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Esslinger Straße 24
D-70736 Stuttgart-Fellbach
tel. +49-711-5747 59
fax +49-711-5747 84
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Structuralism Reloaded. Rule-Based Design in Architecture and Urbanism

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Originally developed in linguistics, the structuralist approach has been introduced as a scientific method in anthropology and other human sciences since the 1950s. In the 1960s and 1970s the double category of primary and secondary structure (langue and parole), essential to structuralism, in which the primary structure's system of rules determines how the secondary elements are placed in relation to one another, also advanced to a leading ideology in the field of architecture and urban planning. From its development in the Netherlands and within the Team 10 circle of architects, structuralism in architecture quickly spread worldwide.

Since the 1990s we have been witnessing a revival of structuralist tendencies in architecture. Whereas the structuralism of the 1970s encountered limits in complexity that were insurmountable at the time, today there is much to suggest that the return to structural thinking is causally connected to information technology, which has opened up new possibilities for dealing with complexity. In the field of digital architecture there is talk of neo-Structuralism. The question arises as to whether primary and secondary structures of the 1960s should be understood today as being in a state of complex interactions with one another that could be described through algorithms. The current interest in design methods based on rules makes the structuralist approach one of the most productive and comprehensive methods for the organization, design, and production of the built environment. At the same time, it provides the systemic and meta-theoretical background for all disciplines involved in the production of space.

This book is a collection of 47 articles by renowned authors including, among others, Roland Barthes, Koos Bosma, Jörg M. Gleiter, Herman Hertzberger, Arnulf Lüchinger, Winy Maas, Sylvain Malfroy, Hashim Sarkis, Fabian Scheurer, and Georges Teyssot. Through well-founded theoretical contributions, the book provides the first comprehensive representation of historical and contemporary digital structural thinking in architecture and urban planning.

Tomáš Valena studied philosophy, art history, architecture, and urban design in Munich and at the Cornell University in Ithaca, New York. He has taught in Ithaca, Munich, Vienna, and Ljubljana and is currently professor of design and urban design at the Munich University of Applied Sciences. Tom Avermaete is associate professor of architecture at the TU Delft. His research concentrates on issues related to public space and public buildings, the architecture of the city and Modernism in non-Western contexts. Georg Vrachliotis is research fellow and postdoctoral teaching assistant at the Institute for the History and Theory of Architecture (gta) at the ETH Zurich and guest lecturer of architectural theory at the TU Vienna. His research focus is the history and theory of postwar architecture.

Distributors

Brockhaus Commission
Kreidlerstraße 9
D-70806 Kornwestheim
Germany
tel. +49-7154-1327-33
fax +49-7154-1327-13
menges@brocom.de

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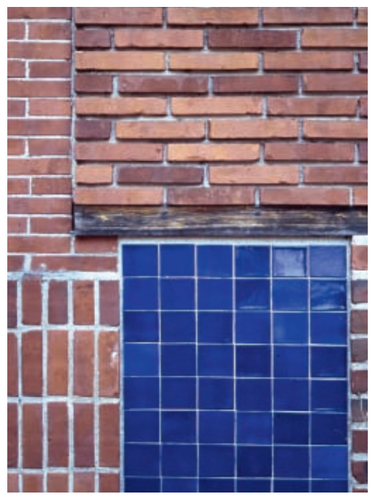


1. Philip Beesley, Hylozoic Soil. (http://www.philip-beesleyarchitect.com/sculptures/0913Medialab_Enschede/enschede_2.html.)
2. International symposium *Structuralism in Architecture & Urbanism Reloaded*, Munich, November 19–21, 2009. (Photo: Sandra Räni.)
3. Herman Hertzberger in conversation with Winy Maas, international symposium, *Structuralism in Architecture & Urban Planning Reloaded*, Munich, November 20, 2009. (Photo Sandra Räni.)
4. *Structura.* Alvar Aalto, model wall in his own vacation home in Muuratsalo. (Photo: Tomáš Valena.)

Tomáš Valena

Structural Approaches and Rule-Based Design in Architecture and Urban Planning

I belong to the generation who, as students, witnessed the intellectual environment of structuralism in the 1970s and experienced the hope, or the delusion, that the design process could be objectified numerically, making it possible to master the world. “We can work it out ...”, sang the Beatles in those days. But the world proved too complex to be controlled by the means that were available at the time. Eventually, the ideals of the sociopolitical and urban planning utopias of the period were thoroughly driven out of us, and an era of dry pragmatism followed.

Then in the mid-1990s, in the wake of the Europan 4 competition at the latest, we pricked up our ears again. Apparently a new generation of architects with a new set of tools had taken up something on which we had foundered earlier. Since that time, digital tools have pushed the limits of complexity to the far horizons of the possible, and thus today we are once again seeing everywhere a goal-oriented, often somewhat naïve optimism in the belief that anything is feasible.

Thus, it seemed justified to investigate the changes and / or the continuity of structural and rule-based thinking and its related architectural and urban planning output, referred to in the 1970s as structuralism and described today as rule-based parametric or algorithmic design or even neo-structuralism with a digital imprint. It was the questions regarding the similarities, affinities, and differences in structural thinking that led me to organize, in November 2009 in Munich, the international symposium “Structuralism in Architecture & Urban Planning Reloaded”.[1]

At the moment structural thinking is part of the mainstream of architectonic interest. Since the rapid and triumphant advance of digital drawing and design tools, work is obviously being done, belatedly, on laying a theoretical foundation for the profession’s new stance. In the process, theorists look not only forward but also backward for confirmation, as is usual in a time of upheaval, suggesting once again the significance of this new era. In colleges and universities everywhere people are working on structural issues, and architectural journals are publishing special issues on relevant topics. The Netherlands Architecture Institute in Rotterdam is preparing an exhibition on structuralism and, following the Munich symposium, three additional conferences on similar topics have already been held, in Bolzano, Kaiserslautern, and Zurich.[2]

This book is a collection of contributions to the Munich symposium. Many of the texts were deepened and developed further in subsequent, sometimes very involved discussions. Nevertheless, the editors did not strive to bring into line the often widely differing positions of individual authors. Thus, an authentic picture of the current status of the discourse on structural thinking in architecture emerges. The symposium contributions have been supplemented with a number of articles that were commissioned separately to adequately cover the broad spectrum of structural thinking.

Structural Thinking in Architecture Based on Apperception and Active Shaping of the World

We often speak without much thought of rules, order, or even laws in architecture, of structure and system. But what do these abstract terms mean? Where do they come from? Without going into the individual etymological derivations in more detail, it may be assumed that, like all other abstract terms, these terms were developed from a concrete spatial experience and apperception (*Anschauung*). Furthermore, the terms historically developed at a time when that which was looked at was not only recognized, but actively used and grasped [the German word for *term* or *concept* is *Begriff,* related to *greifen*, *to grasp*. Transl.]. Thus, the Roman *regula* (German *Regel*) was initially the lath or slat that had been used as a ruler, as a measuring stick, before it became the abstract rule. The Latin *ordo* advanced from the row of threads in a loom to sequence and finally to order as such. S*tructura,* too, was initially simply the masonry and consequently the entire building. The mason in ancient Rome was therefore a *structor*, because he fit together the bricks to form a wall according to a specific set of rules. We ought not to lose sight of this haptic, material origin of abstract concepts, even if we now take it for granted that we describe structure as an immaterial rule, as an invisible law that places the elements of a system in relation to one another.

