Reduced-Waste Design for (Dis-)Assembly
A Design Research In Building Prefabrication and (Dis)Assembly for Future

Spring 2022
ARCH 705-001
Mondays, (Wednesday), 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"
Alenjandro 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 the process of 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 resourses 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 the 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 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

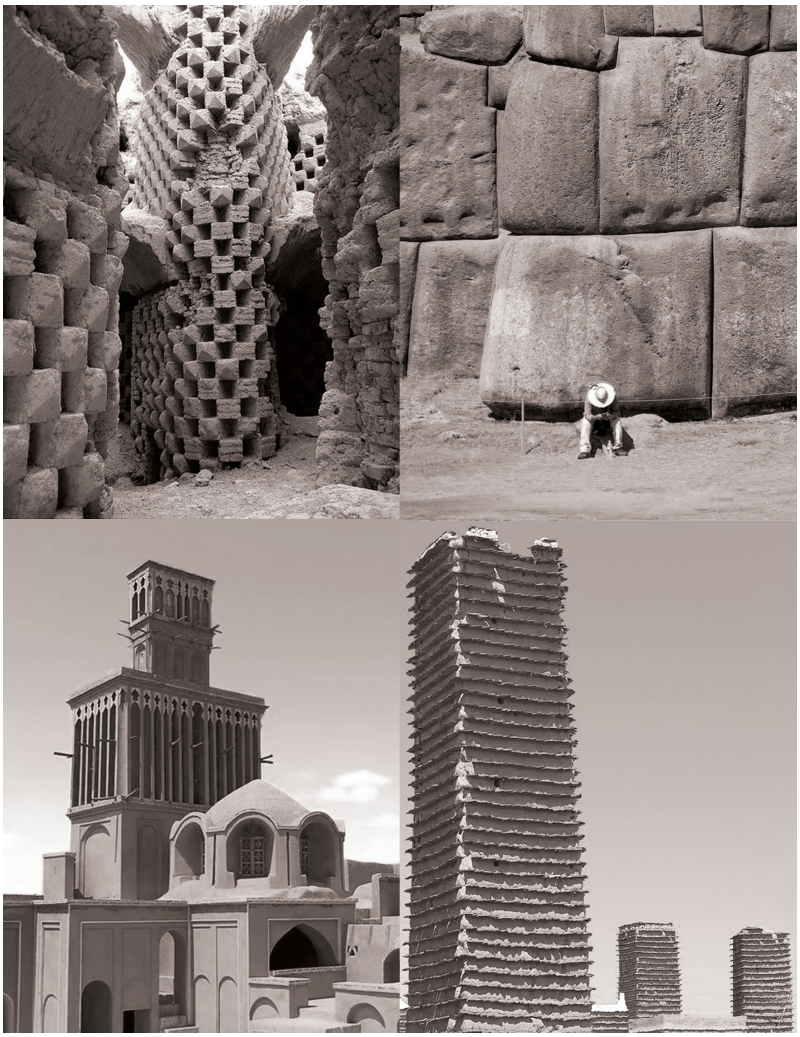

Figure 2: Left to right, top to down: Pigeon towers in Isfahan, Iran (Beazley, 1966); Machu Picchu stone construction, Peru; Cooling towers of Aghazadeh Mansion, Yazd, Iran; Stone towers, Aseer village, southwest of Saudi Arabia: Stone construction against erosion.

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
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- K. Tichelmann and J. Pfau. *Dry Construction: Principles, Details, Examples*. Detail Practice. Birkhäuser, 2008. ISBN 9783034615686. URL https://books.google.com/books?id=lSfVAAAAQBAJ

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

3 Studio schedule

Table 1 represents the schedule of the studio.

Course Sessions		*Titles*
w1	Jan 10	Precedent studies research on the ancient methods of construction
w2	Jan 17	System development based on material and construction research
w3	Jan 24	Structural configuration and spatial development of the system
w4	Jan 31	Computational Development of the system
w5	Feb 7	Physical prototypical model of the proposed assembly method and **travel week**
w6	Feb 14	Structural analysis, feasibility studies, and facade strategies.
w7	Feb 21	Large scale model (24"x24") and **midterm review (Feb 23rd)**
w8	Feb 28	Site identification, program development, spatial configurations and circulations.
w9	Mar 7	Detailed structural design, space, and material development
w10	Mar 14	Prefabrication methods and optimizations
w11	Mar 21	Building configuration, gallery spaces and circulation
w12	May 28	Sectional development and mechanical, electrical and plumbing
w13	Apr 4	Exterior detail development
w14	Apr 11	Finalizing building design and drawing developments
w15	Apr 18	Physical model and detail production
w15	Apr 25	**Final Review**

