiar intersection between the built and the unbuilt form since the moving capacity also hides or replaces some parts of the structure or the space. In many kinetic architecture examples where the moveable part shelters and reveals large spaces, the transformation or rotation also creates a fast transition from the unbuilt to built, or in other words, from atectonic to tectonic. So, this last category of Schwartz can also expand to cover the kinetic structures.

It is also necessary to expand the discussions in the last subdivision of atectonic in the original Schwartz taxonomy to cover the tension between atectonic and tectonic. Undoubtedly, all definitions of tectonics in the theory of architecture refer to the conventional structure, which is supposed to be anchored on the ground. Additionally, the existing theoretical perspective describes an ideal tectonic expression provided through the montage of structural members, each of which clearly performs the duty of load transfer. Kinetic buildings, by definition, automatically fall out of this simple definition since the duty of load transfer cannot be realized in fixed buildings that are not necessarily attached to the ground.

In some cases, the closed and open forms display different spatial definitions that can entirely change the tectonic effect. When the spatial enclosure partially or totally disappears during the movement, our perception of the building shifts from built to unbuilt. The more the space becomes a part of the movement, the more tension between atectonic and tectonic occurs. However, the tension between tectonic and atectonic can be a deliberate design concept, like in the case of Renaissance mannerism, for instance, in St. Lorenzo Library, designed by Michelangelo. However, the perceivable and sudden shift from built to unbuilt is only peculiar to kinetic buildings and can never be found in conventional buildings. For this reason, the switch from one pole to the other is needed while analyzing kinetic buildings.

4 Case study

Starting from the early 20th-century art movements, many architects worked to create adaptable cultural centers to give freedom to the artists and their artistic projects. Various designs attempted to create a transformable space allowing spatial adaptivity of the performance, like rotating or elevating stages, seats, or transformable roofs. None of them reached the flexibility of The Shed in Hudson Yards, which allows maximum adaptability, not only with the move of a couple of building components but with a series of different adaptability strategies. The architects of the building call this approach a

FIGURE 4
The Shed at Hudson Yards; Photography: Iwan Baan, reprinted with permission of The Shed/Diller Scofidio + Renfro.

FIGURE 5
Interior View of the McCourt Hall; Photography: Iwan Baan, reprinted with permission of The Shed/Diller Scofidio + Renfro.

"Swiss Army Knife" that can perform whatever task artists need and want (Giovannini, 2019). For this reason, The Shed is one of the most ambitious designs that fulfilled this scale of transformation for a building for 1750 to 3,000 spectators at one time and became notable in the history of kinetic buildings. This paper selected The Shed as the case study because of the scale of its transformation capacity, one-of-a-kind structural details, and the integrity between the tectonics and spatial design.

Completed in 2019, The Shed is a18500 m^2 visual and performing arts center in Hudson Yards (See Figure 4). The building is nearby the High Line and Penn Station in Manhattan and is attached to the 15 Hudson Yards building. The building features 2,300 m^2 of exhibition space with no columns (the level 2 and level 4 galleries), a theater that can accommodate up to

FIGURE 6
The Boogies; Photography: Iwan Baan, reprinted with permission of The Shed/Diller Scofidio + Renfro.

500 spectators (The Kenneth C. Griffin Theater), a skylighted event space (The Tisch Skylights and Lab), and an adaptable 1500 m^2 shell (The McCourt) that allows the space to expand and contract to accommodate a variety of events and audiences (DS + R, 2019; The Shed, n.d) (See Figure 5). The building has been designed as a huge venue that can accommodate temporary exhibitions and transform depending on the exhibition or event. The most dominant element and the main generator of this spatial flexibility is the huge sliding Shed, constructed as an envelope surrounding the immobile parts of the culture center and capable of sliding to cover the adjacent plaza area. This sliding envelope is made of steel, weighing around 3,600 tons, and has six steel bogie wheels as total touch-down points along the two rails (McCoy and Duffy, 2022) (See Figure 6).