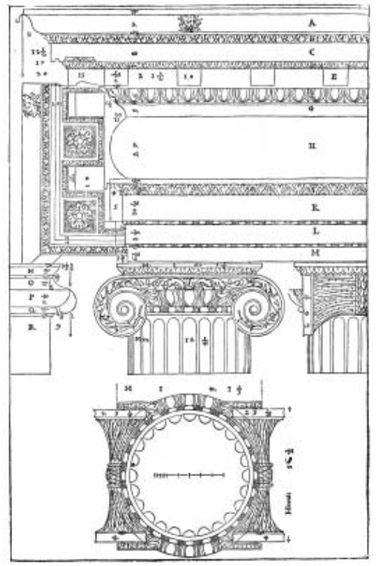
It is notable that every one of the terms referring to order and structure is associated with the active shaping of the human environment. If we agree with Gottfried Semper and his theory of the textile origin of architecture, all three key terms mentioned above even come from the narrower field of building construction. This is not surprising, seeing that building is the oldest and most comprehensive manual skill and craft for shaping the world. It is part of the canon of architectural theory that has been handed down to us that structural principles used in building were originally copied from nature. The translation of natural models into the work of man is done by means of abstraction, with the help of a concept of structure. In describing the origins of architecture or, more abstractly, the development of the idea of the enclosed space of the house from the natural model of the cave, the British architect Stephen Gardiner characterizes this achievement of the first builders as follows: “What they did was observe the minimum structure required to make space” and “to extract the essentials from a hole in a rock and reproduce them as an isolated man-made structure.”[3]

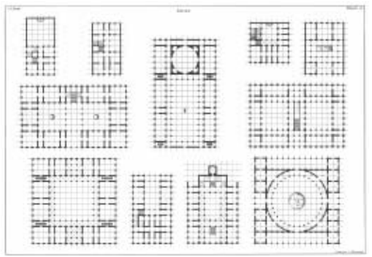
The world we are given is structured. We first experience its structure as a category of physical space. That is why structural thinking is the original domain of the discipline of architecture – which shapes space – and that is why it is inherent to building. Designing according to a rule, according to a preconceived structural idea, is one of the elementary, archetypal activities of building. That this is not merely an excessively powerful profession’s overestimation of its own abilities is shown by general usage, which cannot manage without spatial, architectonic metaphors whenever complex systems and structures are involved. “When the human intellect organizes a series of ideas”, says art psychologist Rudolf Arnheim, “it almost always uses spatial ideas.”[4] Kant, too, uses a spatial, even an architectural image, when he describes “the art of systems” in his *Critique of Pure Reason.*[5] And philosophers fall back on an *intellectual edifice* when they are trying to describe a system of ideas that is logically structured in itself.

To define structural thinking in architecture and the phenomena resulting from it, it is helpful to name the "Other" of what is structural and rule-based, in accordance with established philosophical methods. Thus, we might say that the opposite of what is rule-based is the accidental or spontaneous. With the physicist and philosopher Max Bense, we might also speak of redundancy or regularity versus innovation. The dual antithesis of type and topos (in the sense of *place*) introduced in architectural theory also quite aptly describes the Other of structural thinking. "If *type* means what is general, then *topos* means the individual, the specific and unique. While type produces comprehensible structures and an ideal order, context disrupts and alters them. ... While type tends toward the ideal, topos confronts us with reality."[6] Finally, designing and thinking in images, analogies, and metaphors can also be interpreted as the Other of digital, mathematically based systems thinking in architecture.[7] Thus, we touch on the fundamental antithesis between analog and digital, the two basic ways of being-in-the-world.[8]

According to this dual reading, structural thinking is present in every conscious act of architecture, although, of course, to varying degrees depending on the state of the ever-changing influence of the type and topos on the architecture of the times.[9] However, in the history of architecture there are also pure phenomena that can be assigned entirely to rule-based structural thinking. These phenomena have an impressive tradition that is as old as planning itself. Style architecture, for example, with its codified systems of various orders of columns, belongs in this category and has been widespread time and again. The science of proportion, which is based on strict mathematical laws, led to the idea of measurable beauty in architecture, an idea that was prevalent until the modern age. Thinking and planning in grids has been part of the common knowledge of the profession at least since the introduction of the Hippodamic system in Greek urban planning. The grid and typology are design tools consciously used in classical architecture since antiquity. Their use reached a provisional peak in Jean-Nicolas-Louis Durand's typology theory. And finally, we might also mention the scientific functionalism of the early modern age, which at times was ready to leave the entire architectural production at the mercy of the dictates of whatever scientific worldview prevailed at the time.[10]

5. The Ionic order according to Andrea Palladio. (Andrea Palladio, *Die vier Bücher zur Architektur*, Zurich, Artemis, 1983, 66.)
6. A table from Jean-Nicolas-Louis Durand's *Précis des leçons d'architecture*. (Jean-Nicolas-Louis Durand, *Précis des leçons d'architecture*, 1802–1805.)
7. Claude Lévi-Strauss, 1970. (http://pixdaus.com/pics/1257371838aXpVJ3Z.jpg.)
8. Arnulf Lüchinger, *Structuralism in Architecture and Urban Planning*, Stuttgart, 1981, book jacket.





Systems Thinking and Structural Thinking Outside Architecture

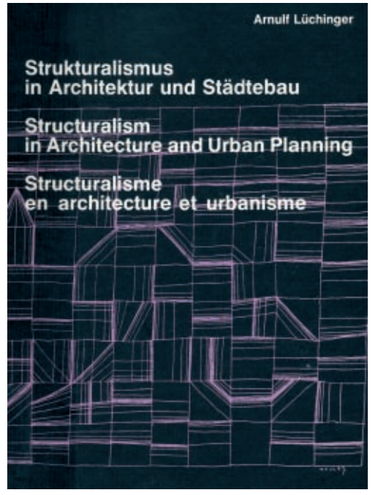
Now that we have postulated the primacy of structural thinking for architecture and described the invigorating and conceptualizing special position of the space-related disciplines, we can take a moment to consider the development of systems thinking and structural thinking outside architecture.

Mathematics – algebra and geometry – came about as the result of practical requirements in actively reshaping the world when it was necessary to measure it. Essentially a formal language, mathematics gradually developed into what is the most abstract numerical and topological system for describing reality. Based to a large extent on mathematical methods and models, the natural sciences also developed as scientific subsystems for investigating and describing various partial aspects (physics, chemistry, biology, geology) of measurable reality (animate and inanimate nature).

In the second half of the 20th century, and particularly since the 1960s, driven by the need to deal with the complexity of modern mass societies, structural research intensified and led to the formation of new scientific fields subsumed under the terms *systems theory* and *structural sciences.* Both claimed to be *the* metascience for an almost identical group of subdisciplines, which is also why it is difficult to clearly differentiate the two scientific fields.

The biologist Ludwig von Bertalanffy founded the school of thought known as *general systems theory* around the middle of the 20th century (although the term systems theory had been introduced in the 1920s in the fields of natural sciences and engineering). Because systems theory provides an interdisciplinary model for the description and explanation of complex phenomena, it is equally suitable for very different disciplines, from mathematics to natural sciences and humanities to subfields of technology. Thus, among others, the following disciplines are subsumed under the term systems theory: cybernetics, information theory, catastrophe and chaos theory, and the theory of complex systems, or the sociological systems theory of Niklas Luhmann.

The term *structural sciences* was coined in particular by Carl Friedrich von Weizsäcker in the 1960s and 1970s as a metaconcept for individual sciences such as mathematics, logic, information technology, information theory, systems theory, cybernetics, synergetics, and semiotics. These lists make it clear that s*ystem* and *structure* are often used synonymously.



However, the first discipline to develop structural thinking into a (structural) science was s*tructuralism,* as already developed in a rudimentary form before World War I by the Swiss linguist Ferdinand de Saussure. He investigated the rules and conventions that underlie individual linguistic expression. By distinguishing *langue* (language) and *parole* (speech), he introduced the double category of primary and secondary structure, in which the secondary individual elements are brought into relation with each other by the primary structure's set of rules. In the period between the world wars, de Saussure's ideas were picked up and further developed, on the one hand by, the Russian formalists, who introduced the term structuralism in the 1920s, and, on the other hand, by the structuralist school of Prague under Roman Jakobson, Jan Mukařovský and Nikolaj Trubetzkoy. After World War II, it was primarily the French ethnologist Claude Lévi-Strauss who, inspired by Jakobson, had adopted, refined, and used the structuralist model for anthropology.[11] During the 1950s and 1960s, the structuralist approach, which tries to explain observable surface phenomena by deeper structures, advanced to become the central method in the humanities. But, in the final analysis, structuralism in areas such as linguistics, ethnology, and anthropology was prompted by the desire to introduce scientifically demonstrable methods in the humanities to lend them the legitimacy enjoyed by the natural sciences, which were perceived as "objective".[12]

