Algorithmic Design and Discrete Architecture : Concrete Prefabrication Rethinking the Construction Industry of the East

Noor Mubesher [a] **, Umer Sajjad** [b]

[a] MArch The Bartlett of Architecture (UCL), London and Institutes of Architects Pakistan (IAP)
[b] BArch, Institutes Of Architects Pakistan, ACYA ,Pakistan

Abstract

The concept of this paper begins with a cross-section of the current context of construction and design that we inhabit. Architects experiment with various design forms to achieve freedom from scale restraints. Logistically, architects can create a framework to translate the algorithmic design to discrete assembly and fabrication in architecture. This research delivers the understanding of "discrete assembly of Concrete as a prefab" where the algorithm controls the design and fabrication is processed as voxel-based aggregation on a socio-economic level. Discrete buildings consist of parts, modules, and elements of similar nature that aggregate together and such assembly can expand, contract, could easily be assembled and disassembled, assembled in another form, or even moved to another location. This process relies highly on the geometry and form derived using algorithms. Additionally, this text investigates the use of algorithms as an exhaustive design tool and practice to improve, develop and refine complex geometries within concrete construction, creating contemporary architecture and constructing buildings according to the user's needs. In the same manner, these algorithms can perform discrete assembly of modules in construction which are straightforward and primitive. Architecture in the East is more universal and diverse in materials and formwork. This paper further examines the feasibility of digitalizing concrete as discrete in the construction industry and making it a norm for small-scale developments in Asia, mainly focusing on low-income housing. This could bypass, geometry, topology, and survey into interlocking volumetric modules organically born from the site. Discrete prefabs are defused within the building form, followed by arguments that will acknowledge the works of the modernists' Peter Eisenman and Frank Lloyd Wright. Similarly, the core of research delivers the understanding of elements that make up a typical building that can be assembled in a factory in a vertically integrated programmed production chain. But in Pakistan, despite all the advancements, the physical production of our built environment remains heavily dependent on labor and on site-building. "Discrete" proposes how

architecture becomes a form of democracy, through the design development and mass production of self-similar building parts which are endlessly interchangeable. Today's design urges for an open distributed platform for construction by increasing access to technology and automating the design process. "Algorithmic design and discrete architecture "proposes a highly effective building component strategy through standard automation to reach a global audience. The amalgamation of algorithm and discrete can be recognized as a new paradigm shift considering circular economy as a primary notion of discipline.

Keywords: Discrete Architecture , Algorithm , Prefabrication, Construction Industry, Socio-economic factors,

Introduction

In this research, the word discrete depicts individuality and a distinctive quality that can be modified into an architectural behavior translated into various materials to develop distinctive blocks for construction. The digital and discrete approach in architecture had a prominent practice during the 20th century and can be depicted in the works of Jean Prouve in Maison Tropical with the finest expression of mobile architecture, a flat pack house designed to be flown out to the remote parts. It was manufactured as prefabricated elements conceived to help elevate the shortage of living space during wartime. When designing the Maison Tropicale, However, provide paid particular attention to ensuring that the individual components, before assembly, could be packed in such a way that they could be loaded onto aircraft for transport oversea.

Under the pressure of the worldwide increase in housing prices and a general lack of automation in the building and construction industry, the idea of modularity and prefabrication has also made a comeback.

Past Construction Theories: Mario Carpo expresses in his book " The first digital turn" (Carpo 2014), the concept of digital architecture and revealed some of the inner contradictions of the paradigm of whole and continuity over the past two decades of digital research. The digital era has been followed by the past theories on architectural construction and building which have now translated into automation and digitalization today. The great pyramids of Giza had a significant link to the discreet and continuous building.

Definition Prefab | Discrete | Material

Prefabrication and discrete had developed a computation relationship that algorithmically generates combinational aggregations. This relationship reflects the innovation for increasing the design process through the adaptability of aggregation it generates. Discrete offers the design whereas off-site manufacturing offers the prefabrications of the elements controlled and monitored by adequate technologies and computational communications. This notion of discrete brings in a new architectural interest. Advocating the digital era, the discrete became a way to kick-start a new architectural project interested in the digital legacy. The notion of automation is increasingly important in the building and construction industry. The narrow focus of discrete design on the form is focused on standard construction. The paper delivers the concept of concrete prefab blocks, and construction in slabs, columns, stairs, walls, and foundations.