The postwar era of architecture created an impetus for the conception and realization of the mobility of buildings. In this instance, the Fun Palace (Price and Littlewood, 1968), developed by Cedric Price for Joan Littlewood in 1961, an unbuilt project, became a perfect seminal example for the next generation of architects who wanted to work on performance halls that can be altered by their users. The Diller Scofidio + Renfro office also refers to the Fun Palaces as a precedent to their conception of The Shed. The original scheme of Price and Littlewood was even more progressive and aimed at creating an art center working almost like a community garden in which contributors could change the space as well as the program (Price and Littlewood, 1968). Unlike the conventional art centers, the visitors would have contributed to the art performances as artists (if they wished) and even combined arts with crafts and/or science labs. The idea of housing the countless types of users and performances led Price and Littlewood to imagine a big, lightweight shed that is not fully enclosed and made of prefabricated building components. The users would be free to reorganize the space by using prefabricating building components like a tool kit for a do-it-yourself project. The operations could also be done with the help of a couple of cranes which are the indispensable parts of the structure and the space like a shipyard (Fun Palace, 2012).

Fun Palaces also became a precedent for the Pompidou Center, designed by Richard Rogers, Su Rogers, and Renzo Piano in 1971. Unlike the challenge of the former Fun Palaces, Pompidou was designed and realized as a contemporary art center and Bibliotheca, where the conventional artist-spectator relationship still remained the same. Pompidou is not a kinetic building but has an uninterrupted space provided by removing the entire electrical and mechanical network and the lifts and escalators towards the outer skin. The large-span halls can be rearranged by using demountable partition walls. The Pompidou does not have an operating crane but caught a similar spirit with the help of a giant zig-zag escalator which represented the footprint of a caterpillar and was hung on the outer skin (Ulusoy and Turkan, 2021). Despite the will and dream of Price and Littlewood, the artist and the audience could never be free to control the space in the succeeding buildings that followed the ideal of Fun Palaces.

4.1 Anatomy of the body- the earthwork, the heart, the roof and framework, and the cladding

Parallel to Schwartz's approach, this section investigates the anatomy of the body according to Semper's four elements, namely the earthwork, the heart, the roof and framework, and the cladding (Semper, 1989). Conventionally, earthwork is the stereotomic construction and part(s) of a building, including all masonry productions.

The Shed building does not include any stereotomic building parts, except for some probable layers in the foundation part. The heart of a building is the main architectural space, which forms all other spaces around itself. Since the Shed building is a culture and arts center, the main hall- McCourt-hosting the biggest and the most important activities, can be accepted as the heart of this building. The formation of the heart in the Shed differs from the conventional examples. In this building, the heart can be identified as a transformable volume, which can be hidden according to the movement of the kinetic envelope. In this way, when the envelope is deployed, the heart shifts inside the building, but when it is contracted, it shifts towards the urban plaza or disappears. The roof, framework, and cladding of a conventional building mostly represent the tectonic parts of a building. Tectonic construction represents the assembly or joining of distinct elements such as wood or metal components (Schwartz, 2017). The tectonic entity of the Shed building has two different types: movable and immovable. The