Because of its fundamental orientation – a search for permanent, universal, deep structures below the surface manifestations of phenomena – structuralism has been called a deterministic and synchronic science, in contrast with the diachronic sciences, which investigate the evolutionary processes of phenomena. From this perspective, process and structure were brought into opposition with each other. However, the concepts of structure and process need not be described as a pair of opposites, but can also be described as a complementary pair. Even the activity of observing and investigating structure has a time dimension and can thus be called processual. Thus a number of structuralist thinkers have rejected this one-sided categorization as a counterproductive constriction. "The juxtaposition of synchrony and diachrony was a juxtaposition of the concept *system* and the concept *evolution*. It loses the importance it has in principle provided that we recognize that every system necessarily exists as evolution and on the other hand evolution inevitably has the character of a system."[13]

It must be noted here that structuralism in the humanities was by no means the homogeneous phenomenon it was considered to be from the perspective of architects. In the humanities, too, depending on the field of specialization and school of thought, it is necessary to speak of a number of structuralisms, of structuralism in the plural. Here also were descriptions implanted by outsiders, factional disputes and disputes about what constitutes "true" structuralism. Lévi-Strauss's sigh is indicative of this: "Nor do I believe that we can still speak of one structuralism. There were a whole lot of movements that claimed to be structuralist, and others that outsiders described as structuralist although they were not structuralist in the opinion of the representatives of the movement themselves."[14] We should keep this in mind as we now look at the interactions between the various structuralisms in the humanities and in architecture.

Structuralism in the Humanities and in Architecture

We have seen that structural thinking and acting is, on the one hand, inherent to architecture. On the other hand, in the postwar period systems thinking and structural thinking had intensified in all areas of intellectual and social life. In the 1960s structuralism was firmly established in the humanities as a scientific method, and its significance was generally recognized. In the 1970s the term was also introduced in architecture. The history of how the term structuralism was adopted in architectonic discourse has not yet been settled beyond doubt.[15] It appears, however, that in the early days the structuralistically active architects had not initially made direct references to the structuralism concept in use in linguistics and anthropology, although it was very familiar, particularly in such circles as *Forum* and Team 10 (which saw itself as a study group investigating "relations between social and built structures"); members of both groups adopted the basic tenets of structuralism.[16] In any case, it should be noted that "structuralism" in architecture was initially not the name used by representatives of the movement, but was introduced only much later and from the outside as a general label for certain phenomena in architecture and urban planning during that period. This is also one reason that many architectural historians (particularly in the Netherlands) have been fighting this "label" as a description of an architectural movement and are still fighting it as inappropriate. However, a subsequent "inappropriate" designation of an intellectual attitude, art movement, or "style" imposed from the outside tends to be the rule rather than the

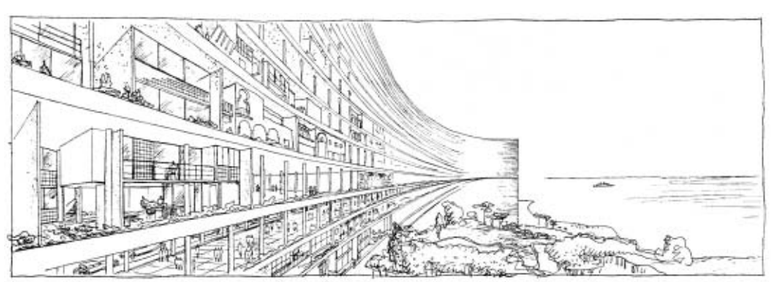
exception in art history (as happened with terms such as Gothic, baroque, and Renaissance).[17] In the end, what is essential, regardless of its appropriateness, is whether and to what extent the designation has been generally introduced and whether it has gained currency. This is clearly the case for what was called “structuralism” in 1960s and 1970s architecture. Worldwide, people understand what kind of architecture is meant by this designation. To fight against it is like tilting at windmills.

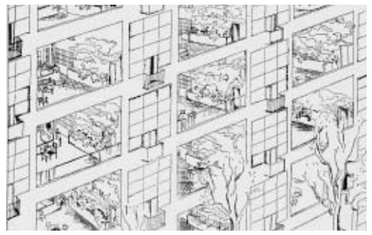
In the special case of architectural structuralism there is admittedly the confusing fact that its name is identical with that of structuralism in the humanities. The latter designates a more or less accepted scientific method, which in totality cannot be applied to architecture. Between the structuralisms in the humanities and structuralism in architecture there is some overlapping but no congruence. That is also why the “scientific nature” of structuralism in the humanities cannot be made into the measuring stick for structuralism in architecture. We shall probably have to get over this “confusion” of terms. It will be all the easier the more resolutely we start out from an original, “autochthonous” concept of structure in architecture.

Moreover, those who want to measure architectonic structuralism in relation to the structuralisms in the humanities misjudge the fundamental difference between the reflexive and the poetic structuralist activity. Although, according to Roland Barthes, “the goal of all structuralist activity, whether reflexive or poetic, ... is to reconstruct an ‘object’ in such a way as to manifest thereby the rules of functioning (the ‘functions’) of this object”,[18] the specifics of analytical and design activity (approach) must be observed here. While the analytically active ethnologist unearths unconscious “deep structures” of cultural artifacts, the poetically active architect (the designer) consciously bases a design on a structure, a rule, a “law”. What is specific to architectonic structuralist activity, however, is the fact that in the built work the immaterial structures on which it is based are manifested permanently and materially, and thus become their visible image.

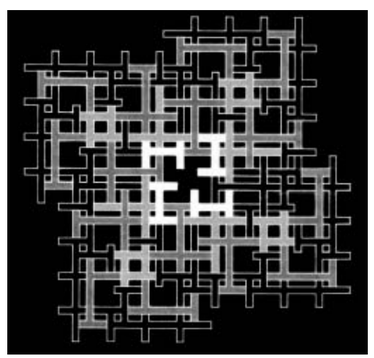
As far as structuralism in architecture is concerned, we are today confronted with a peculiar situation. On the one hand, the term has been introduced and is understood worldwide, and there is general agreement as to which buildings and projects can be classified as structuralist. The term was launched in the 1970s, was picked up by many authors and found its way into the architectural histories of the 20th century.[19] However, there is still confusion regarding the different nature of structuralisms in the humanities and in architecture, an issue that the Munich symposium also failed to surmount.

Most authors writing about structuralism in architecture are confronted with the need to deliver their own definition of structuralism for the buildings and projects they describe. Reyner Banham deals with what was later labeled as structuralist architecture as early as 1976 under the generic term *megastructure* and thus gives the phenomenon a one-sided orientation.[20] Wim van Heuvel, on the other hand, appears to reduce structuralism to the visible structure that organizes space, and we can read between the lines that he would like to declare it a Dutch “national style”.[21] Arnulf Lüchinger[22] distinguishes two currents in a review of this period. First, he characterizes the summation of standardized secondary elements as the “aesthetic of number”, a term he takes from Aldo van Eyck (clearly illustrated by van Eyck’s orphanage in Amsterdam). With the two-component method of construction, in contrast, Lüchinger describes individual secondary elements that are inserted into a primary structure; he identifies this line of development in structuralism with pluralism and user participation (Le Corbusier’s Fort l’Empereur project for Algiers is often cited as an example of this approach). The differentiation between a structure with a long life cycle and less permanent infills is also important for Herman Hertzberger, which puts him in agreement with John Habraken on this point.





9. Le Corbusier, *Fort l’Empereur* project, Algiers, 1931–34. (Arnulf Lüchinger, *Structuralism in Architecture and Urban Planning*, Stuttgart, 1981, 59.)
10. Le Corbusier, *Immeuble-Villa*, project, 1922. (Le Corbusier, *1922. Ausblick auf eine Architektur*, Braunschweig, Bauwelt-Fundamente, Vieweg, 1982, 185.)
11. Cover of Bernard Rudofsky, *Architecture without Architects,* New York, 1964.
12. Piet Blom, Noah’s Ark project, plan of a district unit, 1962. (Aldo van Eyck, *The Child, the City and the Artist*, Amsterdam, 2008, 167.)



For the most part, the following characteristics are mentioned in contemporary literature as distinguishing marks of structuralist architecture and urban planning until well into the 1980s: the summation of identical elements; a modular structure; infinite extensibility because of a clearly predetermined development principle (self-generative structures); a structural framework (primary structure) in which smaller units are inserted (infill, secondary elements); the primary structure as design tool or as actual supporting structure with a much longer life cycle than the secondary elements; handling of a project at the level of the building and simultaneously at the level of the city;[23] and in mat-building, often the concept of superimposition or elevation from the ground.

