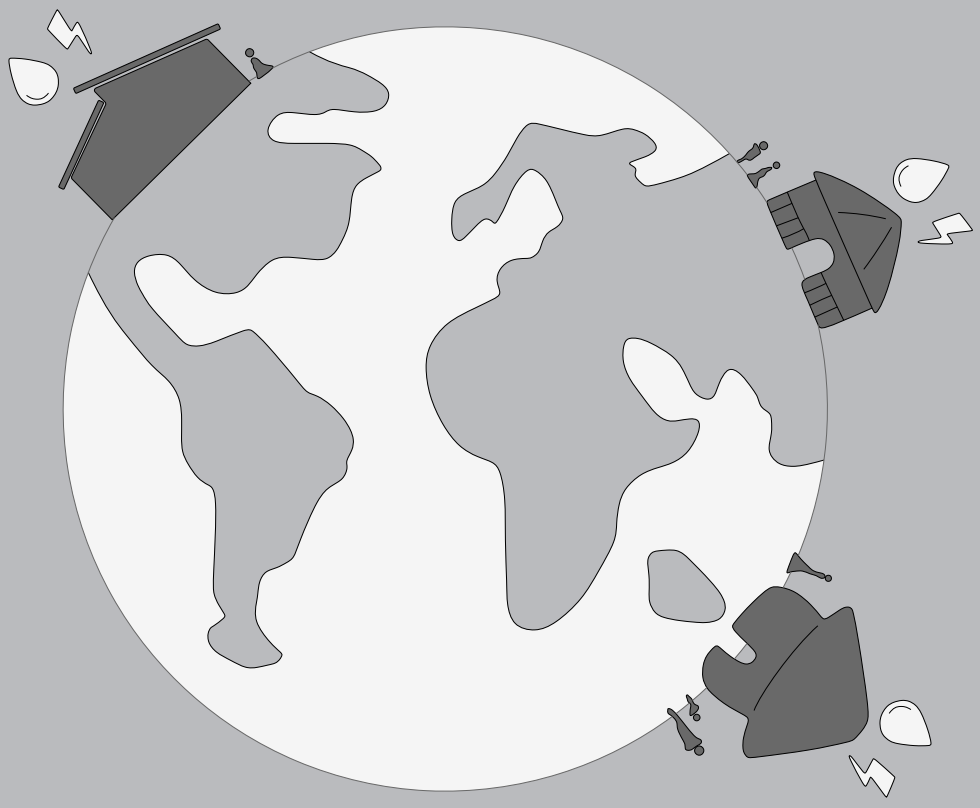
REDESIGN DISASTER:



WATER & ENERGY HUB.

CONSTRUCTION MANUAL

Preface

Name:	Filip Zielinski
Student number:	4746376
Project:	MSc Graduation Project 2020
University:	Delft University of Technology
Faculty:	Faculty of Architecture
Track:	Building Technology
Studio:	Sustainable Design Graduation Studio
Topic:	Redesign Disaster: Water & Energy Hub.
Mentors:	Main mentor: Dr.ing. Marcel Bilow Second mentor: Ir. Eric van den Ham Board of Examiners delegate: Dr. Lei Qu

This graduation project has the goal to improve the living conditions of rural African communities by showing them how to construct off-grid, self-sufficient, and what is most important affordable clean water, energy, and sanitation system. I believe it can be easily adapted by communities of poor regions. Those communities struggle with poor quality water for living which is the cause of many deaths. To change it, a solar-based system is proposed to purify any kind of input water. Widely known simple solar stills are typically designed as single units serving only individuals, moreover, its efficiency is usually low. Therefore, an improved solar still concept is adapted in this research, and its principles are used in the roof system to produce water for the basic living needs of 50 people daily.

The goal of this document is an easy-to-read construction manual to help the target community understand the construction steps of the pilot building and let them acquire the knowledge. Schemes and drawings are simplified to ensure easy and clear communication. The entire building and water system are designed as modular to give and show its versatility and multiple implementations. The module can be clustered or copied in many ways depending on the need. If local people will follow the manual guidelines they can easily use it for building a long-lasting architecture of any function equipped with off-grid water, energy, and sanitation systems.

The pilot building can be constructed in several areas of rural Beira and its function should correspond to the local community needs. The circular economy philosophy implemented in the design shows how to use local materials to let them last long and be easy for refurbishment or different function adaptation.

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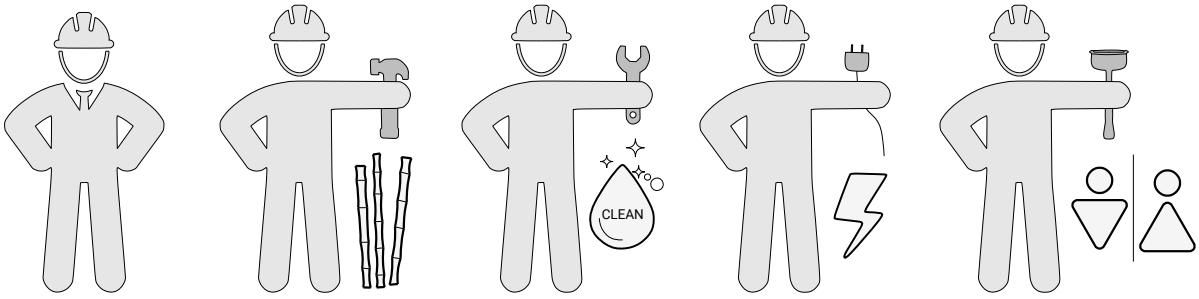
Experts & Tools



Contractor
Investor

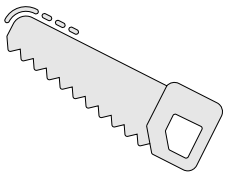
Bamboo expert

Water system
expert

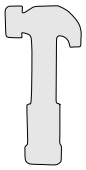
Electricity
system expert

Sanitation
system expert

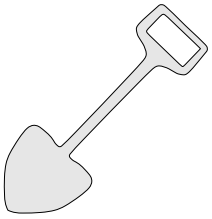
The building is designed to be realizable with simple tools and manpower only. To ensure proper construction and systems functioning, besides general contractor/ investor, material and systems experts are advisable during construction. Using this construction manual, their knowledge can be spread to local people and let them build modules in the future by themself.



Wood saw

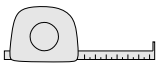


Hammer

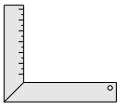


Shovel

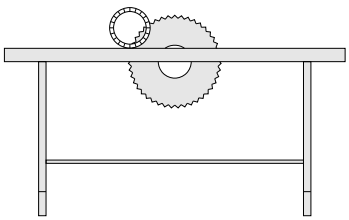
Working table



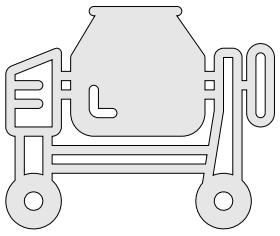
Measure tape



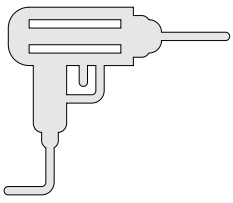
Right angle



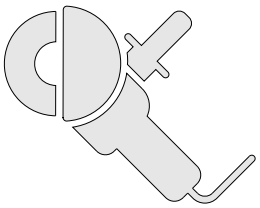
Circular saw



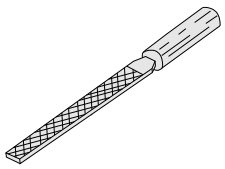
Cement mixer



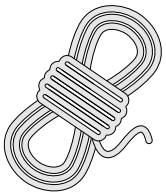
Driller



Angle grinder

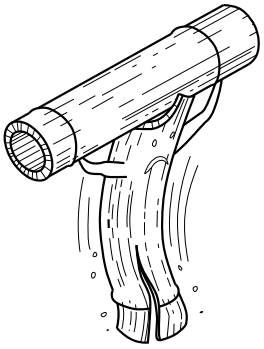


Hand file

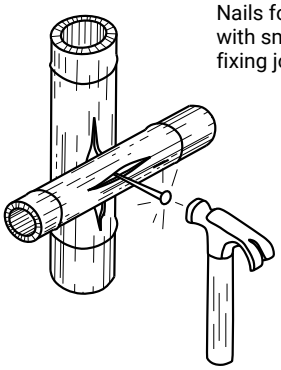


Rope

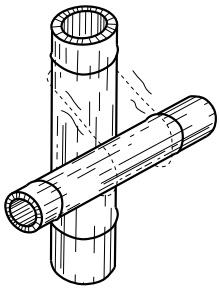
DONT USE FOR CONSTRUCTION



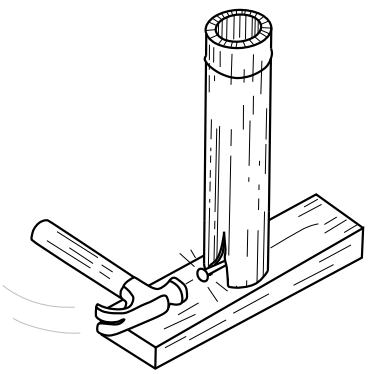
Culms with low compression strength. These include:
1) Young culms less than three years old,
2) Culms which are or have been attacked by insects or fungs,
3) Culms which have flowered,
4) Culms with cracks or which have transversal cuts made by a machete



Nails for fixing lateral culms with smaller diameter, or for fixing joints.



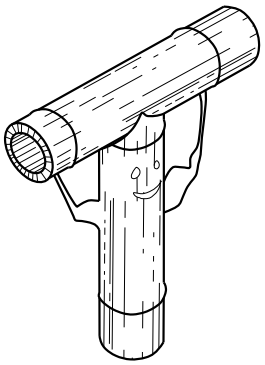
Green bamboos used structurally in permament constructions and tied with wire or ropes. When green culms become dry, they shrink and the ties become free



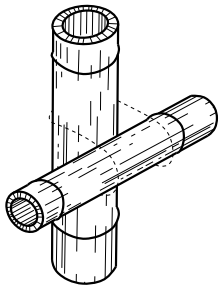
Temporary vertical supports or colums without any node at the lowest end which can cresent cracks at the moment of being fixed.

USE

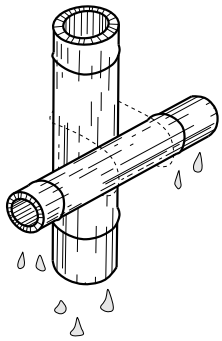
1) Mature culms three years old or older
2) Giant culms with appropriated dimensions and thick walls (more then 9mm)
3) Culms with appropriate joints



If it is necessary to use nails for fixing small diameter culms (4 to 5 cm) or joints of giant bamboos, it is recommended to open a hole previously with a drill bit sligtelly smaller than the nail's diameter
2) For fixing horizontal and vertical structural members in temporary structures use wire ties, nylon or strong vegetal cords



In this case it is convenient to check frequently the ties, or to use dry culms



In this case it is convenient that the temporary column has a node in the lowest end, in order to avoid the cracks.