This way of computer-generated design generates forms instead of singular outcomes, multiple outcomes are developed through inputs and complexity. The focus of the paper also highlights the consequences and implications of discreteness in the construction industry in the Eastern countries of the world. In this manner, it is also helpful to discuss the characteristics of brick and draw a comparison between concrete prefabricated blocks and bricks as they share a combined relationship with mortar in construction. However, brick cannot be considered as discrete as it can already establish itself as a whole. As discussed in this paper, discrete parts can be programmed with specific properties, brick, however, is not independent as a whole. Brick construction is limited to stacking, it cannot form a cantilever nor it can position in a vaulted form.

Essentially on an architectural level, discrete forms itself as distinctive from the whole and does not have a predefined role. It is only once the parts are combined with other elements which then establishes functional features and properties. The positioning of the parts or blocks is done algorithmically and they maintain their autonomy and effectively diffuse in architecture as a whole. This advancement breaks the modernist form function logic and provides the standard construction factors that hold the structure. Such as a column acts as a column but with discrete building parts which can also be used in the same manner in building a floor slab. This results in a hierarchical assembly of fixed architectural typologies. The aggregation growth is organic and one element along with its properties define everything.

Prefabrication allows for a more integrated construction process usually reducing labor intensive on site-work., reducing usage of more materials, and freedom of design and errors. Its advantages are associated with uniformity and repetitive building forms.

Moreover, when used in combination with autonomy and digital production, it makes room for customization and allows limitless lengths.

Phase 1. Algorithmic Design

Through the volumetric modular design, the off-site manufacture is presented as offering the potential to significantly improve construction in the east. In this manner, the construction and design both save time and effort, and the projects are developed in affordable ways. In the first phase of the research, we design parts in their respective of their notion to site, usage, and capacity of the space. This design phase includes an order of the algorithms and codes to create the design project and to be used most efficiently. These operations are the basics to generate codes to create the blocks. The algorithm design is divided into stages. In stage one, the variables, and elements are put together to be identified as data that consists of all information by the architect.

Building blocks: These elements are further categorized into the proportions of the desired blocks. For example adding the data that requires setting the height, length, and width of the block that could always be set as a standard and work as a whole form. These are essential tools to be set as inputs to further work on the desired form. The second stage allows segments to the blocks that can act as a programmable construction feature. These segments include combinational, interlocking, and functional blocks. Providing the information in this order for the algorithm to compute and release the desired aggregations. The third stage in the algorithmic design is loops. This command indicates the sets that are repeated along with the data and variables provided. The loop provides outcomes that save time and effort during the project. The repetitive tasks allow outcomes to be provided with the usage of inputs. These outcomes are set on a series of false and true depending on the desired form and site regulations.

Algorithmic designs are based on conditions and rules set within the project discourse. Conditions allow the execution of certain functions for the aggregation. Such as a combinational block stacking on top of each other and after 3 blocks a services segment needs to be accommodated within the column for an electrical or firefighting course. In another example, a bedroom wall will always have to include blocks that are operable and can include a window aperture. Through more speculative research, the conditions work well with loops and mathematically the functions behave differently with the algorithms. They can be used multiple times throughout the process of generating forms.

Phase 2: Discrete Fabrication

The framework of automation and discreteness explores architectural design and construction from a different perspective. Focused on concrete prefab as discrete building elements, once the algorithmic implementation of the design is completed, the aggregation is finalized with its typologies. The factory process includes the categorizing of each element that is used in the complex outcome. Various blocks are marked concerning their space in the aggregation. This discrete concrete allows for a short and integrated production chain, where only a few machines and tools are needed from the start of the project till the end. These concrete building blocks are versatile elements that can be used for multiple different designs or a building can be deconstructed and reassembled in a different form.