Structuralism as an Architectural Phenomenon of the 1960s and 1970s

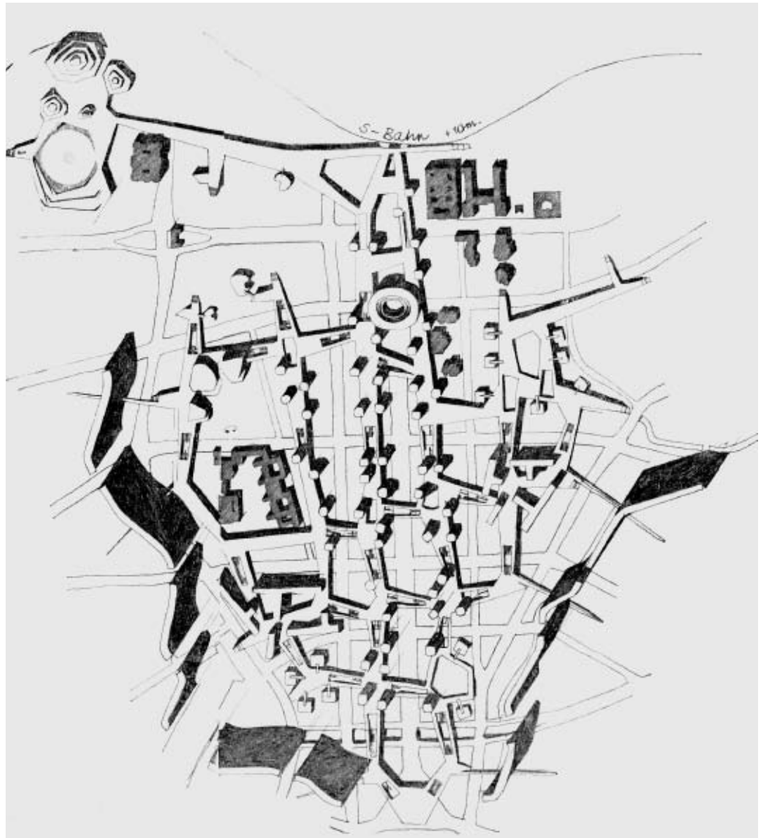
If we examine those buildings and urban planning projects of the 1960s and 1970s that broadly meet the criteria listed above, the result is a very diverse picture, showing an almost worldwide dissemination of the structuralist phenomenon. There are universal motifs and intellectual attitudes and specific local, as well as individual, variants. Just as in the humanities, there are different structuralisms in architecture as well. The essential differences can be seen less in the appearance of the projects than in the basic philosophical position of the creators. There is the humanistic / anthropological orientation of Aldo van Eyck, the technological focus of Eckhard Schulze-Fielitz, the specific philosophy of metabolism in the work of the Japanese metabolists, or the pop-cultural use of plug-ins in the work of Archigram.

If, as we have seen, the structural approach is inherent to architecture, then the structuralism of the 1960s and 1970s not only has “precursors”, but an impressive tradition of its own. To illustrate this, it is sufficient to take a short look at a representative example – the work of Le Corbusier, in which the idea of primary and secondary structure had been present from the very beginning, from the modular Domino House construction system, the module of the Immeuble Villa, which in conformity with various primary structures can be stacked into different types of houses to various projects for mat-building, to his last, purely structuralist project for the hospital in Venice, a “flying carpet” dated 1964.[24]

The return to “structuralist precursors” in historical architecture definitely had a certain tradition among the pioneers of structuralism in Team 10.[25] Presumably inspired by structuralist ethnology and anthropology, an *Architecture without Architects*[26] also provided essential stimuli. In the course of several journeys, Aldo van Eyck studied Dogon villages in northwestern Africa as well as Pueblos in New Mexico and presented them, through articles in *Forum,* as anonymous *incunabula* of structuralism.

The earliest center of structuralist theory and practice in architecture can be found in the Netherlands in the late 1950s in the orbit of the magazine *Forum*. Team 10, critical of CIAM and closely associated with the *Forum* publishing group, was intensively involved in the development of structuralist thought and contributed to its dissemination over diverse contacts. There is evidence of connections to the metabolists in Japan, to the high-tech pop scene in England, to the situationists, to Moshe Safdie’s Habitat, to Le Corbusier’s office, and numerous further connections that still need to be investigated.

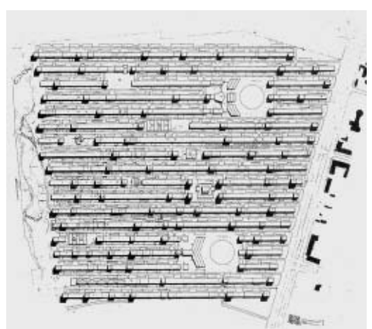
Aldo van Eyck was without doubt the central figure in the early days. As one of the editors of the magazine *Forum* and an active member of Team 10, he gave Dutch structuralism an “ethnological” viewpoint and an anthropological orientation through his research trips and his basic humanist attitude. Moreover, it was also van Eyck who was able to execute an early reference object for structuralist architecture, his 1960 orphanage in Amsterdam. As a student of van Eyck, Piet Blom had already begun to extend the repertoire of architectural structuralism with his Noah’s Ark project. He experimented with multi-component structures and with a multi-layering of carpet structures, elevated to leave the city’s “ground floor” free for the public. This theme also preoccupied Blom in his executed projects De Kasbah in Hengelo (1969–1873) and the tree-shaped developments in Helmond and Rotterdam (beginning in 1972). Jakob Berend Bakema – like van Eyck, active with *Forum* and a member of Team 10 – used his large office to explore the structuralist approach in architectural practice. With the administration building for Centraal Beheer in Apeldoorn (1970–1972), Herman Hertzberger, still the face of Dutch structuralism today, probably achieved the second most important “incunabulum” of structuralism in the Netherlands. With the work of these and many other architects, modularity and the carpet-like weaving of textures became anchored as essential design and construction principles of architectural structuralism.



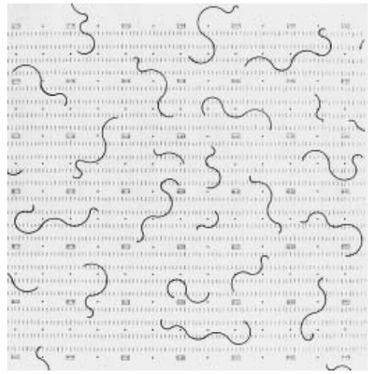
13. Alison and Peter Smithson with R. Sigmond, competition project *Hauptstadt Berlin*, 1958. (*Team 10 Primer*, ed. Alison Smithson, Cambridge, MA, MIT Press, 1974, 56.)
14. Stefan Wewerka, residential development Berlin-Ruhwald, competition submission, 1964. (Volker Fischer and Andrea Gleiniger, *Stefan Wewerka. Architekt, Designer, Objektkünstler*, Stuttgart and London, Edition Axel Menges, 1998.)
15. Archizoom, No-Stop City, 1970. (Marie Theres Stauffer, *Figurationen des Utopischen*, Munich, DKV, 2008, 334.)
16. Kisho Kurokawa, Nagakin Capsule Tower Building, Ginza, Tokyo, 1970–1972. (Kisho Kurokawa, *From Metobolism to Symbiosis*, London, Academy Editions, 1992, 161.)
17. Peter Cook, Archigram, Plug-In City, 1962–1964. (*A Guide to Archigram 1961–1974,* ed. Peter Cook, London, 1994.)
18. Constant Nieuwenhuis, New Babylon. (Ruth Eaton, *Die Ideale Stadt*, Berlin, Nicolai, 224.)