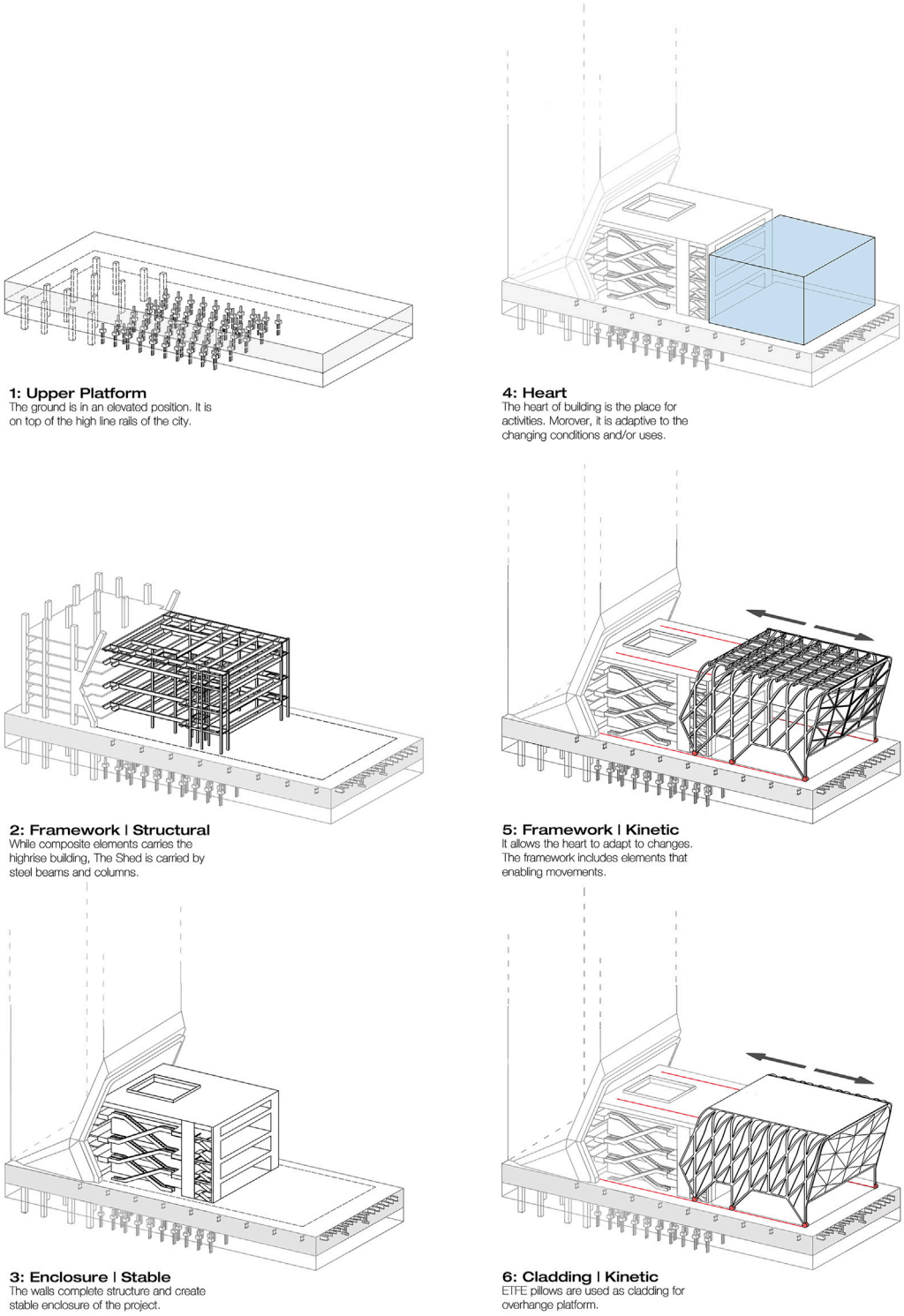

FIGURE 7
Anatomy of The Shed (drawn by the authors).

conventional steel skeleton frame of the immovable mass of the building and the railway facilities under the urban plaza represents the immovable tectonic parts of the building. On the other hand, the deployable envelope, with its steel frame and bogie wheels, constitutes the movable tectonic entity of the building (See Figure 7).

4.2 Anatomy of the movement-

This category is one of the newly added categories to analyze the contribution of movement, its direction, capacity, and character. For this reason, the assemblage of the movement and its cinematographic values would be a part of this subdivision, as presented in Sections 4.2.1, 4.2.2. The Shed is a kinetic building that proposes different spatial transformations *via* various structural and architectural elements. The physical and conceptual dimensions of the movements in The Shed were analyzed systematically in two steps to comprehend the overall contribution of the transformation to tectonics.

4.2.1 The assemblage of the movement

In some kinetic buildings, movement occurs due to data automation controlled by the sensors. The speed of the moving parts changes the perception either as a rhythmic action or a very faded motive that can hardly be discerned. In most responsive façade systems, the movement is assembled digitally and has continuity. However, mechanically assembled movement creates a more dramatic change in the Spatio-temporal essence, like in the example of demountable buildings, such as a circus tend; or convertible bridges. For this reason, the movement of The Shed can be classified as a mechanically assembled movement. This is also the reason why perceivers feel the tension between tectonic and atectonic, which will be explained in Section 4.6.

In addition, the position of the moving parts and the motor system matter in the overall tectonic expression. For a great majority, what makes The Shed special is its kinetic envelope surrounding the conventional fixed mass of the building. This kinetic envelope can be thought of as a giant gantry crane that sits on two rows of rails on the ground with large bogie wheels at six points. Unlike their counterparts, the motors that provide the movement are not on the rails or close to the bogie wheels but at the top of the kinetic envelope. Thus, the activation that provides the movement is given from the top of the shell. In this respect, the shell resembles a "shopping cart" in terms of its working principle. The actual movement of the building takes around five minutes at a speed of a quarter of a mile per hour, but the entire deployment/ contraction process is about 4 h and a crew of four to six staff. In brief, the movement can also be categorized as a horizontal deployment in which activation occurs from top-to-bottom.

