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Citation: Costa Santos, Sandra (2009) Finding a third archetypal technical system in architectural phenomenology. In: Architecture and Phenomenology Second International Conference, 26 - 29 June 2009, Kyoto.

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Finding a third archetypal technical system in architectural phenomenology.

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Abstract

Within the scope of phenomenology and in order to understand architecture, the role of the technical system is as important as those of the purpose of the building or its form. Mass construction and skeletal construction relate to the architectural theory concepts stereotomy and tectonics respectively, which are suitable for describing the fundamental structural and constructive form of architecture. These two systems became established as man built his first shelters and, so far, represented opposite sides of the building industry's possibilities. The development of new construction techniques and the relationship between research and technology have a great impact on architecture, although new processing methods and materials may not necessarily cause genuine tectonic changes. The technical dimension of architecture is analysed in this work describing how technical elements are built from materials, and then organised in systems. First, the paper examines the division of technical systems in two categories (massive systems and skeletal systems); then it studies timber's modern production technologies and subsequently the paper critically analyses how these influence the architectural form. The paper concludes that a third archetypal technical system can be perceived with the assembly of surface elements, joining both the multifunctional aspect of the massive systems and the flexibility of the skeletal systems, this third category being fundamental in phenomenological terms.

Author biography

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Introduction

This work is influenced by Christian Norberg-Schulz's contribution to phenomenology, in particular his understanding of architecture as a whole, where different aspects are unified [1]. These aspects take us to consider three basic dimensions (and their relationships) in order to apprehend the totality of architecture: purpose, form and technology. If architecture involves meeting a purpose through technical means and

within the scope of a particular form, we could say that an architectural system is a characteristic way of organizing architecture as a whole. Within the scope of phenomenology, the technical dimension of architecture is analysed describing how technical elements are built from materials, and then organised in systems. In the making of architecture, components are connected to other parts according to certain rules. Every form of construction is based on a set of rules which are the result of the properties and conditions of the materials employed and the requirements they have to meet. They dictate the specific properties of the building components, their use and their processing. These rules, derived from technical and representational conditions, form a system. Any form of construction involves designing and building with a system. A building system is not a material entity, but an intellectual approach to structure and construction [2]. From this point of view, building systems and tectonic form are closely related.

The technical dimension of the architectural analysis

Architecture, in order to define a portion of space, has a material vocabulary, a constructive grammar and a structural syntax. These, together with the technical and structural basis are the fundamental prerequisites of architecture, the *conditio sine qua non* [3]. The technical and structural basis establish a set of construction principles which are independent of any particular project. However, all these tools remain unrelated and meaningless without the guidance of the spatial concept. They are all incorporated in tectonics, where only in conjunction with this concept do the tools form an architectural body. And because architecture encloses space by means of structural and constructional form, the structural unit can be considered the prime architectural form. It is undeniable that architectural form has a volumetric quality, but it is necessarily achieved by constructional and structural means. In this context, tectonic is the expressive potential of construction and structure. Tectonic form serves to understand why architecture derives from some other reasoning. The body of a building results from the nature of the construction, but mainly from the values latent in one structural conception rather than another. Over the course of history, architectural bodies have been implemented in various ways, and their spatial significance has varied significantly. But one thing is persistent: the presentation and representation of architecture as built entities has always proved essential to the phenomenological presence of architecture and its embodiment in form.

Within the scope of phenomenology and in order to understand architecture, the role of the building system is as important as those of the purpose of the building or its form. If the building system is massive (mass construction), its elements are more or less isotropic and are both loadbearing and enclosing. In the other hand, a skeletal system is a structure of slender linear members that is defined by its distinction between loadbearing and enclosing functions. These two systems relate to the architectural theory concepts stereotomy of compressive mass and tectonics of the frame respectively, which were defined by Gottfried Semper [4] as the two different material procedures to divide the built form and describe the fundamental structural and constructive form of architecture.