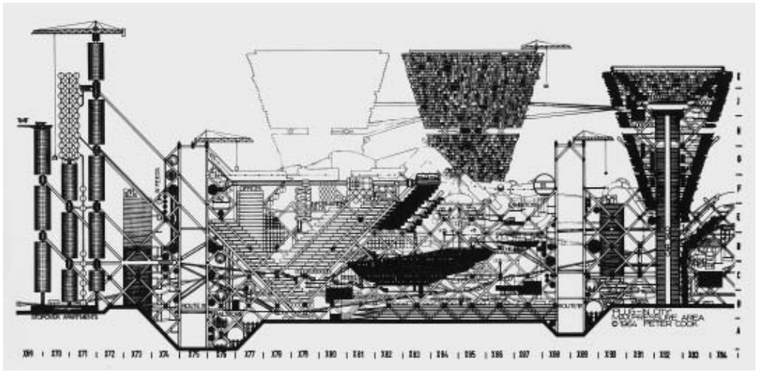
Somewhat apart from this core group of Dutch structuralists but no less influential was John Habraken, who laid the theoretical foundations of participatory structuralism with his work *Supports. An Alternative to Mass Housing*[27] and who was also later the director of the SAR Group (Foundation for Architects' Research). Habraken recognized early on the potentials as well as the dangers of industrial prefabrication in mass housing and ushered in the democratic principle of user participation through the use-neutral, flexible primary structures that could be filled by the individual user.

Team 10 members Alison and Peter Smithson experimented with the principle of the layering of various types of transportation, visible already in their contribution to the competition "Hauptstadt Berlin" in 1958. This project presumably influenced Constant Nieuwenhuis and his New Babylon studies, with their netlike sectors fit on to one another and floating above the ground. Georges Candilis, Alexis Josic, and Shadrach Woods executed the mat-building of the Free University in Berlin (1963–1973)[28] as well as the Toulouse-le Mirail development (1961–1974) with its stem structure. A connection can also be established between these architects and Le Corbusier in his late structuralist phase. Team 10 member Stefan Wewerka designed residential developments of linear rows "fortified" with towers and the structuralist approach was widespread in urban planning competitions in the Federal Republic of Germany during the 1960s and 1970s.



In the 1960s and 1970s, the 20th-century's second utopian heyday, there were hardly any utopian movements that were not touched by structuralism. The Plug-In City (1962–1964), conceived by Archigram member Peter Cook, attained an almost iconic character for structuralism. Here progress-embracing, high-tech pop architecture made use of the structuralist principle to combine durable concrete bearing structures with industrially prefabricated throw-away residen-

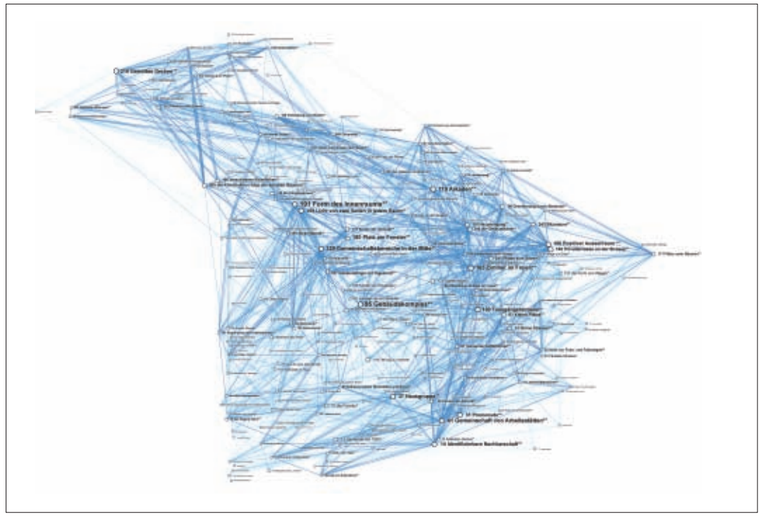


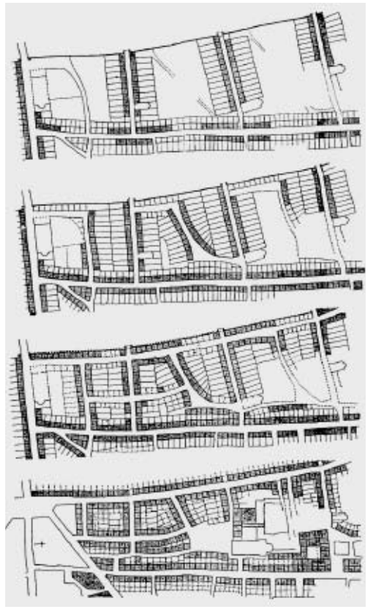


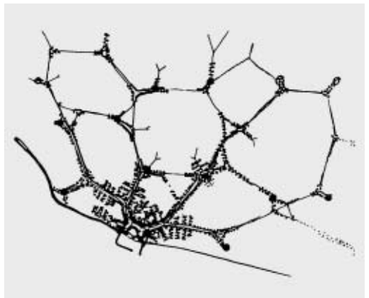
tial cells. Although based on very different philosophical premises, Japanese metabolism arrived at rather similar results structurally, as can be seen, for instance, in the Nagakin Capsule Building by Kisho Kurokawa (1970–1972). The Italian group Archizoom quite obviously followed other goals, but it too organized its ironically intended endless artificial landscapes on the basis of structuralist conventions.

The structuralist principle of the supporting primary structure and in-filled secondary elements is perhaps most purely executed in the special category of the spatial cities or the "flying carpets". The poetic drawings of the Ville Spatiale by Yona Friedman always show a primary spatial framework with flexibly inserted residential cells suspended above the site.[29] This utopian idea was very seriously pursued in Germany in particular. Constructively emphasized designs of spatial cities were made by architects such as Eckhard Schulze-Fielitz; Richard J. Dietrich's Metastadt was one of the rare realizations.[30] The spatial city expanded the structuralist theme of carpet development, the flying carpet, layering and superimpositions, moving toward genuine 3D developments such as residential hill or large-scale tree structures.

It is also illuminating to review several research projects from this period from the perspective of the structuralist approach. Especially rewarding here is *A Pattern Language* by Christopher







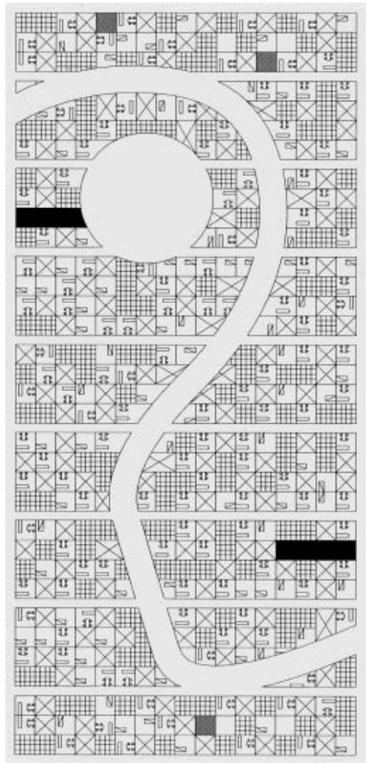
Alexander.[31] A differentiated system of reciprocal references among the patterns forms a complex primary structure, which puts the 253 patterns in relationship to one another. The morphological-typological way of looking at city and territory, introduced by the work of Saverio Muratori and his "school",[32] can be understood as a method for revealing the "genetic code", the original primary structure of a territory, by investigating the mutations of types. The rise of the typology discourse at that time, as well as the discussions of archetypes in architecture, the theory of permanence in urbanism, and the interest in Maurice Halbwachs's thesis of the collective memory,[33] all appear to be inquiries into deep structures, as had been posed earlier by the founders of structuralism in linguistics and anthropology.

It was the great era of normative systems, of serious (often dogged) attempts at (numerical) objectification of the design process, of mistrust of the "arbitrariness" of the subjective, of the individual, of artistic decision. In this context we can recall Constantin Doxiadis's ekistics,[34] the experiments and research by Buckminster Fuller, or Max Mengeringhausen's Mero system.[35] We must likewise consider the extent to which research on self-generative structures, carried out since 1968 by Frei Otto and others within the Sonderforschungsbereich (Collaborative Research Center) 230 "Natural Structures – Lightweight Structures in Architecture and Nature"[36] at the University of Stuttgart, has also involved an intrinsic structuralist issue. And finally, at least in passing, it must be pointed out that the beginnings of cybernetics and computer applications,[37] on which today's algorithmic design with evolutionary (interactive) parameters is ultimately based, are also to be sought in this period.