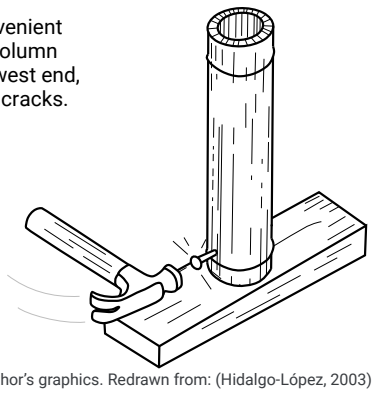


Fig. 1 Principles of using bamboo in the construction industry. Author's graphics. Redrawn from: (Hidalgo-López, 2003)

Module

Dimensions:

Area:	27,5m2
Width:	460cm
Length:	600cm
Roof surface:	30m2
Highest roof point:	490cm
Lowest roof point:	330cm

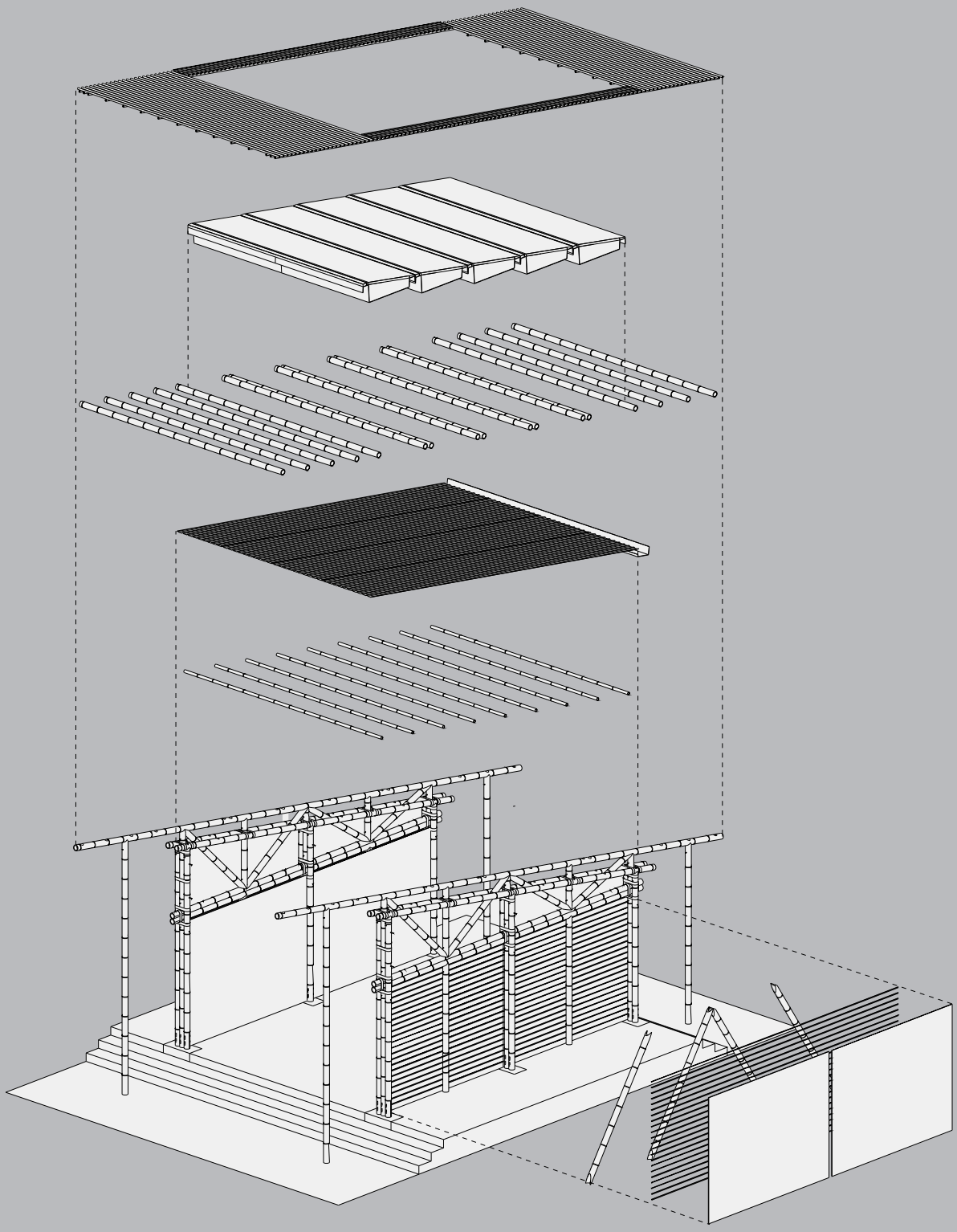


Fig. 2 Module exploded axonometry. Author's graphics.

Foundations

Construction Site

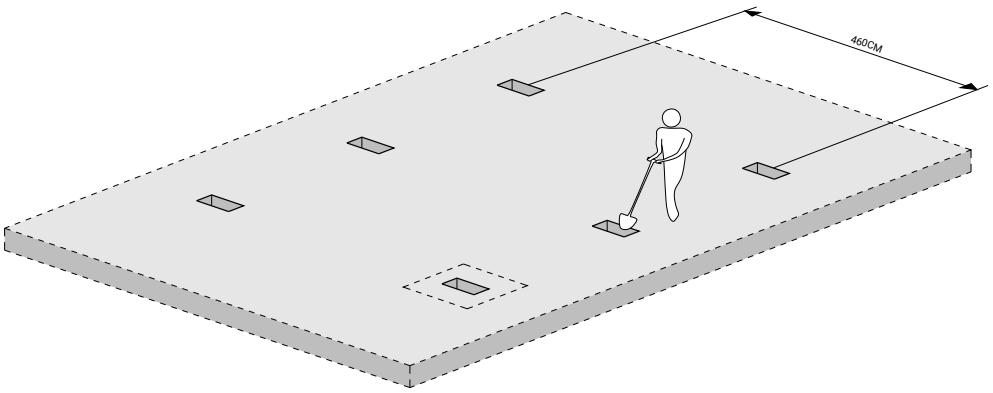


Fig. 3 Foundations holes. Author's graphics.

1. Measure site.
2. Orient the building.
3. Dig foundation holes 30x60cm H=45cm.
4. Dig hole for digester tank. The excavated soil will be used for elevated floor.

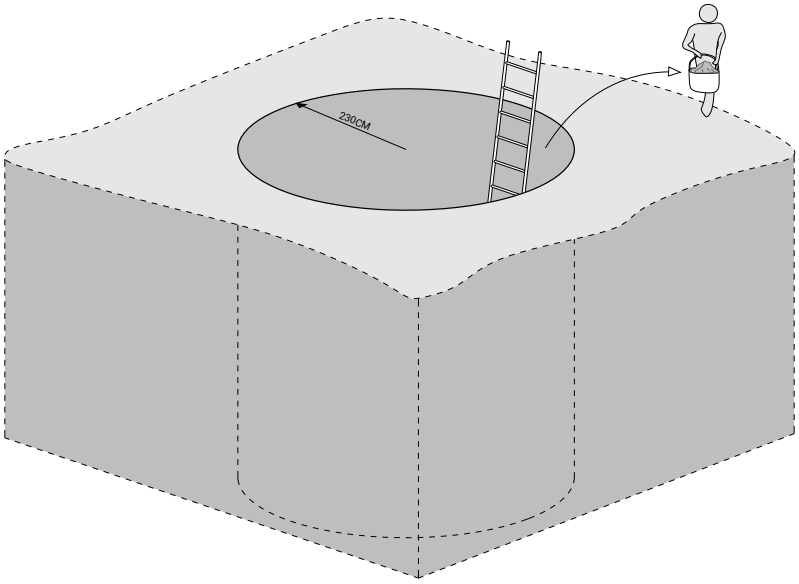


Fig. 4 Digester tank hole. Author's graphics.

5. Prepare wooden formwork 30x60cm H=45cm.
6. Pour coment.
7. Prepare and insert Φ8cm wooden cylinders.

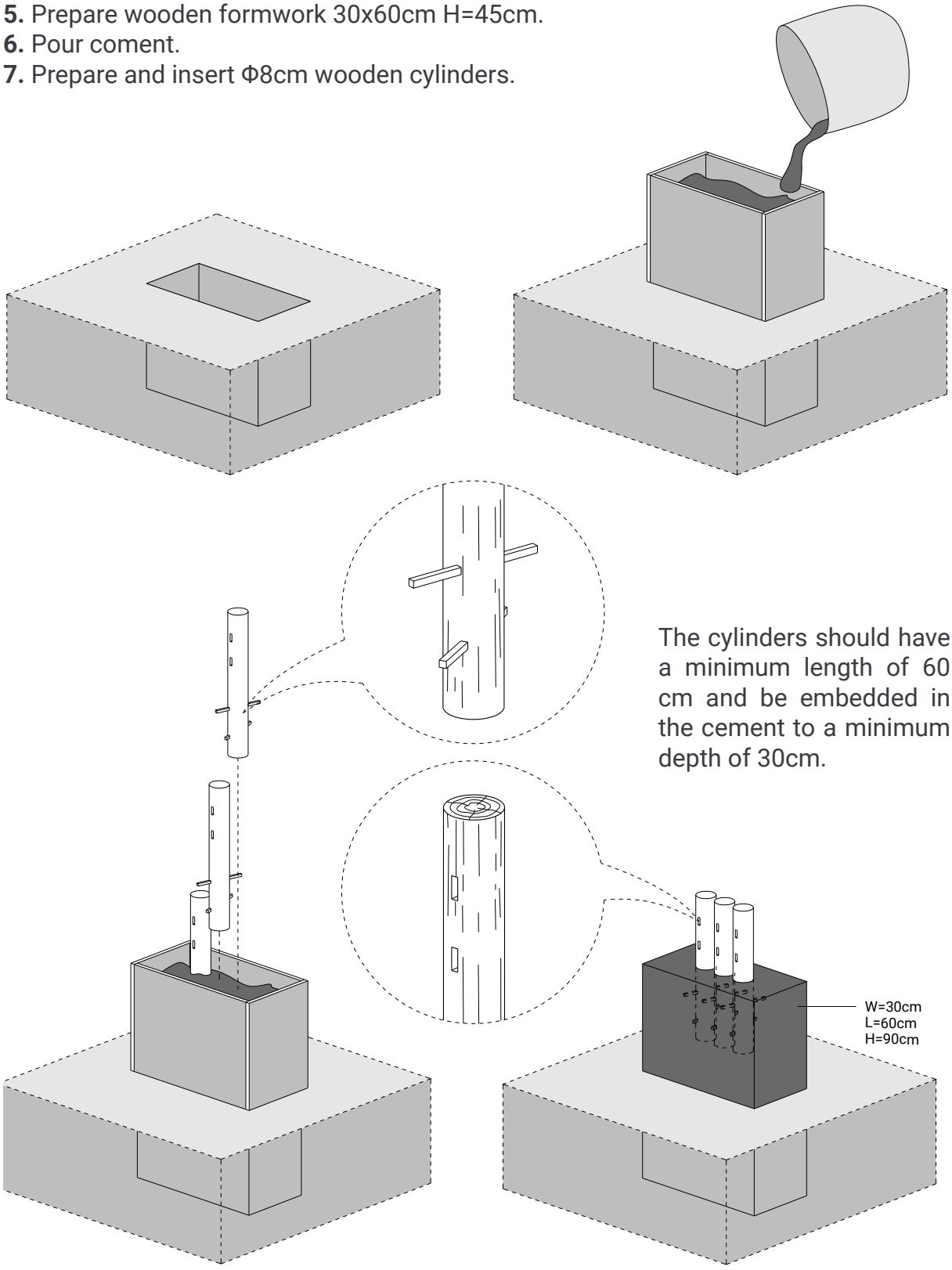


Fig. 5 Det. A. Connection of the supporting structure (columns) with foundations (concrete block). Author's graphics.