Another important factor that changes our understanding of tectonics in kinetic buildings is the size of the transformation. During deployment, the kinetic shell mechanically slides from a position that completely covers the immovable conventional building to a position that substantially exposes the fixed structure. This is a significant mechanical displacement that expands the footprint of the building to 0.86 times bigger. In this manner, the Shed's kinetic envelope has the potential to create more remarkable ontological changes in the architectural space and tectonic character of the building than its counterparts (See Figure 8).

4.2.2 Cinematographic values

As mentioned in the previous section, the movement of a kinetic building or building component creates a cinematographic image for the users; and the readability of the movement is critical in kinetic tectonics, just as material legibility is critical in classical tectonic theory. It is difficult to comprehend the architectural space, structural continuity, and materiality without experiencing these cinematographic events in/ around these buildings. This also applies to The Shed in Hudson Yards. Viewers, who only experience one single configuration of the Shed cannot have an idea about the transformations changing the spatial character, vistas, and inside/ outside relationship of the building. If this single configuration covers the moment when the kinetic envelope contracts over the conventional fixed building, the viewer can never perceive the poetry of the shell sliding over the building and how the movement changes the interior and exterior space. This situation is worse for the viewers who try to perceive the building remotely via images or orthographic drawings. To overcome this perception problem, even the website of the designer office-DS + R prefers to express the spatial atmosphere of the building and the different spatial configurations of the envelope, walls, and telescopic seating elements using animations and videos instead of conventional orthographic drawings or photographs (The Shed - Diller Scofidio + Renfro, 2019).

The Shed building primarily exhibits discontinuous cinematographic experiences to the users. This is because the kinetic building elements, such as the sliding envelope, movable walls, etc., have predefined fixed positions during the sequences. However, in between the action sequences, they are not visible to the users. Only deployment of the kinetic envelope is visible to the audience around the building, whereas the building remains static during this transformation.

4.3 Detail + intersection

Although this subdivision already exists in the original taxonomy of Schwartz, moveable knots and joints and the interplay between moveable and immoveable parts are presented here as the newly added categories in Sections 4.3.1, 4.3.2. Materiality is a critical factor in the design of kinetic buildings. Kinetic buildings differ from conventional static structures in both shape and material. To increase the transformation capabilities, minimizing the weight of any kinetic structure/ envelope is seen to be of paramount importance (Zuk and Clark, 1970). Especially after the

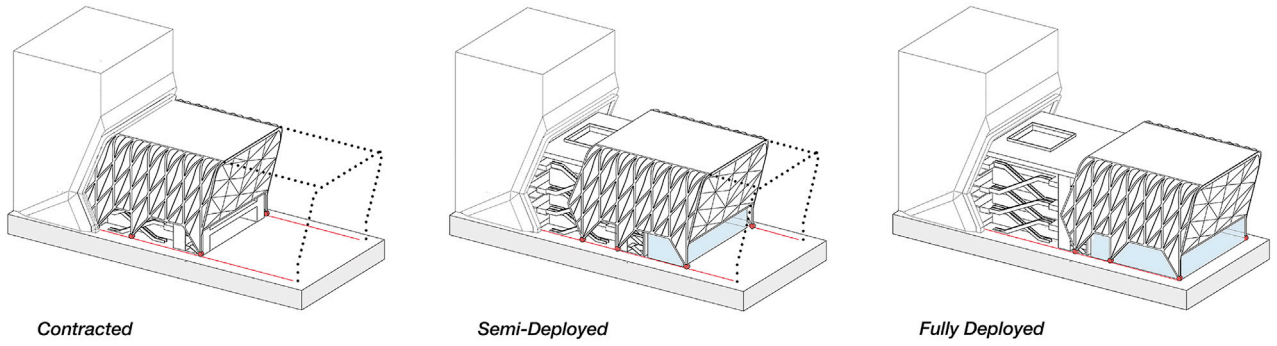

FIGURE 8
Deployment of the Envelope (drawn by the authors).

development of new technology materials, the material has also gained the potential to be a concept generator for kinetic buildings. Using composite walls and layers instead of walls and plaster has changed the approach to tectonics and created new tectonics. There may be a relation between the layered walls and the Bekleidung Theory of Semper. While some elements create the representational legibility between the users and the building, others create the ontological core. These roles can change according to the architect's approach and disposition.