"Applied" or "pragmatic" structuralism spread rapidly throughout most of the world in the 1960s and 1970s. It turns up as design methods used in urban planning, as an organizational model for complex building tasks or simple residential floor plans. The approach generated modular arrangements of large structural systems and formed the basis for the industrialization of building production. We find structuralism at a high conceptual level in the USA in the work of Louis Kahn or Paul Rudolph, or reduced to the industrial prefabrication of building components in the uninspired high-rise *Plattenbauten* of the German Democratic Republic, as well as in elegant modular concrete structures in former Yugoslavia[38] or as the design principle behind residential buildings in Australia.

Nevertheless, by the late 1970s structuralism had lost its appeal as the leading ideology in architecture and urban planning. The era of postmodernism had arrived, the era of poststructuralism in philosophy and the humanities. Although structuralism in architecture initially emerged with a claim of developing more humane environmental structures for mass society and thus was intended as a critique of mechanistic, machine-loving images of the modern age, ultimately it was never able to liberate itself from the taint of seriality and determinism. Its utopian impetus also remained committed to the spirit of the modern age. Structuralism was radically swept away with

19. Christopher Alexander, *A Pattern Language.* A system of reciprocal references among the 253 patterns forming a complex primary structure. (*Arch+,* no.189, October 2008, 1.)
20. G. Caniggia and S. Bollati, restitution scheme of the development of the quarter Tor di Nona in Rome. (Sylvain Malfroy, *Die morphologische Betrachtungsweise von Stadt und Territorium*, ETH Zurich, Lehrstuhl für Städtebaugeschichte, 1986, 104.)
21. Frei Otto, a self-generated settlement structure. (Frei Otto, *Occupying and Connecting. Thoughts on Territories and Spheres of Influence with Particular Reference to Human Settlement*, Stuttgart and London, Edition Axel Menges, 2009.)
22. Louis Kahn, Indian Institute of Management, Ahmedabad, India, 1962–1974, entry-level plan. (Robert McCarter, *Louis Kahn*, London, Phaidon Press, 2005.)
23. Kazuyo Sejima, low-rise housing project, 1994–1995. (*Kazuyo Sejima, Ryue Nishizawa 1987 to 2006*, ed. Yukio Fugatawa, Tokyo, 2005, 50.)
24. Gunther Zsolt and Katalin Csillag, project for Graz-Eggenberg, Europan 4 competition, 1995. (*Die Stadt über der Stadt bauen. Europan 4 Europäische Ergebnisse*, ed. Didier Rebois, Paris, 1997, 205.)

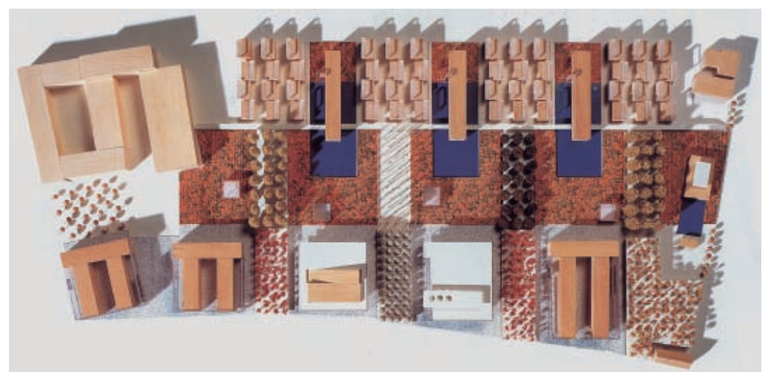


the rise of the new-old values of postmodernism, the return of individuality and the sense of place, context, and history. The models that had been executed, often as megastructures, were believed to be inhumane. They mostly failed in their actual use. Architectural structuralism's lack of hierarchy and the resulting orientation difficulties, the dearth of individuality in view of its serial monotony, and the dominance and determinism of the primary structure as well as the generally non-iconic character of the resulting architecture – all this contributed to the reproach of antihumanism. In the final analysis, however, structuralism also failed because of its unadmitted claim to provide universal, objectified – and thus unchallengeable – foundations for design decisions.[39] This hubris was shattered in the 1970s by the then-insurmountable limits of complexity.

Structural Tendencies Since the 1990s

Since the 1990s we have been seeing an increased interest in structuralist approaches in architecture and urbanism. Although the structuralist tradition presumably never ended completely in the Netherlands, in the rest of Europe it was taken up anew no later than the Europan 4 competition[40] in 1995. The varied proposals for carpet developments and mat-buildings recalled projects of the 1960s and 1970s in a striking way.[41] Despite the differences, it was obvious that young architects had again turned their interests to rule-based design methods. The primary structures mostly followed the orthogonal grid, but complexity was substantially increased, thanks to the new possibilities presented by information technology. The architects of the 1990s discerned the inadequacy of structuralist methods for creating a sense of identity in carpet developments; this led, in contrast to the amorphously proliferating structures of the 1960s, to a preference for a delimiting overall form and often to the extension of the primary structure to elements that were hierarchical and not integral to the system, or even ultimately arbitrary. There was a conscious confrontation of an overdetermined system with intruding or even irrational elements (see, for instance, the low-rise housing project by Sejima or the placement of the Philological Library in the mat structure of the Free University of Berlin by Norman Foster from 2005). Parallel to this revival, interest in the utopian aspects of structuralist currents in the 1960s also increased. In the search for inspiration since the turn of the new century, a continuous series of publications, exhibitions, and symposia[42] have looked at the unique mixture, often playful and even sometimes explosive, of faith in technology and the future, addiction to pleasure, and utopian social ideas of the "Swinging Sixties".

The so-called digital "neo-structuralism"[43] of the early twenty-first century differs not only from its precursors in the 1960s, but also from the forms of the revival of structuralism in the 1990s. Many of its protagonists appear to have neither a historical knowledge of classical structuralism nor any interest in reflecting on the cultural background of the phenomena. But based on detached observation, it becomes obvious that today's neo-structuralism originates to a great degree in a mind-set similar to that of "heroic" structuralism, exhibits a comparable readiness to surrender to the rule and a similar faith in progress and feasibility, and still hangs onto the dream of fulfilling "the promise of individuation ... through numerical planning and production technologies".[44]



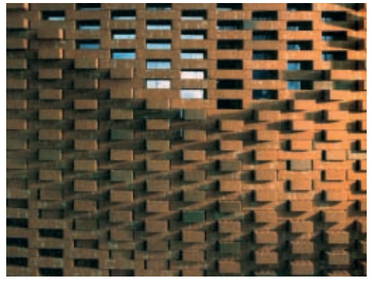
Thus, the question arises to what extent the new themes and phenomena, and the current ambiguous concepts of digital design, represent something completely new or may be interpreted as the further development of the structuralist approach. Of course, there is no longer talk today of primary and secondary structure but rather of the algorithmic, parametric, interactive, and evolutionary (even genomic). Naturally, these can all be combined under the heading "rule-based", where certainly the structuralist approach and older rule-based design methods can also be subsumed. Let us, then, try to "demystify" the new terminology and thus penetrate to the core of its meaning. The deterministic algorithm can be compared with a set of instructions (like Ikea assembly sheets or a cooking recipe) which puts the ingredients or building elements into a relationship with one another through multiple sequential steps, so that the same result always comes out at the end. Although more complex than the primary structure of a simple orthogonal grid, which organizes the position of the individual infill elements, the algorithm remains essentially a system of rules. If the individual elements can be varied by us in size, shape, or arrangement and the overall result changes accordingly, then we could refer to a "parametric algorithm"; If we, moreover, make it possible for the individual elements to react (cybernetics), according to certain behavioral rules we implant, to changes in the other elements, or in the overall system (the environment), we could speak of an "interactive parametric algorithm".[45] Although the complexity can be increased that way almost beyond bounds, this "evolutionarily" developing algorithm can still be characterized as a dynamically evolving rule (evolutive matrix), which sets in a dynamic way the position and the characteristics of the elements in relation to one another. Ultimately, everything that can be programmed follows a rule, no matter how complex; it is rule-based. In the structuralist terminology, this rule was called *langue* – deep or primary structure. Whether one searches analytically among the world's existing or manmade structures for this rule, which forms the basis of the surface phenomena, or one works "poetically" (i.e., designing and building something new according to a rule), it is rule-based practice and one is, in the words of Barthes, performing a structuralist activity.[46] Only on this level does it seem meaningful to talk of there being a renewal of the structuralist project, of a continued development from the old primary structure to algorithm.