Bamboo Structure

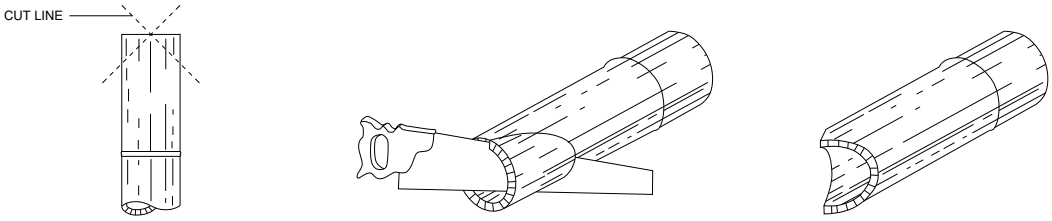


Fig. 6 Det. B Bamboo cutting. Author's graphics. Redrawn from: (Hidalgo-López, 2003)

8. Build 45cm elevated floor. Prepare 3x15cm steps and ramp where necessary.

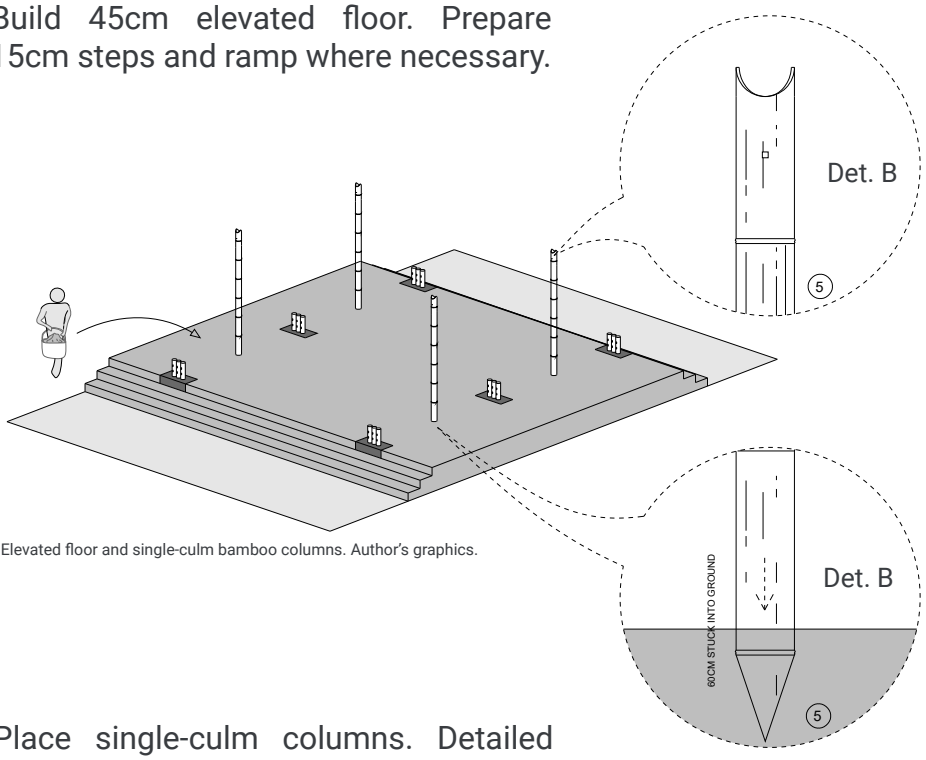


Fig. 7 Elevated floor and single-culm bamboo columns. Author's graphics.

9. Place single-culm columns. Detailed drawings with all bamboo elements can be found at the end of this chapter.

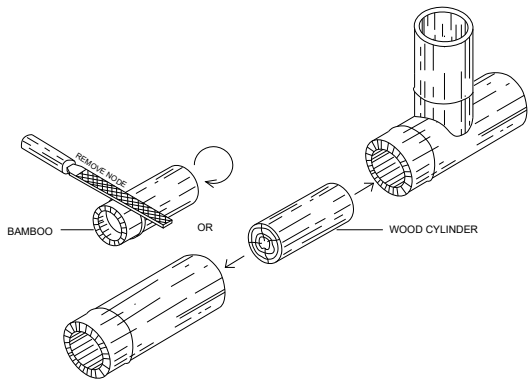


Fig. 8 Det. C. Bamboo horizontal joining technique. Author's graphics. Redrawn from: (Hidalgo-López, 2003)

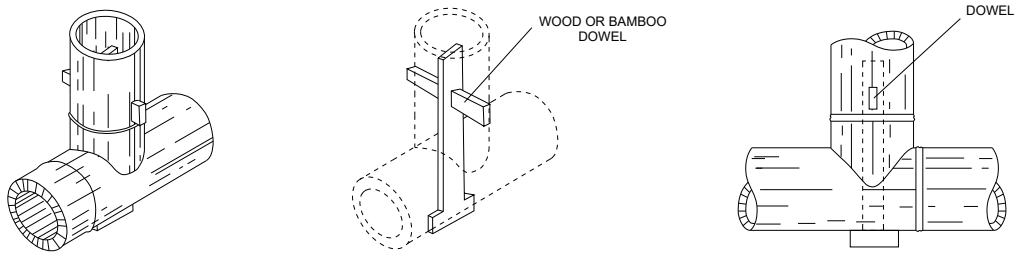


Fig. 9 Det. D. Bamboo perpendicular joining technique. Author's graphics. Redrawn from: (Hidalgo-López, 2003)

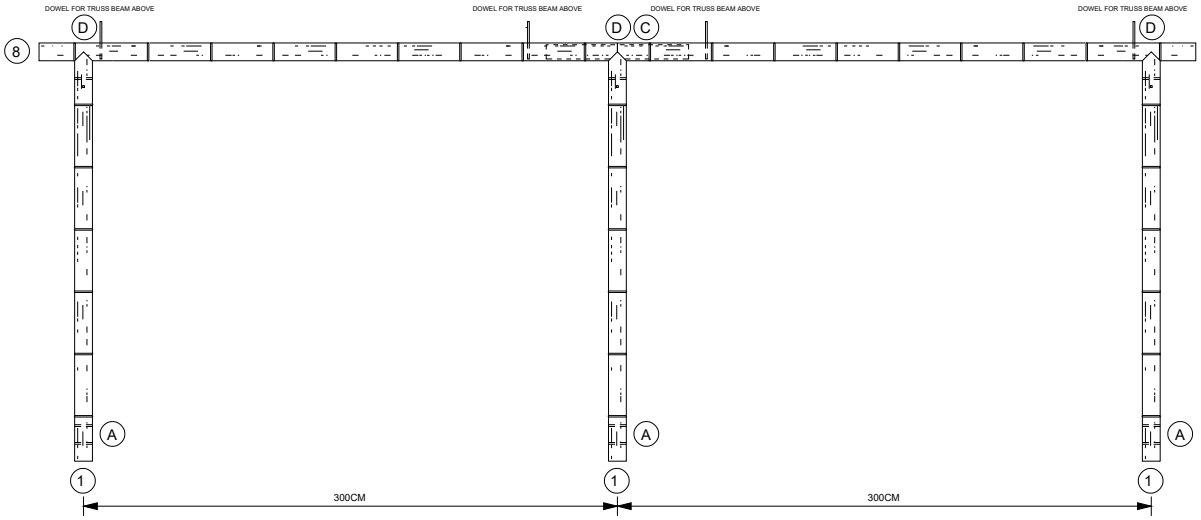
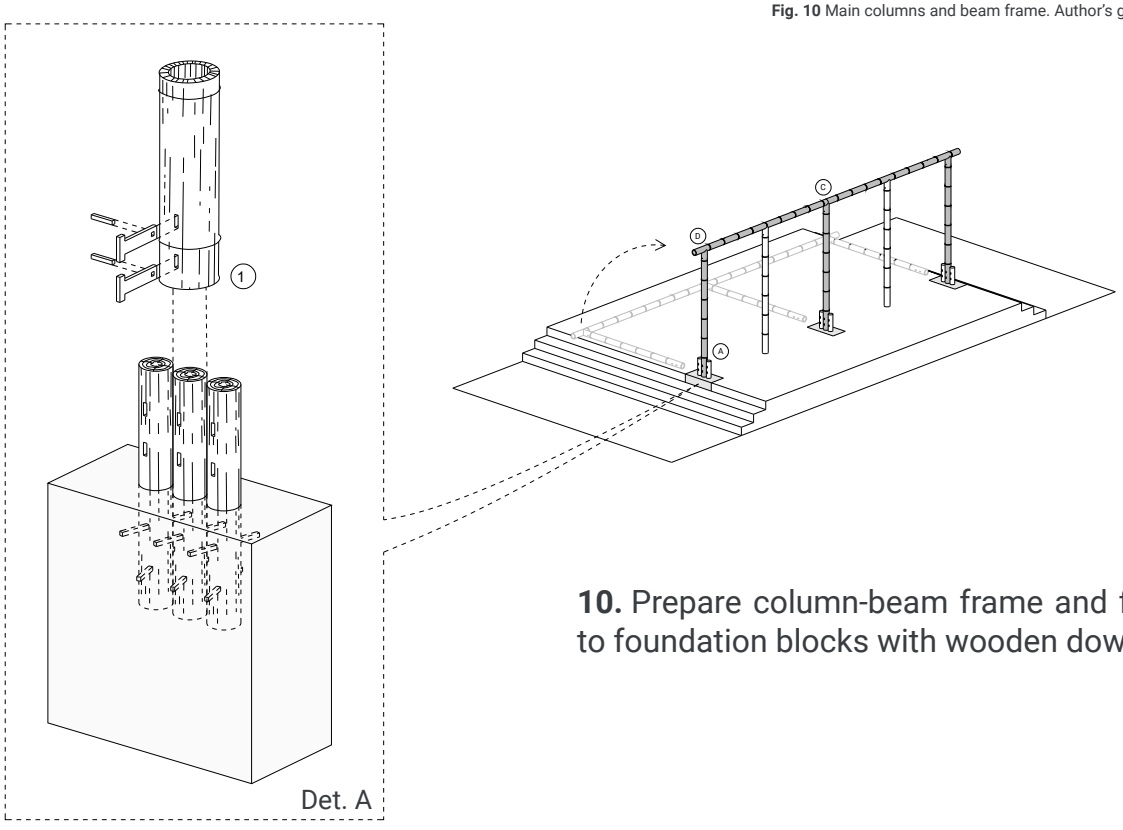


Fig. 10 Main columns and beam frame. Author's graphics.



10. Prepare column-beam frame and fix it to foundation blocks with wooden dowels.

Bamboo Structure

11. Insert diagonal beams between columns. Diagonals can be skipped if space in two adjacent modules is meant to serve as one room. At least every second wall should have diagonals.

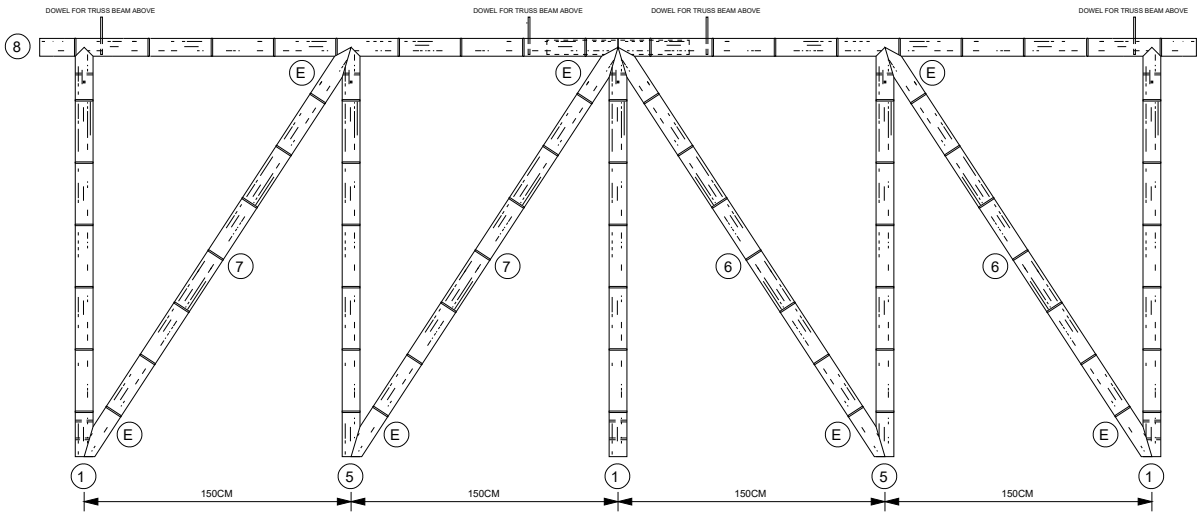


Fig. 12 Diagonal beams. Author's graphics.