Tectonics of the frame

A frame construction is a structure of slender rod-like members assembled to form a two- or three-dimensional composition in which the loadbearing and enclosing functions are fulfilled by different elements. According to this, we can identify two very different kinds of building elements: primary elements and secondary elements, being primary elements those that are load-bearing and form the frame. In order to create an architectural space we need to close this open framework; we need to clothe it, to clad it. The relationship between the internal and external space in the tectonics of the frame is achieved not by the structure itself but by non load-bearing elements. Appropriate openings to the construction match the divisibility of the framework; thus, openings are not accidental perforations but active parts of the system. We can consider tectonics as a hollow-body construction, where the filling has to be rigid and fixed within the frame. This requirement makes the filling an active element in the overall spatial conception. Since framework and filling tend to be made from different materials, the logical conception of a frame construction leads naturally to formal articulation or contrast, allowing clear symbolic expression of the two elements. The non-loadbearing filling carried the symbolism of non-participation through history, at the same time that it could give the loadbearing frame an extra-structural purpose (or functional purpose) as focal element. The expression of a frame's structural purpose can agree with the expression of its functional purpose; however, the structural purpose may distract from the symbol since it recalls the supporting properties of the frame's material and, therefore, its materiality. The architectural significance of the frame can be considered objective because it expresses its relationship with the outside world by formal means. While the frame and the filling enclose an interior, the functional (or extra-structural) purpose of a frame is defining an interior, and the arrangement of its parts is rhythmic with regard to this purpose. The

tectonic principles of the frame were already recognized by the Hellenes [5]. These principles are based on the laws of phenomenology, according to which, the formal combinations that are most satisfying to the eye happen when nothing in them evokes or raises doubt about the idea of material existence and duration and, therefore, stability. Vertical (with a correct proportion of height to base) and horizontal elements do not remind us of weight as an active force, rather they symbolize static rest. In the other hand, two posts propped against each other show a different situation: the masses immediately appear to us as active forces. If we are considering a structure that is complete in itself and is not intended to support anything else, formally speaking, the viewer would demand that appears self-contained and complete.

Compressive mass

The main features of solid construction are heaviness and compactness. Its prime element is a massive wall made up of layers of modular materials or by casting a material that solidifies upon drying. It can be said that the joint in solid construction works by means of casting and layering (where in an ideal case the simple layering and the pull of gravity are enough for the stability of the building, without any additional joining media). Solid constructions (may that be wall or roof structures, such as domes and vaults) can accommodate, most of all, compressive forces and (unlike frame structures) hardly handle tensile forces. Thus, stereotomy is referred to as tectonics of compressive mass. The stereotomy or tectonics of compressive mass is the second material procedure described by Semper [4]. Even though the most common materials have been brick, stone and concrete, mass construction is also a possibility with solid wood, where identical units are piled up constructing the built form. In stereotomics, modular materials come to serve as regular pieces in systems relying on compressive strength as the most critical constructional principle. In addition to compressive strength, cohesion is the next critical structural factor. (By cohesion we understand strength related to vertical forces directed at a right angle to the longitudinal axis of the structural elements.) Cohesion is affected by the bond between the structural elements. The bond or linkage creates a solidly jointed whole that evenly distributes the load. Without a proper bond, the different parts would overload at particular points. Although compressive mass systems are divided into many parts, they remain unarticulated. Many identically or similarly shaped pieces are linked together according to a specific canon. The functions of these pieces are basically the same (structurally and mechanically) and they allow a structural-mechanical formal expression. This is a clear difference with the tectonics of the frame, where different kinds of activity resulted in articulation of the different elements (i.e.

columns, beams or filling). In *Style in the Technical and Tectonic Arts; or, Practical Aesthetics*, Semper [5] defined eurythmy as 'stringing together uniform segments of space to form and enclosure'. This could be done with even intervals, and therefore each element is identical to the others. Stereotomics is dominated by the rules of eurythmy. Thus, Semper argued that the formal regularity in stereotomics corresponds both to the eurythmic principle and to structural needs. Moreover, we could say that massive systems, due to structural requirements, allow a more limited number of spatial configurations than frame structures and their openings are more restricted in size and positioning.