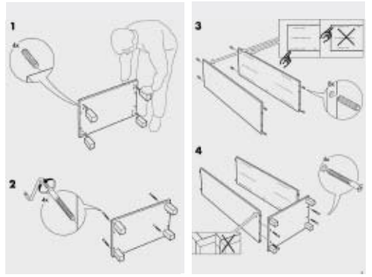
The new digital design tools, if used consistently, generate a new architecture. At the same time, we are currently observing that at the leading edge of developments there is a split into two fundamentally different approaches. First is the still predominant iconic design, except that now it is implemented with the new design tools. This "iconically" designed architecture is subsequently geometrized, provided with mathematical rules, and made "buildable" (usually by specialists). Thus, for instance, the buildings of Frank Gehry are created by a subsequent "rationalization" of the sculptural iconic concept. And when Patrik Schumacher describes *parametrism* as the new International Style with unmistakable formal, iconic distinguishing marks,[47] what is involved is not a rule-based, parametric design process, but rather an image-based one. This line of development in architecture is thus part of the old tradition of designing that starts from an image or a metaphor, a tradition to which postmodernism also belongs.

On the other hand, there is a digital, geometrically and mathematically grounded, "rule-based" design. From the start it is based on languages, sets of rules and programs, and is thus part of the tradition of structural, rule-based thinking in architecture. Because of the complexity of form achieved in the meantime and the mathematical and geometric expertise required to produce it, this type of design is increasingly relegated to the research departments of large firms or to special service providers.[48] It is along this line of development that the heirs of structural thinking in architecture can be found today. In the medium term, this is also where a split of architecture into two professions is in the offing, similar to the emergence of civil engineering as an independent profession in the nineteenth century.

The current massive return to the term and thus also to the phenomenon of structuralism forces us to reflect more deeply about the nature and the tradition of structural thinking in architecture and urban planning. For this reason, in the present publication it seemed necessary to examine in particular the contents, mind-sets, and accompanying manifestations of historical structuralism to be able to adequately contextualize present-day phenomena. If the term structuralism in architecture is to be more than a label for a past or present historical period, then it must describe, in an abstract manner, the specific principle of thought, design, and generation for an architectural approach that in the broadest sense is based on rules. The term structuralism may initially have developed in other disciplines and been imported, possibly even with specific deposits from these disciplines, into architecture. However, for architectural use structuralism as a term should be liberated from all sediments from other fields and should be newly defined from the

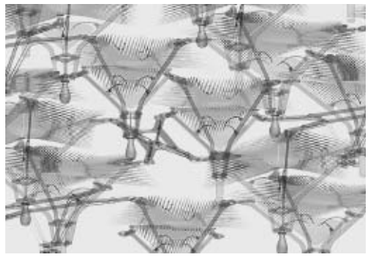
25. Zaha Hadid, Soho City, Peking, project 2003. (*Arch+*, no. 195, November 2009, 107.)
26. Gramazio & Kohler, brick wall fabricated by an industrial robot, 2006–2007. (Fabio Gramazio and Matthias Kohler, *Digital Materiality in Architecture*, Baden, Lars Müller Publishers, 2008, 62.)
27. Ikea construction manual.
28, 29. Philip Beesley, Hylozoic Soil. (http://www.philipbeesleyarchitect.com/sculptures/0913Medialab_Enschede/enschede_2.html.)

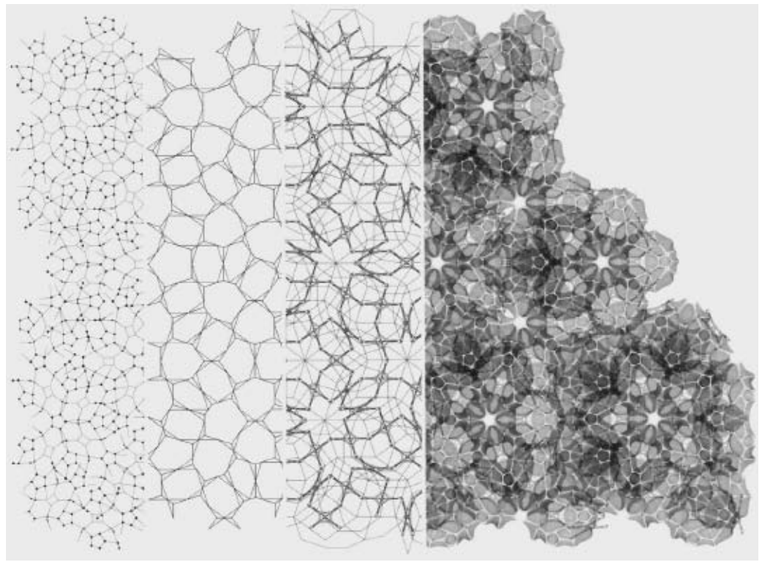




autonomous sources of its own discipline of spatial construction. However, to avoid confusion, the term should not veer unnecessarily far from the definition originally developed in linguistics. Roland Barthes's basic description of structuralist activity, which refers to the underlying rule, could again be helpful here. The definition will revolve around the rule, the deep structure, the primary structure that assigns the separate elements (whether standardized or individual) their position and thus places them in relation to one another. Structuralist activity, inherent to architecture, allows us to build a bridge not only between the heroic phase of structuralism in the 1960s and 1970s and today's new structuralism, but also to related phenomena in building activity overall. It is on this level that an attempt can be made to place these various phenomena of a structural, rule-based architecture in the context of a history of ideas.

[1] http://www.architektur.hm.edu/aktuelles/strukturalismus_e.de.html. See also the catalogue for the symposium.
[2] "Digital. Material. Structural. Ornament Today", conference at the Department of Design and Arts, Free University of Bozen / Bolzano, May 31–June 1, 2010. "Structural Thinking in Architecture", international symposium at the Technical University of Kaiserslautern, Department of Architecture, June 9, 2010. "The New Structuralism. Design, Engineering and Architectural Technologies", a symposium organized by the Architekturforum Zürich, October 7, 2010.
[3] Stephen Gardiner, *Evolution of the House* (New York, 1974), 3.
[4] Rudolf Arnheim, *Die Dynamik der architektonischen Form* (Cologne, 1980), 276.
[5] "Ich verstehe unter einer Architektonik die Kunst der Systeme. Weil die systematische Einheit dasjenige ist, was gemeine Erkenntnis allererst zur Wissenschaft, d. i. aus einem bloßen Aggregat derselben ein System macht, so ist Architektonik die Lehre des Szientifischen in unserer Erkenntnis überhaupt, und sie gehört also notwendig zur Methodenlehre." Immanuel Kant, *Kritik der reinen Vernunft, Werke IV* (Frankfurt am Main, 1968), 695. "By an architectonic I understand the art of constructing systems. As systematic unity is what first raises ordinary knowledge to the rank of science, that is, makes a system out of a mere aggregate of knowledge, architectonic is the doctrine of the scientific in our knowledge, and therefore necessarily forms part of the doctrine of method." *Immanuel Kant's Critique of Pure Reason*, trans. Norman Kemp Smith (New York, St. Martin's Press, 1968), 653.
[6] Tomáš Valena, *Beziehungen. Über den Ortsbezug in der Architektur* (Berlin, Ernst & Sohn, 1994), 13.
[7] See, e.g.: O. M. Ungers, "Designing and Thinking in Images, Metaphors and Analogies", in: *MANtrans-FORMS: An International Exhibition on Aspects of Design*, ed. Hans Hollein (New York, 1976), 98–113. See also the article by Thomas Will and Roland Züger about O. M. Ungers in this book.