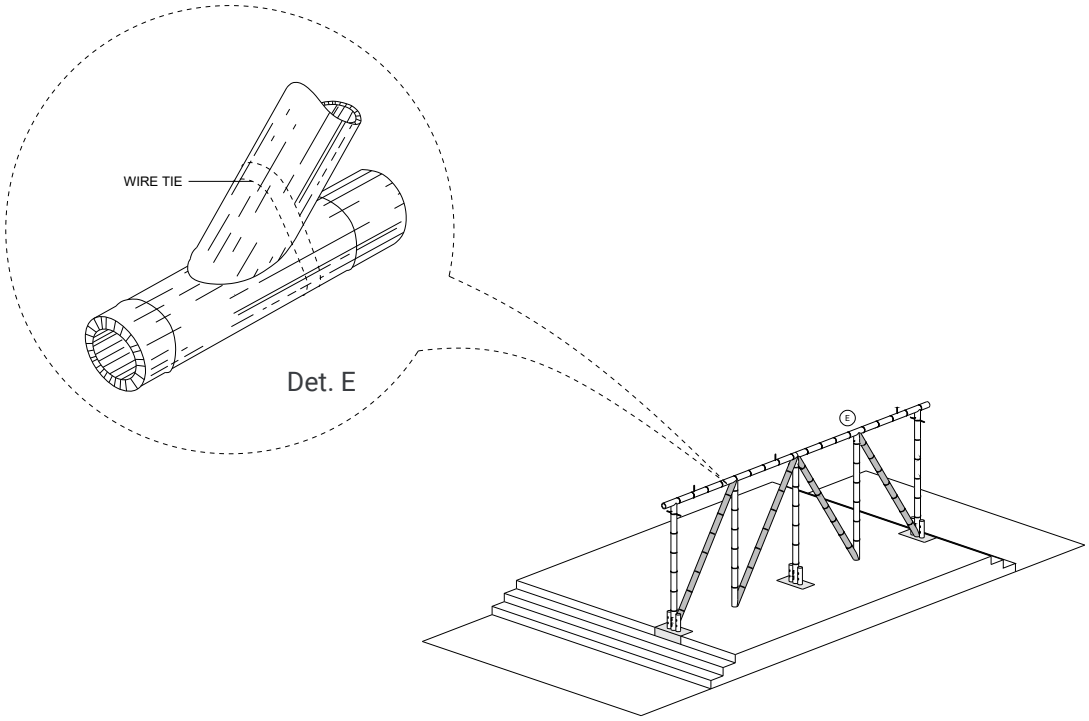


Fig. 11 Det. E. Bamboo diagonal joining technique. Author's graphics. Redrawn from: (Hidalgo-López, 2003)

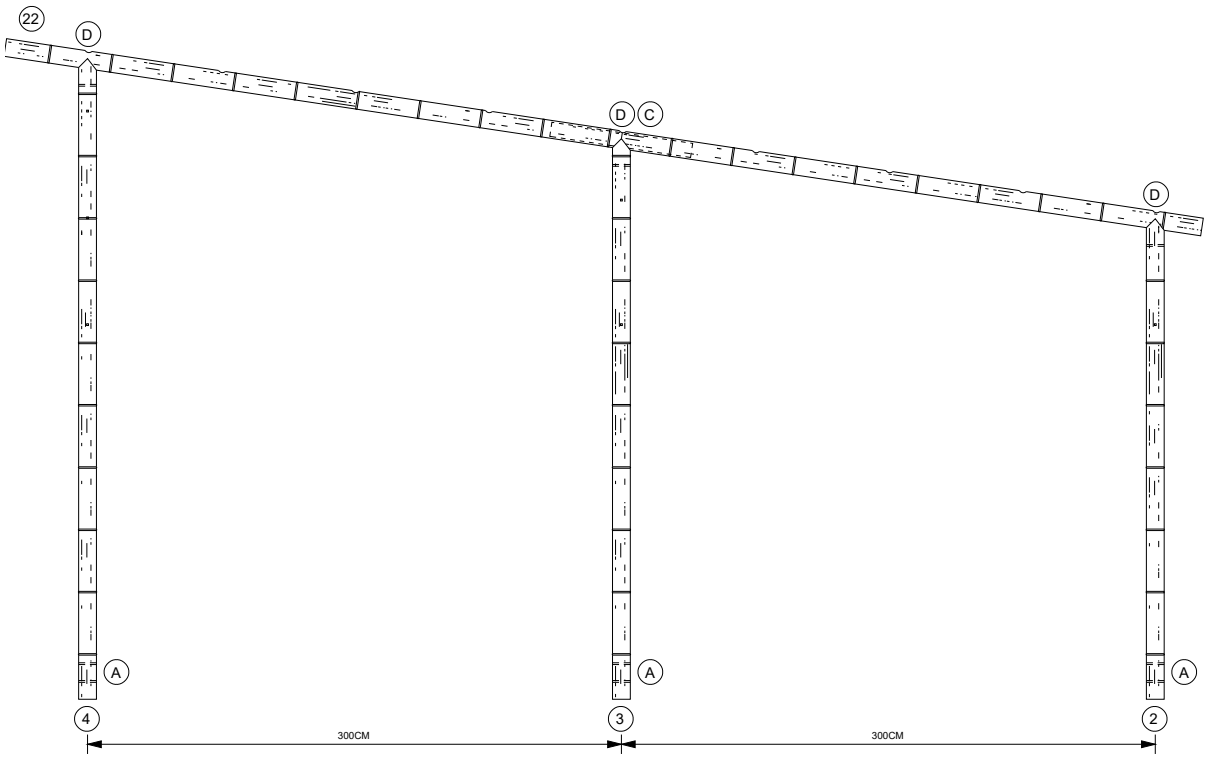


Fig. 13 Main columns and roof beams . Author's graphics.

12. Prepare column-beam frame and fix it to foundation blocks with wooden dowels.

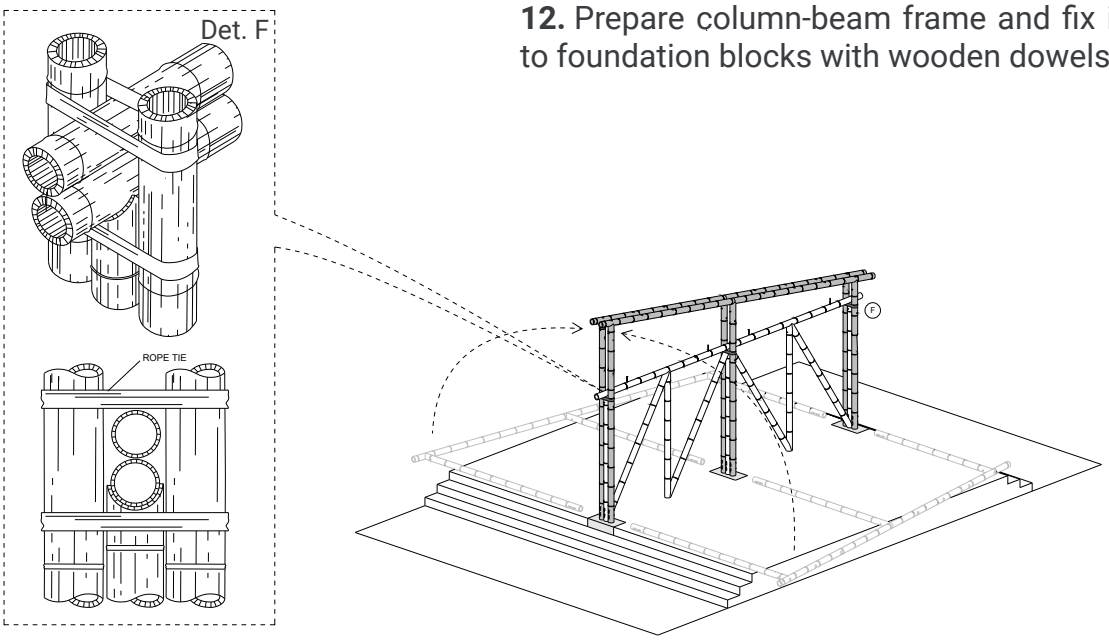


Fig. 14 Det. F. Bamboo rope joining technique. Author's graphics. Redrawn from: (Hidalgo-López, 2003)

Bamboo Structure

13. Construct truss frame and place it on top of the main beam.

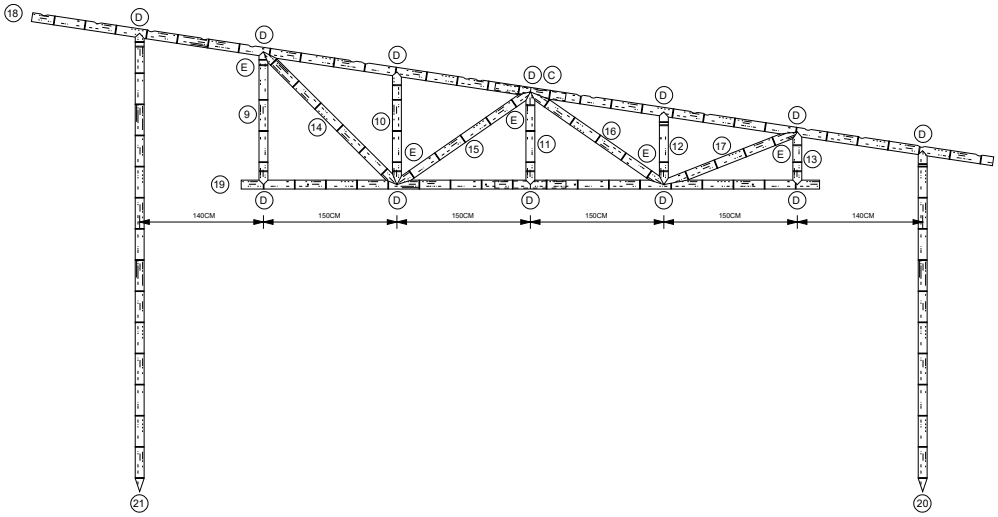
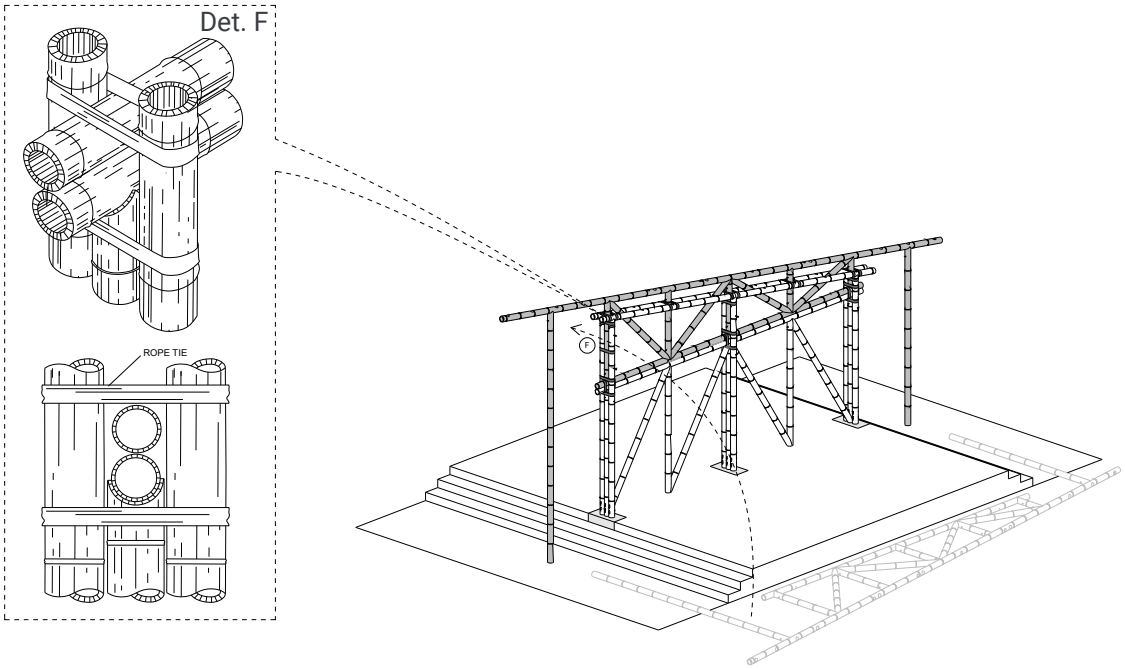


Fig. 15 Truss placed on main columns and beams. Author's graphics.

The assembly of the truss can be carried out on the ground with manpower use only.