4.3.1 Moveable knots and joints

According to Semper's dressing (Bekleidung) theory, the dressing of a building is made up of repeating knots, which best represent the idea of connecting the parts and the whole (Semper, 1989). These knots are the smallest repeating components and details that make up the whole building. In the Shed building, the smallest components/ knots that generate the kinetic envelope of the building are the bogie wheels and the steel grids that accommodate the ETFE (Ethylene tetrafluoroethylene) coating. These knots contribute to the movement/ kinesis: The bogie wheels, which are six feet in radius, are the elements creating the movement, and the ETFE details create lightness to support the kinesis.

The bogie wheels do not only create the physical movement of the kinetic envelope but also make a gesture to the industrial heritage of the site. These wheels are the key elements representing the mechanical movement observed from the urban plaza on the upper platform. Wheels are the archetypal symbols of movement and represent a potential dynamic capacity even when not rolled. For this reason, boogie wheels step forward in making legibility of the movement with their form, position, and size (See Figure 9).

Steel grid detail accommodating the ETFE is the other important knot for enabling movement. This detail/ knot and its substructure are designed as lightweight as possible to decrease the total load of the crane-like kinetic envelope. The selection of ETFE pillows as a cladding material is mostly because of their lightness compared to glass. Steel grid with the ETFE pillows are always visible inside and outside the structure and are elements that form the identity of The Shed building.

4.3.2 The interplay of movable and immovable parts

There are different kinetic structural and architectural elements offering movement in the Shed building. While some components and systems are interconnected with the immobile parts, some establish a relationship of autonomy. As the most dominant movable element, the kinetic envelope surrounding the conventional fixed mass of the building has a relatively autonomous relationship with the immovable parts of the building. Although the rails of its actuators are connected to the top of the fixed mass, the deployment/ contraction of the kinetic envelope and the resulting spatial/ volumetric changes on the urban plaza do not require any changes to the immovable parts. In addition to the kinetic envelope, the Shed building also offers some other spatial transformations. Movable flexible walls of the Level 2-4-6 galleries, demountable seating units of the Griffin Theater and McCourt, guillotine glass walls separating and joining the plaza, McCourt, and the galleries, and the crane systems on top of the kinetic envelope that allow hanging different building elements are the other movable building elements creating the flexible spatial character. These movements are schematically represented in Figure 10. The situation is primarily different in these movable parts. For instance, when the demountable seating units at McCourt are active, the size and the spatial character of the Level 2 and Level 4 galleries change. Again, in some configuration alternatives, all individual spaces should be interconnected, and all spatial hierarchy and circulation pathways should change according to this configuration.

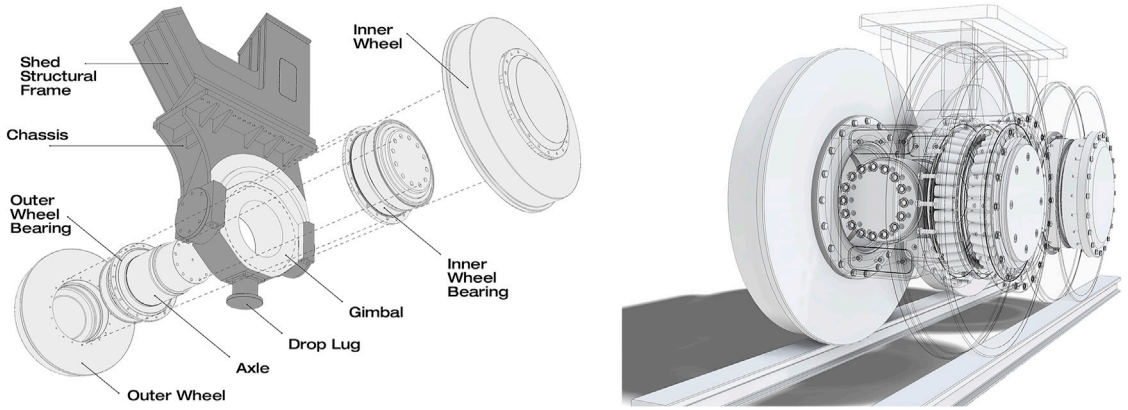

FIGURE 9
Details of the Boogie Wheels; reprinted with permission of The Shed/Diller Scofidio + Renfro.