Tectonic changes: a third archetypal system in architectural phenomenology

The architectural theory concepts stereotomy and tectonics name two categories of architecture-making which are fundamental in morphological and phenomenological terms. If the point of view to approach critical comparings in architecture is not historical or stylistic, but rather considers the tectonic form in different cultures, we can find some coincidences. A loam and straw house in Romania and a modern reinforced concrete building in Austria are similar in terms of the production process (mould and casting) and the finished appearance of the wall (pattern of the mould). The difference lies in the materials and the moulding technology. The concrete works as a more developed, processed, and therefore permanent loam. Both of them include solids such as gravel, sand or straw, plus dust-like components which form mineral glue when water is added. Also, a traditional timber frame building in Voralberg and the three-dimensional structure, made from standard steel sections, of a skyscraper in Chicago can be similarly compared. Despite the spans, the stability of the members and the connections being different, their almost identical tectonic principles allows assembly of linear members to form a framework. These examples show that where different cultures had access to similar resources of materials, they developed very similar forms of building more or less independently of each other. Theories that followed the 19th century one drew the conclusion that the two categories (stereotomy and tectonics) are suitable for describing the fundamental structural and constructive form of architecture and for demonstrating the principles of the origin and evolution of the architectural form. The development of building techniques and the relationship between science, research and technology have a great influence on the building process and, therefore, on the resulting architectural form. However, this development may concern only the optimisation and refinement of the production and processing methods (workmanship, industrial production process) and therefore the products (the building materials). If timber is swapped for stone (an organic

for a mineral material) in order to improve weather resistance, a completely different type of building process will be triggered. This is reflected in Semper's theory of metabolism [5]. His theory is about the consequences for the architectural form at the time of the change from tectonics to stereotomy, a kind of move from timber construction to solid construction. Mass construction and skeletal construction became established as man built his first shelters and, so far, represented opposite sides of the building industry's possibilities. This traditional duality explains why new materials not necessarily release a genuine tectonic change but lead to material transformations and hybrid tectonic forms. For instance, the structural and tectonic logic of steelwork is similar to that of timber frame construction. So far, these two concepts (solid construction –stereotomy –and frame construction –tectonics) designated the two archetypal construction systems, and all the subsequent forms of construction were derived from them. In the tectonics of compressive mass or stereotomy, solid walls are erected and perforated during the building process to create openings. This is how space is created and enclosed, appearing to be permanent, inflexible and rigid. On the other hand, in the tectonics of the frame a framework of slender linear members is erected first. This frame defines the space but does not enclose it: either it has to be clad with a skin, or the spaces between the linear members have to be filled in to create surfaces. By these means interior and exterior spaces are created. Since the framework does not dictate which bay is closed off or not, this tectonic form has increased flexibility, also during use. In this case, spatial flexibility appears to be inherent in the system. Architecture defines space and places it in an enclosure. This space can be further developed, either by increasing the volume or by multiplying the compartments which will then be linked together. Structurally, the linking of individual compartments shows a direct relationship between the openness of the space and the construction system. In compressive mass constructions, the openness of the interior spaces with respect to each other and also to the exterior space is greatly restricted. The solid walls are the dominating elements and the openings have to be introduced subsequently. In the other hand, the tectonics of the frame allows openings of any size anywhere, as long as they respect the logic of the framework. It could be said that the tectonics of the frame does not create architecture by means of connecting the spaces with each other. It defines a framework where individual spaces must be created by means of separating elements.

The third archetypal constructive system is first perceived with the use of boards. The use of timber boards in framework systems as stiffening elements might seem to seek structural and constructive improvements because solid and frame construction, in their true character, have long been unable to address new demands, thus moving towards