14. Place bamboo beams for metal sheet panels.

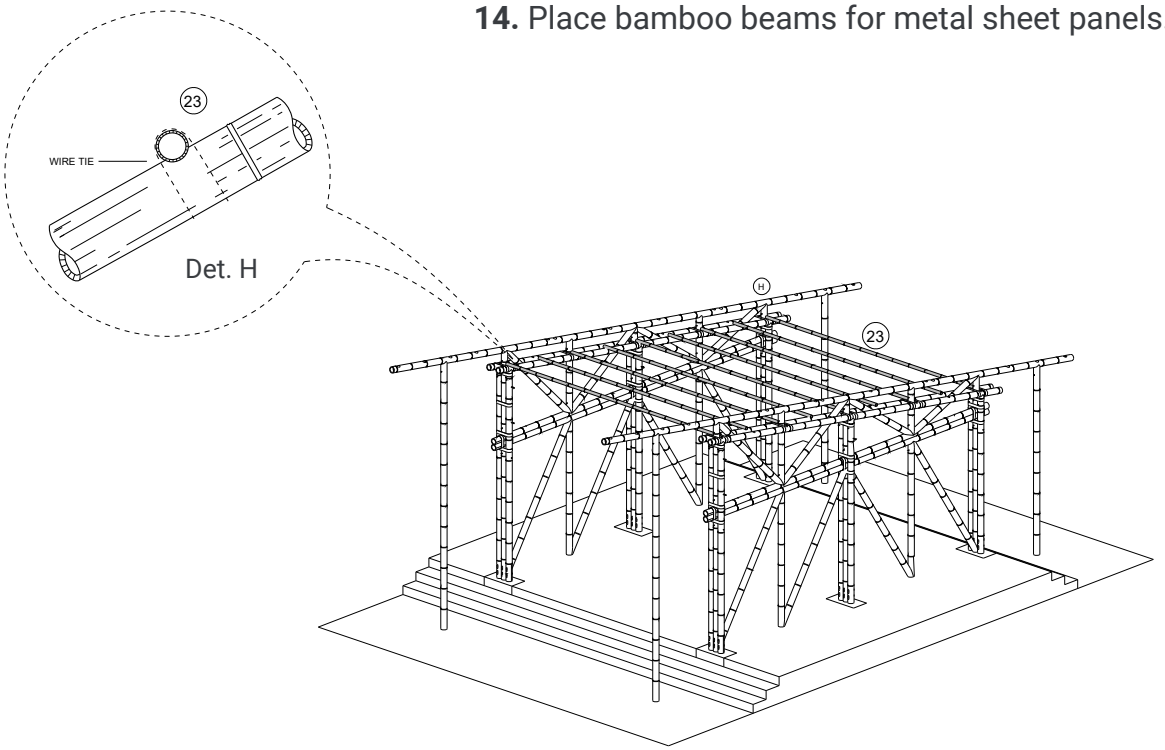


Fig. 16 Det. H. Perpendicular roof beams joining technique. Author's graphics. Redrawn from: (Hidalgo-López, 2003)

15. Use bamboo mat and waterproof film under the metal sheet panels.
16. Install rainwater collection gutter.

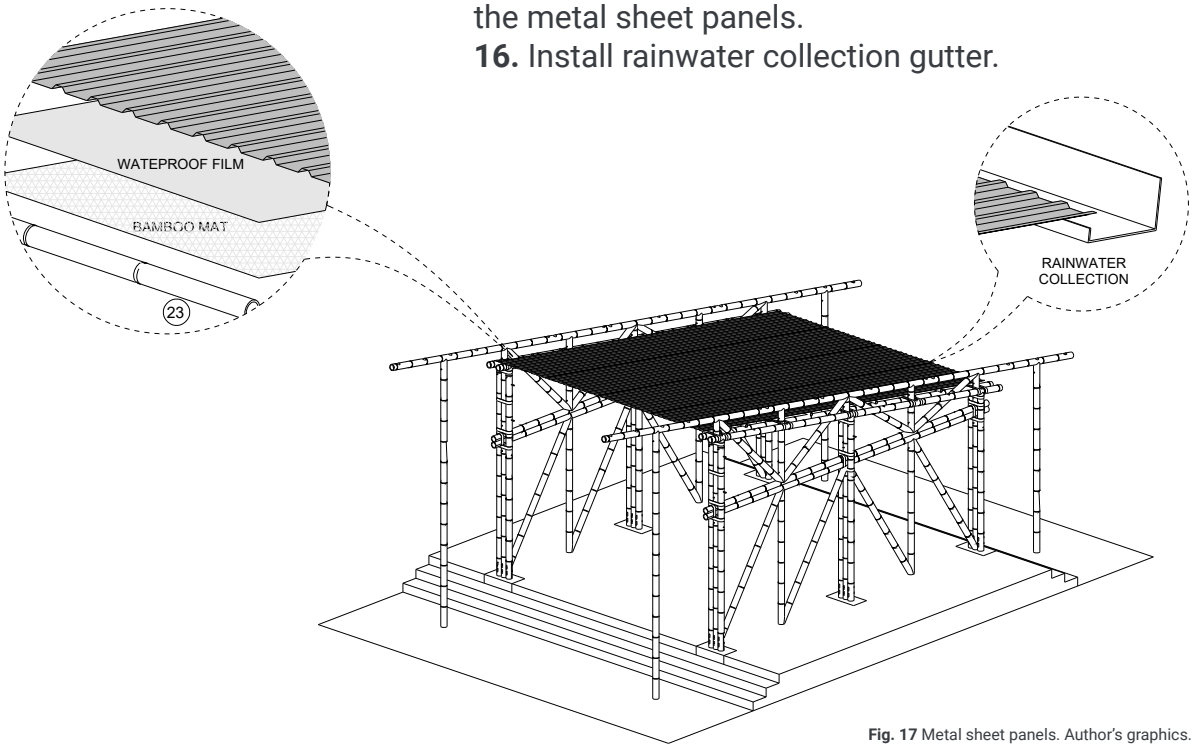


Fig. 17 Metal sheet panels. Author's graphics.

Bamboo Structure

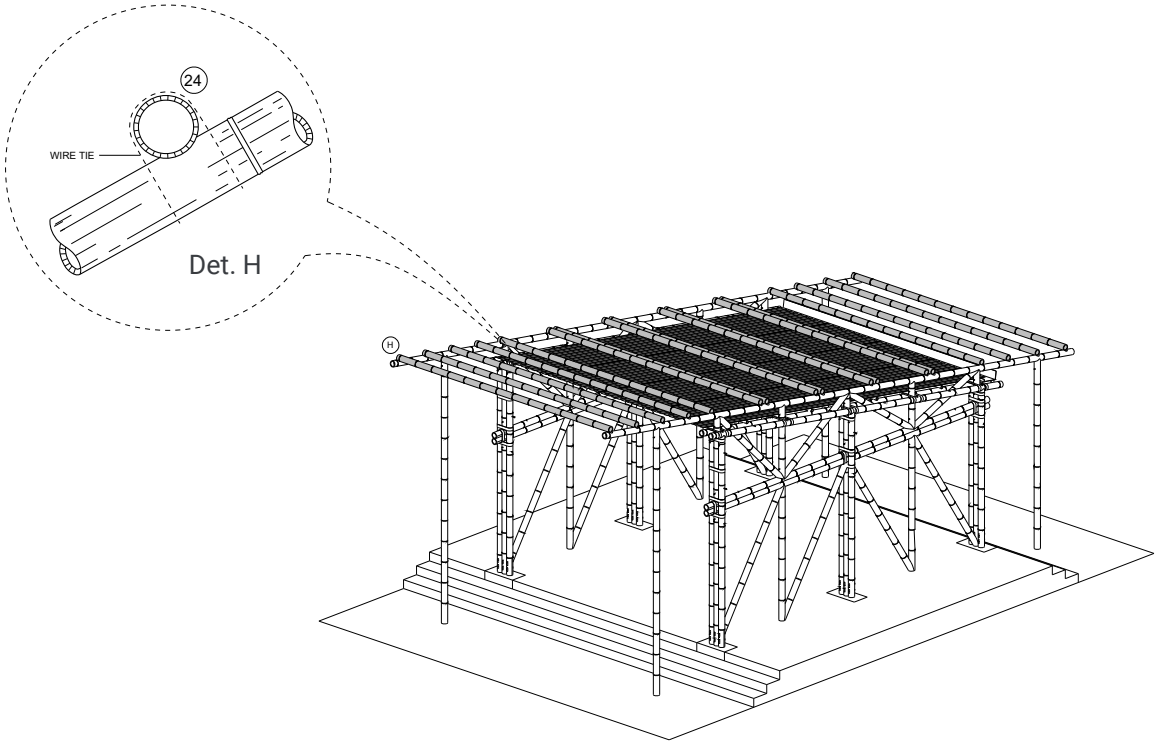


Fig. 18 Beams for water and electricity production systems. Author's graphics.

17. Place bamboo beams on top of the truss frame.
18. Install solar-still units or PV panels.

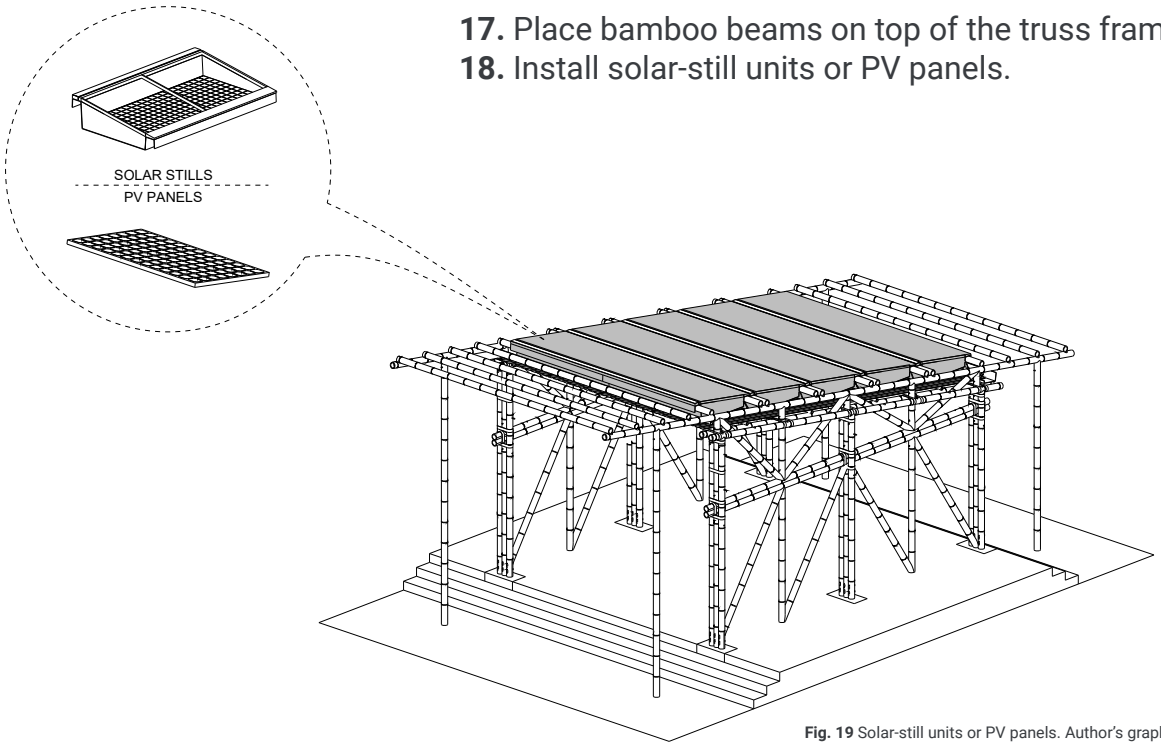


Fig. 19 Solar-still units or PV panels. Author's graphics.