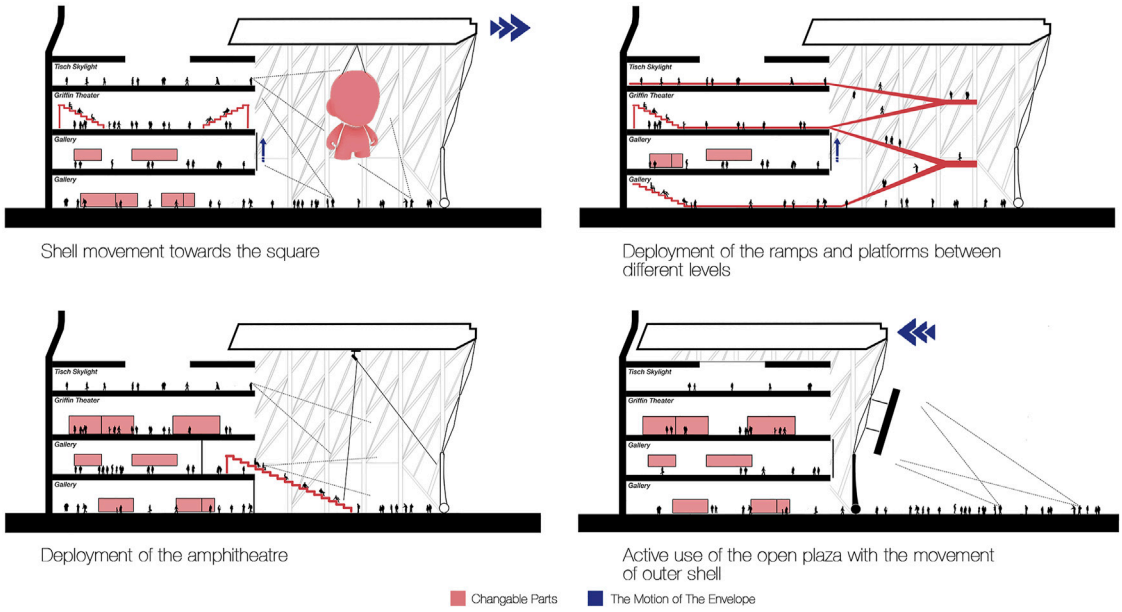

FIGURE 10
The Interplay of Movable and Immovable Parts (drawn by the authors).

4.4 Place

Schwartz's (2017) taxonomy on the "Place" gives reference to Semper's thoughts on vernacular and emphasizes "the local conditions of culture and environment" and "intrinsic, invisible energies that are latent in their sites." Conceptual and contextual ideas of the DS + R during the design of the Shed building consciously support these ideas. In the first decades of the 20th century, the Hudson Yards region was an industrial area occupied by rail yards and supportive functions. The region has started to be transformed with the Hudson Yards redevelopment plan since the first decade of the 21st century (HYDC, 2019). The Shed project is a part of this redevelopment project.

It is not a coincidence that a giant crane or railway system is preferred, while the desired kinetic system could be achieved in

other ways. The designers were inspired by the industrial history of the High Line and the West Side Railyard and tried to utilize the main instruments of this industrial legacy to establish a contextual relationship with its site. The material selection followed the contextual idea, as well.

4.5 Representation, ornamentation and spatial essence

As suggested in Section 3.1.4, the subdivisions of representation and ornamentation are here analyzed together with spatial essence. An expanded definition of tectonics does not deny the expressive potential that the surface may offer. The postmodern perspective of the surface as an autonomous billboard for an architectural brand recalls Semper's warning that "masking does not help. . . when behind the mask is false or the mask is no good" (Semper 1989; Van Eck, 2009). This statement condones the use of a mask but warns that it must correspond to the network of tectonic elements, including coreform and artform. However, simply returning to the 19th-century understanding of this relationship denies that culture and its means of looking at architecture have changed within the past century and now include the impact of media and technological changes. Thus, architects must look for new ways to incorporate surface, not merely as a dominant image, but within an integrated architectural experience of tectonic expression. The expanded notion of tectonics positions architecture as the venue for a multi-faceted experience, where the encounters that take place reference the complex, layered nature of everyday life. (McCoy, 2009), and movement and adaptation can be a new way of creating new tectonics.

