

## **Generative Prefabrication**

A Design Research In Building Prefabrication and Assembly

Spring 2023

ARCH 6020-205 course: Design Studio IV.

Mondays, Wednesdays, (and Fridays) 2:00 pm–6:00 pm

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*"Value is not based on the quality of material, but on creative and distinctive use instead"  
Alejandro Aravena's installation using 100 Tons Of Waste Material at the Venice Biennale 2016.*

## 1 Brief

The architecture and construction industry is indeed responsible for serious waste problems. The construction process leaves significant waste and debris, including demolishing structures to construct new buildings at the end of the life cycle and the waste and debris resulting from the material processing and preparation for new construction. They all contribute significantly to the waste problems globally. To address this problem and eliminate waste, the continual use and reuse of resources should be at the core of the design process. Consequently, an architect should carefully select the construction material and analyze the method of construction and preparation of the materials to minimize waste and allow for re-usability in the future. Moreover, the building design and use characteristics should also be involved in this process. Only then, a circular design process may be established, which would be at the intersection of the material properties and building design and use (Geldermans, 2016; Van den Berg et al., 2019). This design approach values the "creative and distinctive use" rather than the quality of material (Aravena, 2011).

In this regard, recycling and reusing construction materials from existing sources of waste or demolition is considered a viable design approach. However, the recovered materials from previous construction might not always thoroughly fulfill the material and functional needs of new construction. Besides, it is only applicable if the material can be recycled.

The advent of new construction technologies in developing prefabricated parts can yield more efficient construction by reducing waste and debris on-site. However, the pre-production of material for prefab construction may also involve a lot of waste in energy and resources that should be carefully considered in the design process. This studio aims to investigate innovative design methods, assembly, and disassembly of prefabricated parts in the construction of mid-rise buildings.

### Design Research Objectives

Viollet-le-Duc calls a 'valid architecture' a coherent response to the available materials and means of construction, environmental factors of the site and climate, and cultural requirements. The structure and programmatic function of the building work harmoniously together (See *The Architectural Theory of Viollet-le-Duc* by Hearn in his book [Viollet-LeDuc \(1990\)](#)). This studio aims to investigate innovative methods of design, assembly, and disassembly of prefabricated parts that meet the functional requirements of a mid-rise building. The assembly method should evolve progressively to ensure the structural integrity of the building and consider the environmental factors of the site. The

overarching objective of the studio is to:

- learn from the ancient local methods of assembly;
- propose innovative, site-specific prefabricated methods of construction and labor;
- minimize waste in both pre-production and post-production;
- facilitate reusability of the parts in the future; and
- value the cultural factors that form the architectural function.

### **Building Program Objectives**

The studio intends to design a building for *community resiliency* against social injustice. It is a place with maximum flexibility for people to attend, share, and communicate their thoughts and feelings through performative art. The building will be served as a mediator space to include voices and experiences of diverse artists and communities to bridge the societal gaps among different groups, ethnicity, and gender. It comprises various artistic, social, cultural, and educational spaces for multiple purposes. For instance, the building should allow Community artists to have temporary installations or public performances. It comprises spaces for meditation and communication through the power of design.

Figure 1 shows a *toguna* building, an example of such buildings, erected by the Dogon people in the West African country of Mali. The Toguna building was a place of gathering where the community discussed pressing issues of the village. Togunas are built with a low ceiling height to force the visitors to sit and avoid violence during heated discussions.

### **Site**

Six sites will be picked around the globe to consider the local environmental aspects, material use, and the ancient construction method and proportionally design research proposals will be developed for future construction methods.

## **2 Design Research Approach**

The design method starts with assembly research by analyzing the conventional construction methods. The choice of materials and components will be based on the availability of the material, and the assembly should be compatible with the climate and environmental factors. While the prefabrication is at the core of this studio, six different sites with different cultural and environmental factors will be chosen to answer the following questions:



Figure 1: Left to right: A toguna (or palaver hut) is a public building erected by the Dogon people in the West African country of Mali (Doquet, 1999); Granary, Burkina Faso, an amazing Mosque in Bobo Burkina Faso, built using mud and tree trunks.

- What might one learn from historic construction methods in a specific site?
- How can this method be adopted for future methods of construction?
- How can prefabrication reduce the use and waste of the particular material?
- How does the assembly of the structural system conform with the programmatic function of the building?
- How can this process minimum energy and waste in the future to recycle the material and use it for other purposes?

### The Sectional Model

The main outcome of the studio will be a sectional model for midterm and final. The size of the model will be 24"x24." The model will demonstrate all the necessary details of the parts and their assembly to establish a building. The students should exhibit all the construction research in prefabrication of the parts and the building system via the development of the sectional model.

### Travel plans

From Feb. 6th to 9th, the studio will visit multiple design and fabrication and engineering firms in NYC as well as multiple public and cultural



Figure 2: Left to right, top to down: Pigeon towers in Isfahan, Iran ([Beazley, 1966](#)); Machu Picchu stone construction, Peru; Cooling towers of Aghazadeh Mansion, Yazd, Iran; Stone towers, Aseer village, southwest of Saudi Arabia: Stone construction against erosion.



Figure 3: sand-casted concrete facade clads Anne Holtrop's green corner building in Bahrain (Holtrop, 2020).

buildings and spaces.