19. Place bamboo sticks for shading.
20. Attach bamboo slats to wall columns and beams.

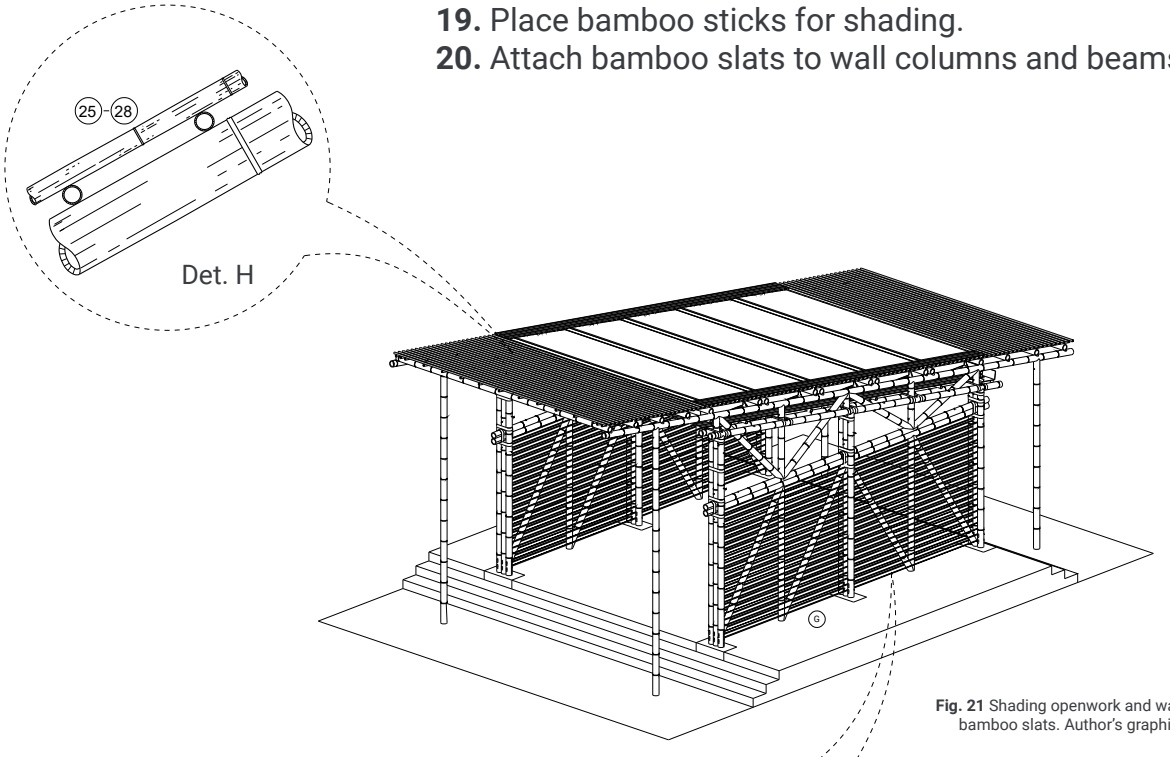


Fig. 21 Shading openwork and walls bamboo slats. Author's graphics.

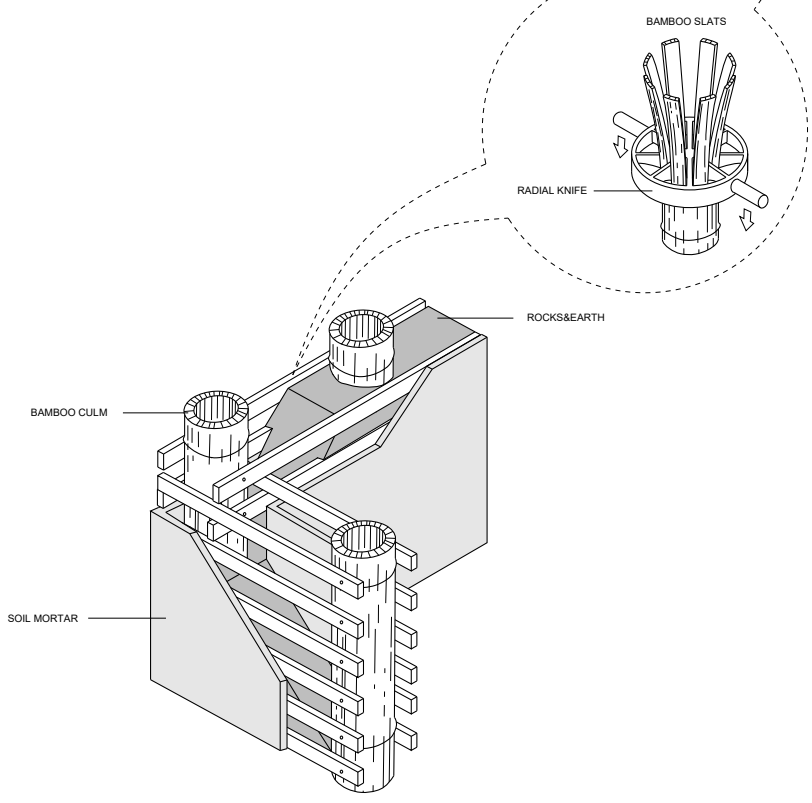


Fig. 20 Det. G. Wall construction technique. Author's graphics. Redrawn from: (Hidalgo-López, 2003)

Bamboo Structure

21. Fill wall's basket with mixed rocks and earth.
22. Plaster walls with soil-cement mortar.

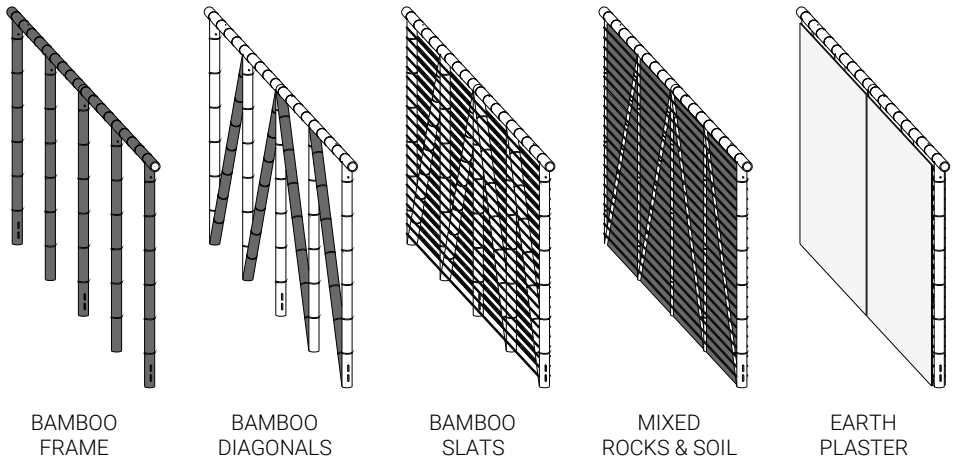


Fig. 22 Wall construction steps. Author's graphics.

23. Install mat against mosquitoes and insects.
24. Finish area above walls with bamboo sticks.

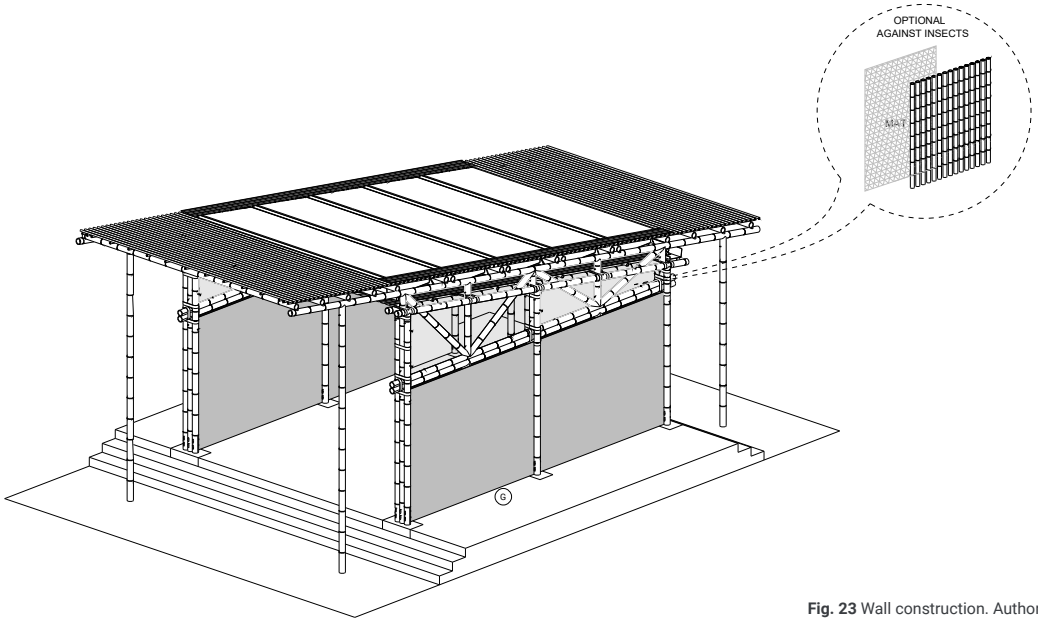


Fig. 23 Wall construction. Author's graphics.