[8] See, e. g.: Otl Aicher, *Analog und digital* (Berlin, Ernst & Sohn, 1991).
[9] Tomáš Valena, 1994, 68.
[10] See, e.g.: Rostislav Švácha, Soňa Ryndová, Pavla Pokorná, *Form Follows Science. Teige, Gillar and European Scientific Functionalism, 1922–1948* (Prague, 2000).
[11] It is common knowledge that Lévi-Strauss's ideas of the deep and surface structures were also influenced by the layer model of geology.
[12] Cf. e.g., the remarks of Peter Bexte in the present publication, p. 18: "In the 1950s Lévi-Strauss had attempted to create a base for structuralism by means of a mathematics that he borrowed from the Nicolas Bourbaki group."
[13] Jurij Tynjanov and Roman Jakobson, "Probleme der Literatur- und Sprachforschung", in: *Texte der russischen Formalisten*, vol. II, ed. Wolf-Dieter Stempel (Munich, 1972), 389.
[14] Lévi-Strauss, "Intervista a cura di M. d'Eramo", in: *Mondoperaio*, 32/2 1979, 118–124, 118 b–119 a. Quoted from the German publication: "Die strukturalistische Tätigkeit. Ein Gespräch mit M. d'Eramo", in: *Mythos und Bedeutung* (1980), 252–274.
[15] Cf. the contributions of A. Lüchinger in the first and Tom Avermaete in the third chapter of the present publication. Wim van Heuvel acknowledges that the term *structuralism* in architecture was only popularized internationally by A. Lüchinger. See: Wim van Heuvel, *Structuralism in Dutch Architecture* (Rotterdam, 1992), 36 f.
[16] Opinions differ as to what degree this happened, which is also documented in the present publication in the essays of D. van den Heuvel, H. van Bergeijk, G. Teyssot, T. Avermaete, and K. Bosma. Herman Hertzberger, for one, makes the clearest reference to the double concept *langue* and *parole* of de Saussure. See Lüchinger, 1981, 64. See also Andri Gerber, "Italian Structuralism", footnote 51, in the present publication.
[17] The term "Gothic" as the designation of a style in the sense of "barbaric" was not coined until the Renaissance, by Giorgio Vasari. The term "Renaissance" as well, even though already first used by Vasari, only came into general use as the designation of a period in the 19th century. The designation "baroque" (from the Portuguese word "barocco" for unusually shaped pearls) was initially used in 18th century France pejoratively for something that was not classical.
[18] Roland Barthes, "The Structuralist Activity", reprinted in the present publication.
[19] E.g., by Arnulf Lüchinger, Wim van Heuvel, Jürgen Joedicke, Kenneth Frampton, Anders Ekholm et al., Charles Jenks, Vittorio Magnago Lampugnani, et al.
[20] Reyner Banham, *Megastructure: Urban Futures of the Recent Past* (London, 1976). On p. 8 he refers to a 1968 definition of megastructure by Ralf Wilcoxon (*Council of Planning Librarians Exchange Bibliography*, Monticello, IL, 1968, 66), which can readily be applied to structuralism: "frequently 1 constructed of modular units; 2 capable of great or even 'unlimited' extension; 3 a structural framework into which smaller structural units (for example rooms, houses, or small buildings of other sorts) can be built or even 'plugged in' or 'clipped on' after having been prefabricated elsewhere; 4 a structural framework expected to have a useful life much longer than that of the smaller units which it might support."
[21] Wim J. van Heuvel, *Structuralism in Dutch Architecture* (Rotterdam, 1992).
[22] Arnulf Lüchinger, "Strukturalismus – eine neue Strömung in der Architektur", in: *Bauen + Wohnen*, 1, 1976). Arnulf Lüchinger, *Structuralism in Architecture and Urban Planning* (Stuttgart, 1981). See also: Arnulf Lüchinger, *2-Komponenten-Bauweise – Struktur und Zufall* (The Hague, 2000).
[23] See Aldo van Eyck's frequent reference to the equation of the big house and the little town, which can be traced back to Leon Battista Alberti.
[24] See, e. g.: *Case: Le Corbusier's Venice Hospital and the Mat Building Revival*, eds. Hasim Sarkis with Pablo Allard and Timothy Hyde (Munich, Prestel Verlag, 2001).
[25] Favorite examples of such "precursors" were Diocletian's Palace in Split, the amphitheater in Arles, or the Ponte Vecchio in Florence. Reyner Banham later referred to these examples as *mégastructures trouveés*, by which in his terminology he meant structuralist precedents. See also the article by Medina Warmburg in the present publication.
[26] See the influential book by Bernard Rudofsky, *Architecture without Architects* (New York, 1964).
[27] N. John Habraken, *De dragers en de mensen. Het einde van de massawoningbouw* (Haarlem, 1961). English: *Supports – An Alternative to Mass Housing* (London, 1972). See also the contribution in the present publication by Koos Bosma.
[28] See the contribution by Anne Kockelkorn in the present publication.
[29] See the contribution by Cornelia Escher in the present publication.
[30] See the contributions by Markus Stempl and Michael Hecker in the present publication.

[31] Christopher Alexander et al., *A Pattern Language* (New York, 1977). Cf. also the interview with Christopher Alexander in *Arch+*, no. 189, 20–25, and the contribution by Georg Vrachliotis in chap. 1 of the present publication.
[32] See, e.g., Sylvain Malfroy, Gianfranco Caniggia, *Die morphologische Betrachtungsweise von Stadt und Territorium. Eine Einführung in die Terminologie* (Zurich, 1986). Cf. also the contribution of Sylvain Malfroy in the present publication.
[33] See, e.g., Aldo Rossi, *Die Architektur der Stadt. Skizze zu einer grundlegenden Theorie des Urbanen* (Düsseldorf, 1973; Padova, 1966).
[34] Cf. the contribution by Bernhard Langer in the present publication.
[35] On the topic of standardization and individuality cf., e. g., Max Mengeringhausen, *Komposition in Raum. Die Kunst individueller Baugestaltung mit Serienelementen* (Gütersloh, 1983).
[36] A brief summary can be found in: Frei Otto, *Occupying and Connecting. Thoughts on Territories and Spheres of Influence with Particular Reference to Human Settlement* (Stuttgart and London, Edition Axel Men-ges, 2009).
[37] See the contribution by Peter Bexte in the present publication.
[38] See the contribution by Andrej Hrausky in the present publication.
[39] Cf. the critical voice of Karl Friedrich von Weizsäcker regarding the structural sciences: "The structural sciences bring with them the temptation to confuse all reality with a feasible structure that can be planned. The inhumanity of technocracy is the result of the victory of structural thinking along scientific lines." Karl Friedrich von Weizsäcker, "Das 198. Jahrzehnt. Marion Gräfin Dönhoff zu Ehren", in: *Die Einheit der Natur* (Munich, 1969).
[40] *Die Stadt über der Stadt bauen: Europan 4 – Europäische Ergebnisse* (Paris, 1997).
[41] Werner Sewing, "Die Moderne unter den Teppich gekehrt", in: *Arch+*, no. 133, 71–76.
[42] As an example, mention could be made of the project Megastructure Reloaded (http://www.megastructure-reloaded.org), which included a symposium and exhibition in Berlin in fall 2008. See also the book accompanying the exhibition by *Megastructure Reloaded. Visionäre Stadtentwürfe der Sechzigerjahre reflektiert von zeitgenössischen Künstlern*, eds. Sabrina van der Ley and Markus Richter (Ostfildern, 2008).
[43] A term introduced by Nikolaus Kuhnert and Anh-Linh Ngo in the editorial of *Arch+*, no. 189, 8. During the symposium in Kaiserslautern, on June 9, 2010, Anh-Linh Ngo called it "perhaps somewhat unfortunate". Another example of somehow frivolous handling of the old concepts is the term "The New Structuralism", coined by Rivka and Robert Oxman for the "cultural shift" toward design engineering and priority of materialization in architecture. Rivka and Robert Oxman, "The New Structuralism. Design, Engineering and Architectural Technologies", in: *AD*, no. 206, July / August 2010, 15.
[44] Editorial, *Arch+*, no. 189, 8.
[45] This rather weird term is, of course, not in use in the field but illustrates the successive increase in complexity of the interlocking systems of rules.
[46] Roland Barthes, "The Structuralist Activity", reprinted in the present publication.
[47] Patrik Schumacher, "Parametrismus. Der neue International Style", in: *Arch+*, no. 195, November 2009, 106–113.
[48] E.g., the Advanced Geometry Unit (AGU) of the firm Arup, founded in 2000 by Cecil Balmond, or the company designtoproduction with Fabian Scheurer and Arnold Walz.