composite forms of construction. Modern timber manufacturing technologies allow the production of increasingly strong and slender materials that form the basis for the new tectonic form. More accurately, the new archetypal construction system is based on the panel. However, we could object that panels are not new to architecture: Loos, Rietveld, Le Corbusier, Schindler....all these architects used panels to achieve floating planes or to reconcile difficult junctions of spaces which differ in height. But in concrete construction, every step in a surface needs its own pour (casting), thus increasing the cost and labour involved. This meant that the concrete spatial constructions of the modern masters didn't find a total broad acceptance. But the surface elements (panels) produced by modern timber technology can develop new directions in architecture. Panelised construction is determined by load-bearing slabs or panels which are joined to form a stable assembly and ultimately the architectural form. An important characteristic that determines the design with panels is that they can span in two directions. Panels, which can span in any planar direction, are those made from timber by-products whose structure within the plane of the panel tends to be isotropic. Since timber is naturally a directional, or anisotropic, material, this distinction has only become possible due to progress in the manufacture of semi-finished and timber-based products (such as cross-laminated timber panels, for example). Their cross-layered composition gives panels great strength and rigidity; but most importantly, they are also directionally neutral, extendable in all directions and openings can be cut out where required. The homogeneous composition of the panel eliminates any recognizable internal hierarchy. In terms of production technology, it can be extended almost ad infinitum in the two surface dimensions. (Transport is the only practical limit.) Thus the panel becomes directionally neutral or indifferent to direction [6]. This becomes obvious in the treatment of openings. They can be freely cut out of the elements as if cut out of cardboard, making assembly and cut similar to model-making: openings do not even require a lintel, provided that there is enough material above the opening. Structurally speaking, panels carry different functions (load-bearing, bracing...) but not only is the structural behaviour modified, but their physical perception too because they do not show a structural hierarchy of primary and secondary elements. In surface tectonics, panels are joined together without a hierarchy that articulates their formal expression. Timber panels are synthetic elements. They are multifunctional from both a structural and a constructive point of view. The linear members that were once assembled on site can now be joined to the board in the workshop achieving a prefabricated surface unit. That way, on-site assembly both creates and encloses the space; and, due to the added structural stability achieved with the panel, this making process of the architectural form is not inflexible or rigid, but can be modified. Thus, surface tectonics also moves towards synthetic surfaces: intelligent

surfaces that solve problems of structure, building physics, weather protection and finishing, and at the same time simplify (reduce) the layered make-up of the element and challenge the traditional tectonic form based on nucleus and cladding. All these qualities can be considered not just innovative contributions to architecture but authentic tectonic changes. The third material procedure (or third archetypal system) of the built form is based on the assembly of surface elements and involves re-thinking the traditional spatial envelope in architecture. The third material procedure joins the multifunctional aspect of the tectonics of the compressive mass and the flexibility of the framework, being fundamental in phenomenological terms.

Conclusion

The architectural theory concepts stereotomy of compressive mass and tectonics of the frame were defined by Semper as the two different material procedures to divide the built form and describe the fundamental structural and constructive form of architecture. Theories that followed drew the conclusion that these two categories are suitable for describing the fundamental structural and constructive form of architecture and for demonstrating the principles of the origin and evolution of the architectural form. Therefore, stereotomy and tectonics designated the two archetypal construction systems, and all the subsequent forms of construction were derived from them.

Modern timber production technologies can produce multifunctional (loadbearing, enclosing, insulating...) panels that are directionally neutral, extendable in all directions and can be freely modified to achieve great flexibility. Their qualities can be considered not just innovative contributions to architecture but a trigger for authentic tectonic changes. The paper concludes that a third archetypal technical system can be perceived with the assembly of surface elements, joining both the multifunctional aspect of the massive systems and the flexibility of the skeletal systems, this third category being fundamental in phenomenological terms.

Endnotes

¹ Christian Norberg-Schulz, *Intenciones en Arquitectura*, GG Reprints. (Editorial Gustavo Gili, SA. Barcelona –Mexico 1998)

² R. Krippner, "Building with Systems- Learning from the 1960?", *Detail* Serie no. 4 (2001) Modular Systems: 602-607

³ Kenneth Frampton, "Rappel à l'Ordre: The Case for the Tectonic" in *Labour, work and architecture, collected essays on architecture and design*. (Phaidon 2002)

⁴ Gottfried Semper, *The Four Elements of Architecture and other writings*. (Cambridge University Press, 1989)

⁵ Gotfried Semper, *Style in the Technical and Tectonic Arts; or, Practical Aesthetics*. (The Getty Research Institute, 2004)

⁶ Deplazes, A., "Wood: indifferent, synthetic, abstract – man-made", *Werk, bauen + wohnen* no. 1-2 (2001): 78-81