25. Construct the next module.

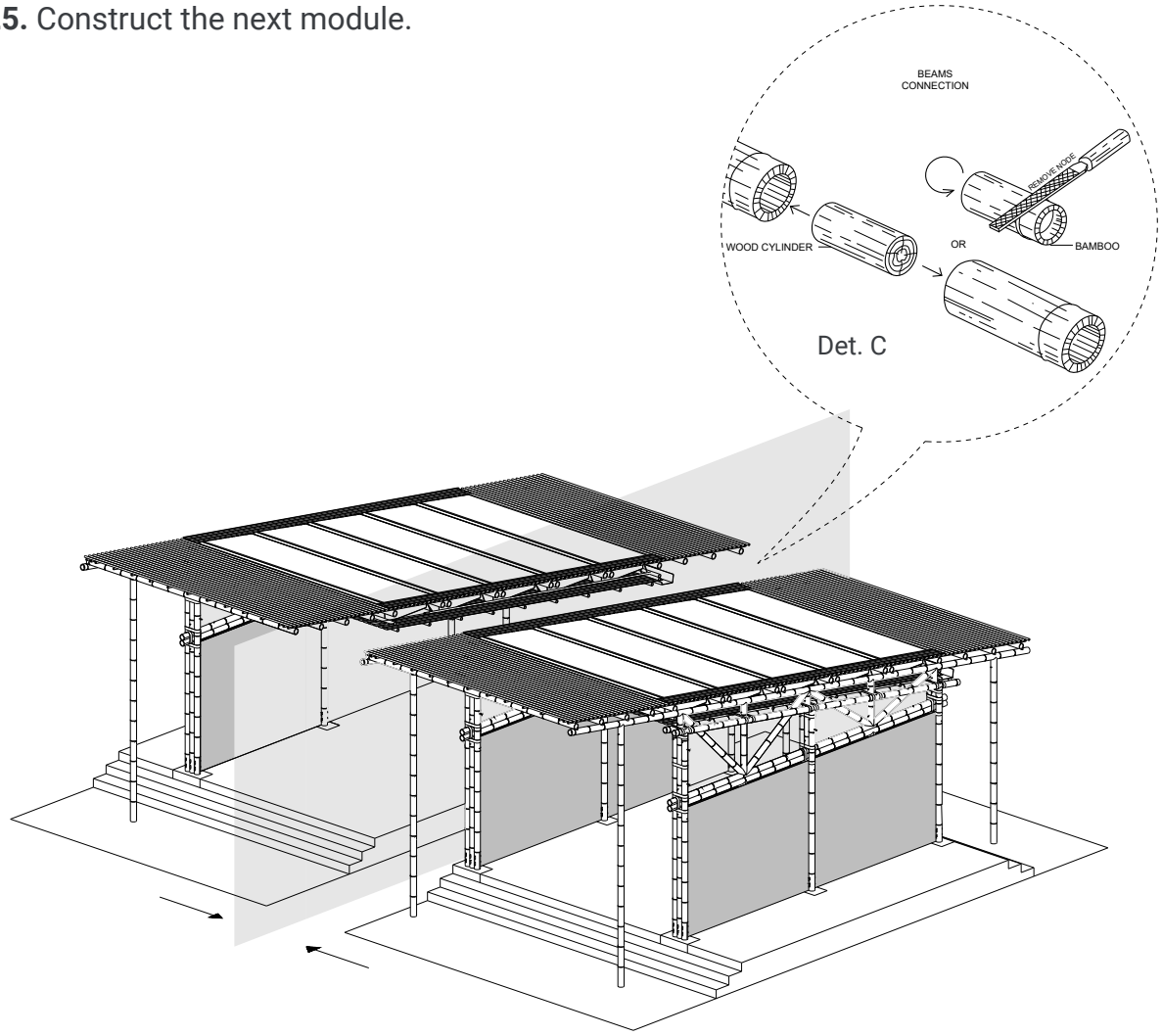
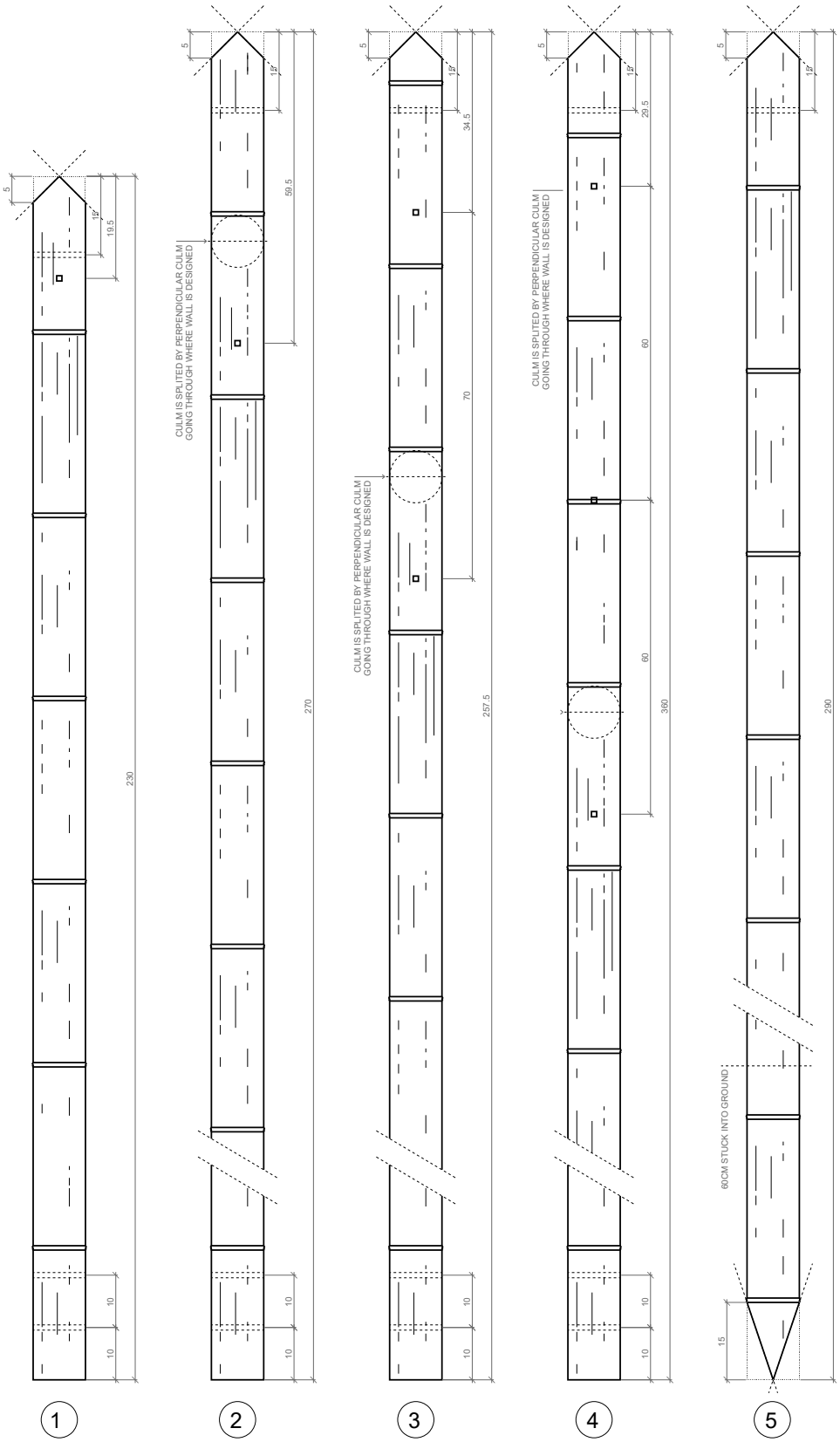
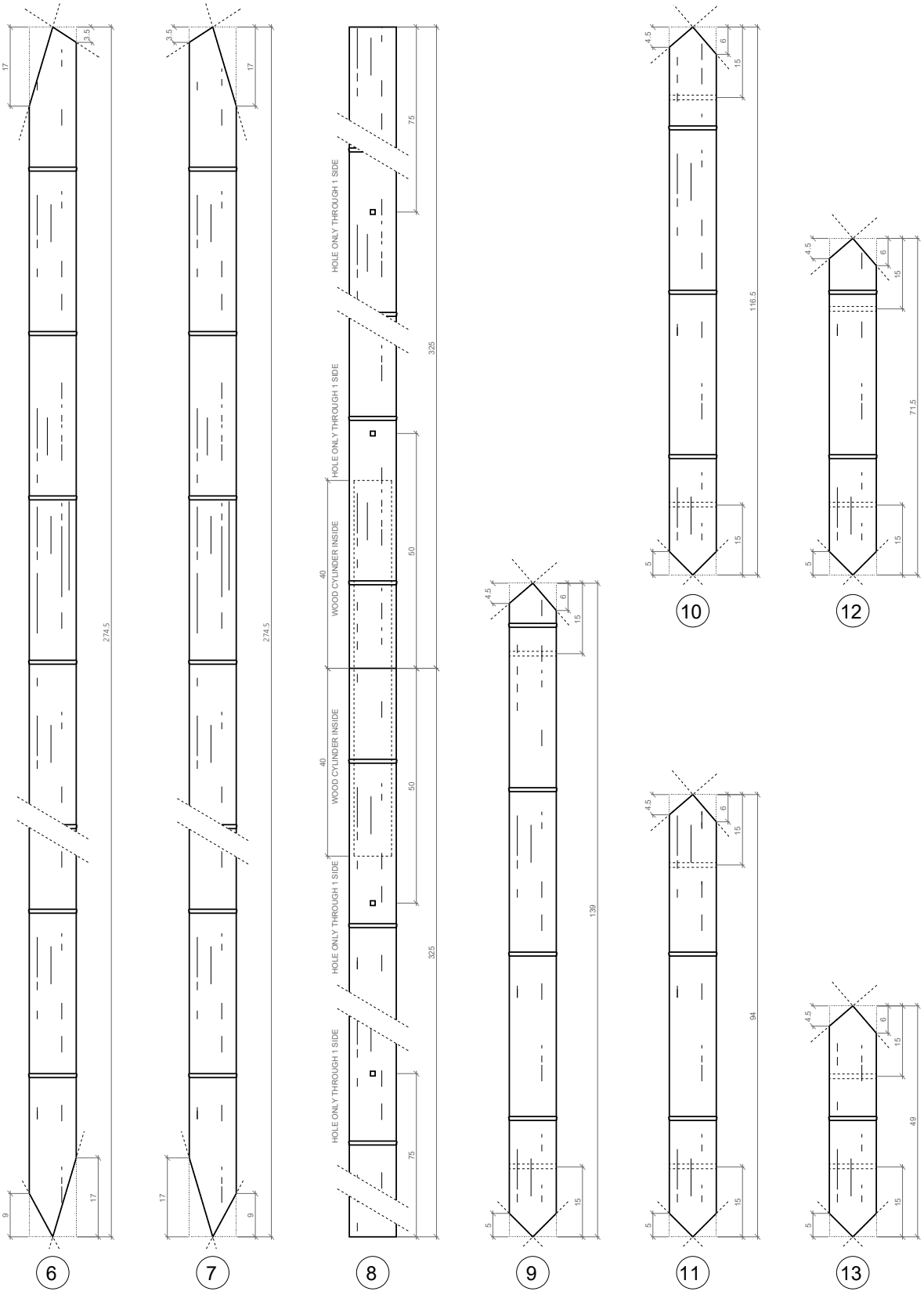


Fig. 24 Modules connection system. Author's graphics.

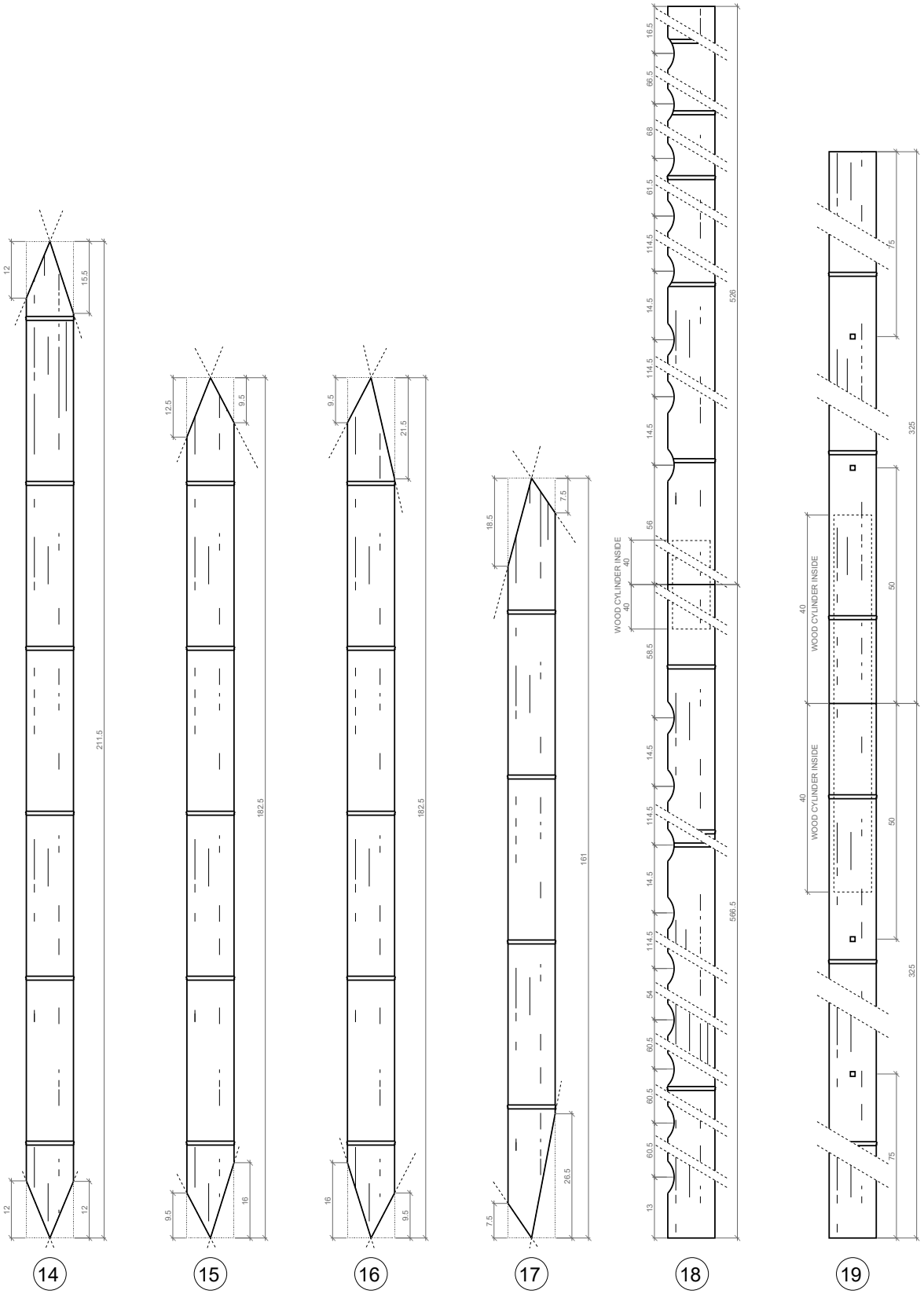
The building system is modular. Modules can be easily attached and the facility can grow depends on need.