The Shed provides many potential curating possibilities to the artists with its flexible space design. However, the organization of the events and their spatial planning are operated by central management just like all other Cultural Centers, which are not necessarily as flexible as this building.

The McCourt Hall- the convertible arena underneath the retractable telescopic overhead plane has an unobstructed span of 33.5 meters, of which the overhead plane is divided by 5.6 m × 4.8 m steel grids. Despite recalling an industrial space, McCourt has a high sound performance which can also be enhanced by electrical and data wiring systems. The integrated building components have a history of more than 40 years in the building industry. However, the application of such a system in a kinetic system is a challenging potency.

The designers describe the spatial quality of the building as all muscle and bones instead of fat (Architectural Digest, 2017). This expression is a metaphor that brings connotations of health and physical performance and adds almost an athletic character to the building. Since the Dancing Column by Joseph Rykwert (1996), the pursuit of bodily space has continued to be phenomenal in modern architecture. Although Rykwert's mental journey was a step established between the order and the tectonics in classical architecture, his name never came up in the first rank with the other scholars who worked on the theory of tectonics. The tectonics of the Shed was designed to maximize its bodily performance in the heart of the building, which is McCourt Hall. The immovable part contains unobstructed long-span performance halls, which can be flexibly organized by lightweight partition walls. Although the fixed part is designed to be spatially integrated with the McCourt Hall with the help of the movable claddings, this does not contribute to the overall kinetic capacity at the representational level.

4.6 The tension between the atectonic and tectonic

This category, as discussed in Section 3.1.5, is one of the additions to the original Schwartz taxonomy. The Shed stands on an existing Plato supported by columns and beams, left from the earlier dock and railyards facilities. The Plato was re-leveled before the construction of the Shed, which created unique circumstances and systems in the transfer of the loads. The building transfers the loads to the existing dock structure instead of the ground, which is the first-degree reason for classifying the building as atectonic. The existence of rails and wheels at the skirt of the moving part intensifies the atectonic expression since this is another deviation from the tectonic norms of standard connection to the ground.

For these reasons, The Shed is strongly atectonic in terms of the classification of Sekler (1965), in whose writings atectonic was defined as the load transfer that cannot be visible or deliberately obscured. Not all kinetic buildings need to be atectonic according to their relation to the ground but may have other types of unusual relations, such as the relation between the cladding and the structure; or between the substructure and the ornament, as widely discussed by Nan-Wei and Chao-Ching, 2014. The triangulated steel member between The Shed and The 15 Hudson Yards Tower resembles an ornament and interrupts a clear reading of structure, cladding, and substructure. This member pretends that there is an articulation, a joint between the horizontal and vertical buildings. It helps to strengthen the atectonic expression by imitating a gain despite being a fixed joint. This triangulated steel member can be seen in Figures 1, 3, 6, 7 from different perspectives.

The term atectonic is always associated with the open or unbuilt form, a subtle category that Wölfflin used for Baroque art. Again, Wölfflin emphasized that architecture can only be built/ tectonic/ closed, and all other spaces can be understood as unbuilt/ open/ atectonic (Wölfflin, 2012; Hartoonian, 2015). In the line of this discussion, some kinetic buildings are capable of both closed and open spaces and thus can only be understood as a tension between tectonic and atectonic forms of

expression. The movement of the canopy of The Shed provides a perfectly open plaza when it is retracted. Since the canopy's movement can be visible to the spectators, this transmission can be understood as the tension between the built and unbuilt forms. The movement of the overhead panel and the sliding glazing leave an unobstructed open space without a trace from the enclosure.

5 Results and discussion

The discussions on tectonics were widely developed for immovable buildings. Most of the concepts derived from this framework can also be used in the context of kinetic buildings, too. The development of the theory of tectonics in history has shown us that the previously studied categories were always renewed and updated over time as building technology changed. The addition of kinetic building technology to the theory of tectonics is relatively a less studied realm that this paper tried to fill. Movement, in general, has its own structure, which also develops an artistic expression. As a part of performance arts, the kinesthetic systems could have been potentially another source to be translated into architecture to better cover the tectonic aspects of the kinetic buildings. Instead of following such a path, this paper approached the subject from an analytical point of view and preferred to dismantle the compact theory of tectonics into subcategories as well as the totality of the building into components.