The assembly process of these building blocks includes the bonding of mortar which structurally create continuous monolithic elements. The building blocks as per the schedule are engineered to perform the stacking and provide the specific function.

Conclusion

Concrete Construction and Architectural Consequences

The rapid development of concrete has been historically associated with craft and bespoke construction. Prefabrication of concrete brings in new possibilities and freedom of design. Traditionally concrete is battered together with bricks, sand, and mortar, following the structural standard of columns and beams together and waiting for seasons to dry. The cast and molding of prefab concrete obtain the same strength in all directions. This has also raised global interest in architectural thinking for the environmental crisis. This production chain can be understood as monolithic, rather than the various materials and processes that on average would make up a building, in discrete design only a few would be used.

This paper has outlined and explored the architectural consequences of the shift to algorithmic and discrete construction. Concrete prefabrication reveals changing attitude towards digital design and its assembly as mass customization. While this paper mainly proposed an alternative for the construction in the East, radially a new type of architectural assembly with its own syntax and unique qualities, emerges, breaking both with the modernist precedent and the paradigm of continuity. This same strategy has been

explained in this paper. The acceptance and convincing advancements have challenged the course of work and life in different countries. Fast emerging technologies and broad innovation are blending in faster than previous periods. This research for sustenance has led us to understanding the necessity of architectural sadvancements through the lens of automation and discreetness.

References

Deamer,Peggy. ***The Architecture and Labor****: Architectural Production and Consumption, Architectural Labor, Architectural Cooperativization* . London, UK : Bloomsbury, 2015.

Deamer,Peggy. ***Architecture and Capitalism****: Introduction, Context 1800 – 1860, Context 1870 - 1914 . London, UK : Bloomsbury, 2013*.

Doria, David. ***Public parts: Resocialized Autonomous Communal life****,* London, UK : Barlett, 2021.

Fishman, Robert. ***The Global Crisis of Affordable Housing****: Architecture Versus Neoliberalism.* Chichester, UK : 2018

Hansley, Lansley. ***Estates; An Intimate History****: Homes Fit for Living.* Granta Books, UK : 2017

Morel, Phillipe. ***Computation or Revolution; Made By Robots****: The Market of Robots, Artificial Intelligence and computation as "Communism Of Genius".* London, UK : 2014

Castoriadis, Cornelius ***.The Imaginary Institution of Society :*** *Autonomy and Alienation Cambridge ; Malden, MA 1997*

Marx, Karl and Engels, Friedrich. ***The Communist Manifesto****: Marxist theory of the Development of Capitalism.* London, UK : 1848.

Scrnicek, Nick. ***Platform Capitalism****: Industrial Platforms, Product Platforms, Lean Platforms and Great Platform Wars.* 2016.

Ward, Colin. ***Housing: an Anarchist approach****: Direct action for houses, Are architects to blame?, Participation or Control. London, UK: 1976.*

Klaus, Schwab. ***The Fourth Industrial Revolution****: The Fourth Industrial Revolution, Economy.* World Economic Forum 2016

Carpo, Mario. ***The Digital Turn in Architecture 1992 - 2012:*** *Field Conditions (1997) Stan Allen, Object to the field.*

Murray, Collin. ***The Myths of Metaphor,*** *Descartes Rene, 1596 – 1650, Newton, Isaac, 1642 – 172, Columbia, University of South Carolina, 1970*

Abel, Cris. ***Architecture, Technology, and Process****: London 2004*

Aureli, Pier Vittorio, ***The Project of Autonomy,*** *Princeton Architectural Press NewYork 2008*

Ingels, Bjerke. ***Forgiving****. Making Taschen, 2020*

Claypool,Mollie, Garcia, Manuel Jimenez, Retsin, Gilles and Soler, Vicente. ***Robotic Building****: Architecture in the Age of Automation, Craft, Cyclopean Cannibalism, London 2019*

*Sant'Elia, Antonio****. The Work of Antonio Sant'Elia:*** *Retreat Into the Future*