Table 1: Studio schedule with the outline for various sections and exercises

4 Assignment 1

The first assignment is designed to assess your research skills on ancient construction methods. For this exercise, each group should present a form of construction in the following steps:

- translate the research you did on ancient methods of construction into a 3d model;
- make a 3 model of the assembly based on the same material with a bounding box of a cube with the same width, length, and height dimensions;
- render the cube in a white background;
- show all the construction parts with their related materials and how the assembly gets completed in a step by step animation of parts added to the structure in each step;
- describe the parameters you have used for modeling the parts and how these parameters can be changed to create different effects.

5 Assignment 2

This exercise is prepared to address questions concerning (a) building a physical model, (b) design clarity in transferring the loads, (c) circulation ideas, (d) prefabrication strategies, the versatility of the system. The main objectives of this exercise are as follows:

- Show how the assembly logic of your proposed methods translates itself into a physical model using real constructive elements.
- Show the spanning element works in tandem with the vertical load-bearing elements or can be combined and can geometrically transform into each other.
- How would your system provide circulation in conjunction with architectural spaces and structural elements?
- How can your construction method be turned into prefab modules for faster, cleaner, and easier assembly and production?
- Can your system adjust itself to asymmetric architectural programs?
- What is the artistic effect of your installation? What is the provocative element of your design?

5.1 Deliverable

This exercise is due on Monday, February 7th. The following items are necessary for our upcoming meeting:

- An assembly model addresses the questions in a small installation of elements.
- Your models should sit on a 3/4" plywood base with 12"x12" dimensions. There is no limitation for the height. However, the installation should have had at least two horizontal floors in addition to the ground floor.
- The floors should have sectional/elevational differences, i.e., different heights.
- The model should be clean and precise, representing the technique by which a full sectional building model would be constructed for the mid-term review.

6 Mid-Term Review Documentation

The following items need to be delivered for the materials presented in the midterm review. These files will be selected for a book publication based on the content of the studio with appropriate credits to your names and credentials. Therefore, please pay attention to this documentation if you want to be included in this publication.

Start with making a folder under your name and your teammate's name and include the following sub-folders inside:

- 3dm
- rendering
- drawing
- photos
- media

6.1 File Submissions

The mid-term materials should be documented, organized, and delivered before I can finalize your mid-term presentation grades. The deadline for the documentation of the midterm materials is Monday, Feb. 28th, session. It would be best to organize your files and drawings, and model shots for this round of documentation.

3D models

You need to deliver your research and the rhino model of your building design presented in the mid-term as part of your delivery.

Precedent Analysis: Name the file of your precedent analysis Please save each research iteration in a rhino file from the beginning of the semester until the mid-review in a clean format, appropriately named, representing the chronological order of your studies.

Mid-term construction technique Include the 3d model of the mid-term construction techniques in a step-by-step procedure as you presented in your drawings/renderings.

Note: The 3d models you used for renderings with proper ordering can be used to submit the above section.

Renderings

Include all the renderings with consistent scene and lighting in this folder, including all the renderings you have had since the beginning of your research until the mid-term presentation.

Photographs

The photographs should be taken with the same background and lighting for the entire studio. These photos include multiple shots of the sectional model, including both interior and exterior detailing and close-up shots presenting the spatial quality of your designs.

Drawings

The drawings include diagrams, construction drawings, and in sum, anything related to your presentation on the Miro board that represents a drawing.

6.2 Physical Models

As discussed, I intend to have a large exhibition of your semester work at the end of the semester. Thus, please complete your models, fix all their related problems, and move them to my office to store them in a safe place to exhibit them in the final review of the course for the entire faculty and students. You may need to make an acrylic box to protect them.

6.3 Paper Submission

I am confident that you had put down your thoughts to explain your approach and design for the reviewers for the mid-term presentation. Therefore, it is time to document your thoughts and ideas.

Shawn will provide you with a template of an in-design file to write a short paper presenting all your ideas about your design. You can explain the advantages of using your system and minimizing construction waste by learning from the ancient, local construction techniques to inspire the future of design using natural, recyclable materials.

6.4 Social Media Files

Please select a maximum of four images of your models/drawings to be shared on social media. Include a sentence or two, accrediting your names and the project's main idea. Please select the best photo shots for this purpose.

References

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