There are five major results that can be deducted at the end of the analytical method of the paper. Firstly, this paper proved that Schwartz's taxonomy could also be applied to kinetic buildings with some modifications. Secondly, the classification of the kinetic buildings according to the categories of ontological and representational is a novel contribution to the existing literature.

Thirdly, the preferred method allowed the authors to see that there is an overarching concept in the tectonics of the kinetic architecture, which influenced the analysis of almost all subdivisions studied. Frampton's dual categories, ontological and representational, are the foremost aspects essential to kinetic architecture. While some kinetic buildings, structures, or building parts present ontological changes in architectural space, some others only create representational changes. Responsive and interactive façade systems are mostly representational elements that are not that much different from the "Bekleidung" or carpet in Semper's theory. They significantly contribute to the envelope's performance but cannot radically transform the spaces. However, most convertible roofs, some demountable seatings, etc., shape the space and represent ontological changes in spatial qualities.

In contrast, some movement strategies that affect how we perceive and utilize the space may not make a discernible contribution at the representational level. The analysis of the Shed showed that moveable claddings might drastically combine two adjacent spaces; change the interaction between the closed and semi-closed spaces, and create a dimensional expansion. In this way, although it is necessary to categorize them as ontological movements, they have a silent representational character, give no clue about how they function, or do not necessarily contribute to the art form of the building. The agent of space plays a vital role in the analysis of kinetic buildings. Based on the applied method, representational and ontological presence was understood in terms of the interrelations between movement and space. Based on how much the moving parts affect the sensual and physical definitions of space, the tectonics of kinetic structure turns out to be either ontological or purely representational. Reading the representational and ontological essence in combination with space is important in kinetic buildings. To review kinetic components as agents of spatial change and simultaneously as a part of the artform would make a much more valuable and meaningful contribution to the theory of tectonics. In this way, the circumstantial character of kinetic components, which moves back and forth between representational and ontological essence, becomes an important result of this paper.

As a fourth result, this paper contributed to the existing theory by expanding the discussions of atectonic. The analysis of The Shed made it possible to understand how the tension between atectonic and tectonic makes the overall character of the kinetic buildings. The products of the kinetic architecture cannot be evaluated/ perceived using conventional representation tools. Cinematographic tools and concepts are needed. The captured motion can create a more understandable relation between the body, space, and action. In many cases, video diagrams provide a clearer understanding of the moving parts rather than a video shootage of the building. The video diagram of The Shed provided by the designers is a perfect example of this since it makes the phases of the motion readable which normally cannot be captured with a real-time or accelerated video. In the analysis of conventional buildings with fixed joints, the assemblage order and layers become important. Although exploded perspectives can reflect the montage order, kinetic building analysis get benefits from action graphics. The temporal representation of movement needs further discussion, and it would be a new line of research to understand how it may reveal other interconnections between the categories of scenography and representation for the kinetic buildings.

Lastly, the movement (of the kinetic parts) makes the categories of tectonics fluid and sometimes interchangeable due to the alteration of the way we perceive or conceptually comprehend the interrelations between space, structure, and envelope. For instance, the discussions of representation, ornamentation, and scenography made it possible to understand these categories as converging concepts due to the moving parts and their contribution to the space at different levels. Although such a collision can hardly be seen in immovable conventional buildings, the categories are much more flexible and interchangeable for most kinetic buildings. Similarly, the

analysis made it possible to understand how kinetic buildings can swing among different categories that were historically developed for conventional buildings in the theory of tectonics.

The metaphor of the 'shade,' in reference to the title of the paper, is a reflection of the fact that the moving envelope of The Shed cannot be simply categorized either as a tectonic or atectonic building. The fluidity between representation and ornamentation or atectonic and tectonic, as discussed in the paper, is due to the kinetic character of the building. The results of the analysis in this article cannot provide a template for the extent to which the boundaries of tectonic concepts can be fused for all kinetic buildings. On the contrary, it emphasizes that the categories of the analysis should be reconsidered for every case.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

Author contributions

YA and ÖE organized the article structure, supervised the contributions, wrote the main texts, and prepared Figures 2, 3. CK prepared the other figures and diagrams. All authors contributed to the article, reviewed the text, and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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