### Suggested List of Readings

- Eugène Emanuel Viollet-LeDuc. *The architectural theory of Viollet-le-Duc: readings and commentary*. MIT Press, 1990
- RJ Geldermans. Design for change and circularity—accommodating circular material & product flows in construction. *Energy Procedia*, 96: 301–311, 2016
- Marc Van den Berg, Hans Voordijk, and Arjen Adriaanse. Circularity challenges and solutions in design projects: an action research approach. In *35th ARCOM Conference*, 2019
- Alejandro Aravena. *Alejandro Aravena: The Forces in Architecture*. Toto, 2011
- Noura Al Sayeh Holtrop. Tres buenas preguntas. Una entrevista con anne holtrop. *Croquis*, (206):1, 2020
- Gottfried Semper et al. *The four elements of architecture and other writings*. Cambridge University Press Cambridge, 1989
- Matthias Kohler, Fabio Gramazio, and Jan Willmann. *The robotic touch: how robots change architecture*, 2014
- H. Engel and R. Rapson. *Structure Systems*. Hatje Cantz Verlag, 2007. URL <https://books.google.com/books?id=8NMLAQAAMAAJ>
- P.J. da Sousa Cruz. *Structures and Architecture: Beyond their Limits*. CRC Press, 2016. ISBN 9781317549956. URL <https://books.google.com/books?id=njiPDQAAQBAJ>
- M. Meijs and U. Knaack. *Components and Connections: Principles of Construction*. Birkhäuser, 2009. ISBN 9783034610636. URL <https://books.google.com/books?id=1lT7Xw7HMAYC>
- M. Hauschild and R. Karzel. *Digital Processes: Planning, Designing, Production*. Detail practice. Birkhäuser, 2011. ISBN 9783034614351. URL <https://books.google.com/books?id=OdDTAAAAQBAJ>
- K. Tichelmann and J. Pfau. *Dry Construction: Principles, Details, Examples*. Detail Practice. Birkhäuser, 2008. ISBN 9783034615686. URL <https://books.google.com/books?id=1SfVAAAAQBAJ>





*Ensemble studio, Cyclopean house construction, Cambridge, United States.*

### 3 Studio schedule

Table 1 represents the schedule of the studio and the objectives and their associated timelines.

<i>Course Sessions</i>	<i>Titles</i>
w1 Jan 11 Jan 13	Introduction to the studio approach Research on the ancient and contemporary methods of construction and prefabrication
w2 Jan 16 Jan 18 Jan 20	MLK: no class System development based on material and construction research
w3 Jan 23 Jan 25 Jan 27	Structural configuration and multi-story development of the system
w4 Jan 30 Feb 1 Feb 3	Computational Development of the system Master Lecture
w5 Feb 6 Feb 8 Feb 10	Physical prototypical model of the proposed assembly method <b>Structures week Joint presentation</b>
w6 Feb 13 Feb 15 Feb 17	multi-story building configuration Master lecture; MEP review with Pamela Cabrera Structural analysis, feasibility studies, and facade strategies.
w7 Feb 20 Feb 22 Feb 24	<b>Midterm review:</b> Large scale model (24"x24")
w8 Feb 27 Mar 1 Mar 3	Site specifications, program development/refinement, spatial configurations and circulations. Detailed structural design, space, and material development Cladding review
w9 Mar 6 Mar 8 Mar 10	Spring Break: no class Spring Break: no class Spring Break: no class
w10 Mar 13 Mar 15 Mar 17	Prefabrication Optimizations Meeting with the Facade Consultant Climate Studio Analysis
w11 Mar 20 Mar 22 Mar 24	Building configuration, gallery spaces and circulation
w12 Mar 27 Mar 29 Mar 31	Visit NYC at Transsolar and knippershelbig Sectional development and mechanical, electrical and plumbing
w13 Apr 3 Apr 5 Apr 7	Exterior detail development; cladding review Master lecture
w14 Apr 10 Apr 12 Apr 14	Finalizing building design and drawing developments <b>Cladding week joint presentation</b>
w15 Apr 17 Apr 19 Apr 21	Physical model and detail production:
w16 Apr 24 Apr 27	<b>Final Review:</b> Large scale model (24"x24")

Table 1: Studio schedule

## References

- Alejandro Aravena. *Alejandro Aravena: The Forces in Architecture*. Toto, 2011.
- Elisabeth Beazley. The pigeon towers of isfahān. *Iran*, 4(1):105–109, 1966.
- P.J. da Sousa Cruz. *Structures and Architecture: Beyond their Limits*. CRC Press, 2016. ISBN 9781317549956. URL <https://books.google.com/books?id=njiPDQAAQBAJ>.
- Anne Doquet. *Dogon masks: learned ethnology and indigenous ethnology*, volume 212. KARTHALA Editions, 1999.
- H. Engel and R. Rapson. *Structure Systems*. Hatje Cantz Verlag, 2007. URL <https://books.google.com/books?id=8NMLAQAAMAAJ>.
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- Marc Van den Berg, Hans Voordijk, and Arjen Adriaanse. *Circularity challenges and solutions in design projects: an action research approach*. In *35th ARCOM Conference*, 2019.
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