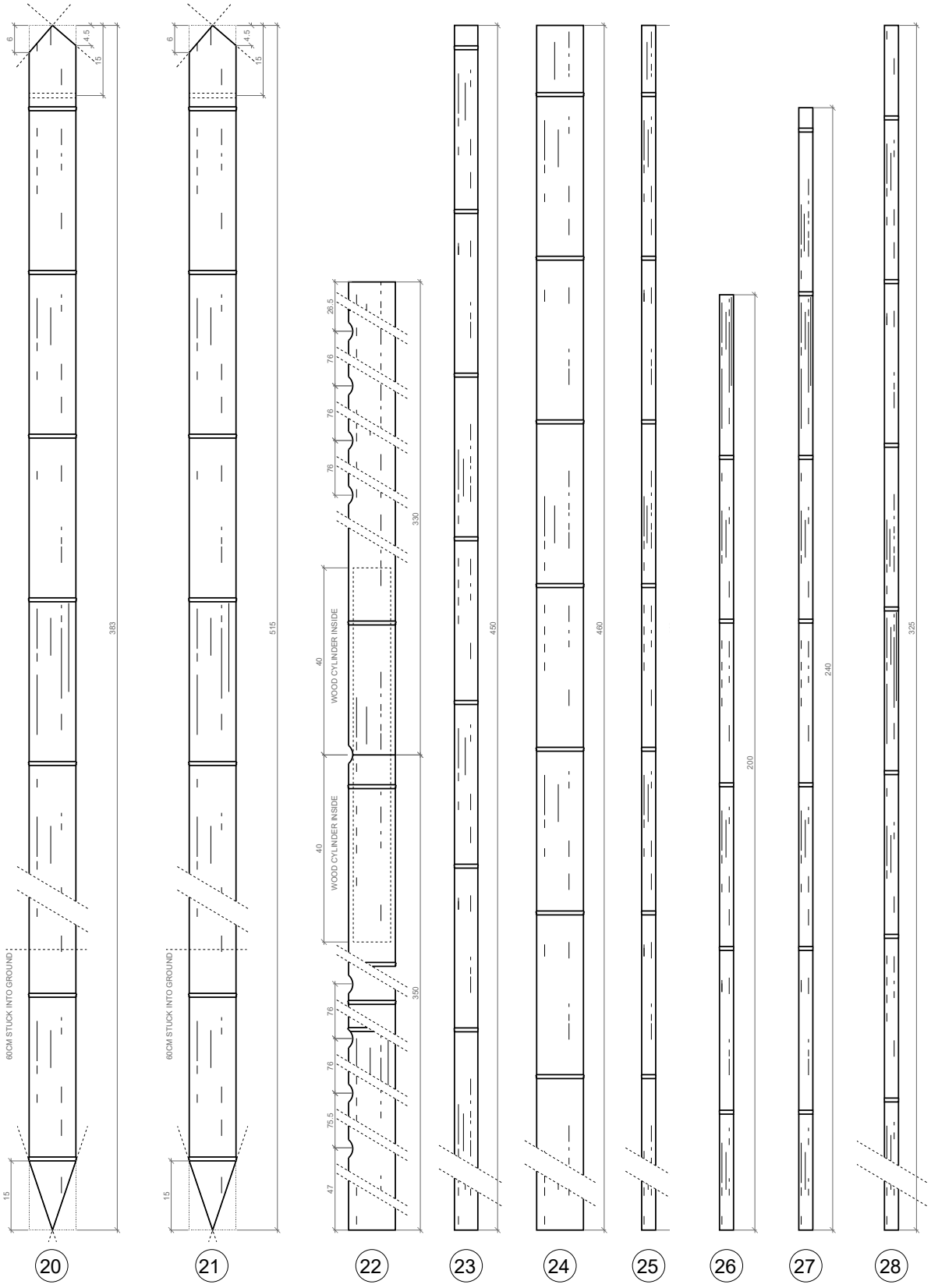
Bamboo Elements




6
7
8
9
10
11
12
13
HOLE ONLY THROUGH 1 SIDE
WOOD CYLINDER INSIDE
HOLE ONLY THROUGH 1 SIDE
WOOD CYLINDER INSIDE
HOLE ONLY THROUGH 1 SIDE
274.5
274.5
325
325
116.5
139
94
71.5
49

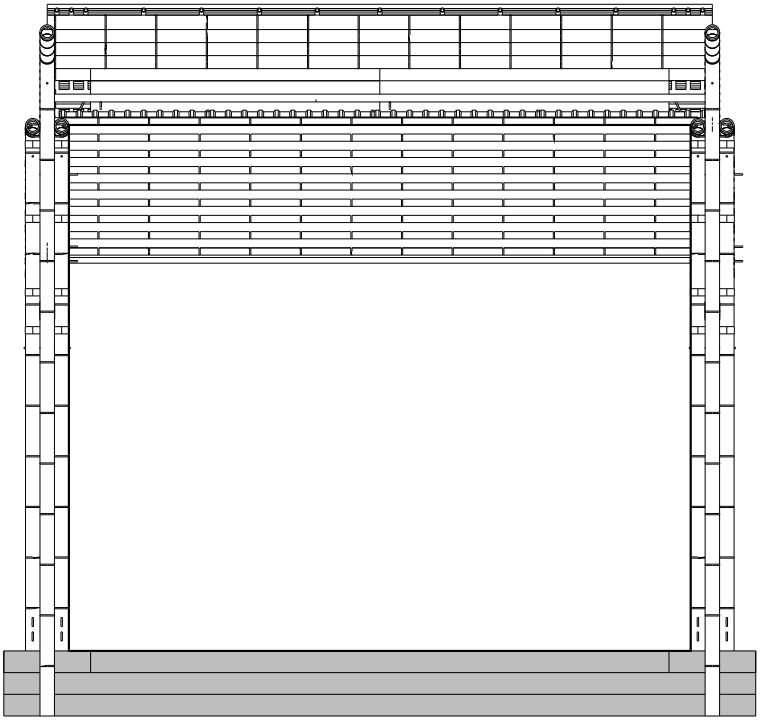
Bamboo Elements



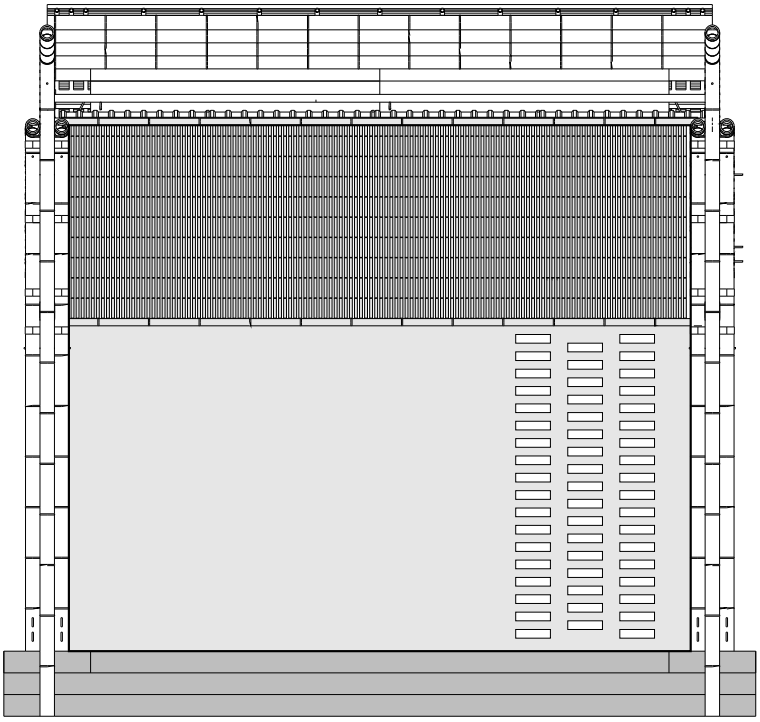

6
4.5
15
383
60CM STUCK INTO GROUND
15
20
6
4.5
15
515
60CM STUCK INTO GROUND
15
21
26.5
76
76
76
330
40
WOOD CYLINDER INSIDE
40
WOOD CYLINDER INSIDE
350
76
76
75.5
47
22
450
23
460
24
25
200
26
240
27
325
28

Front & Back Walls

Optional



Fully open



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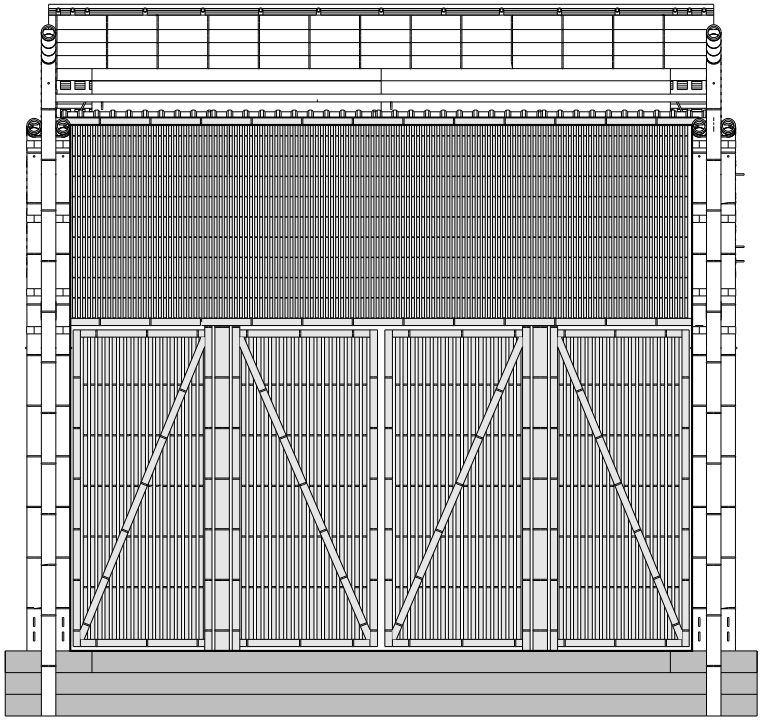
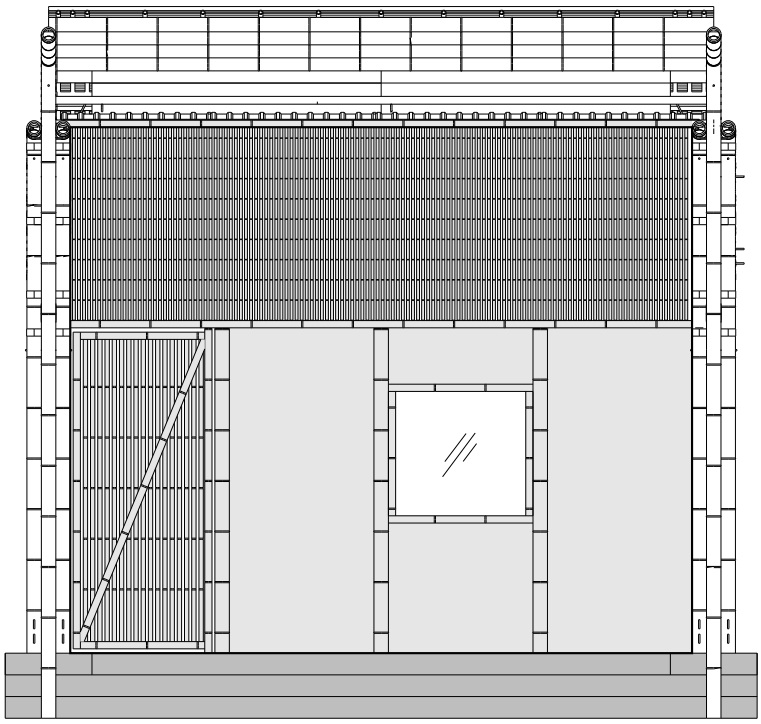


Openable



With doors/windows

Fig. 25 Front/back wall options. Author's graphics.

Central HUB

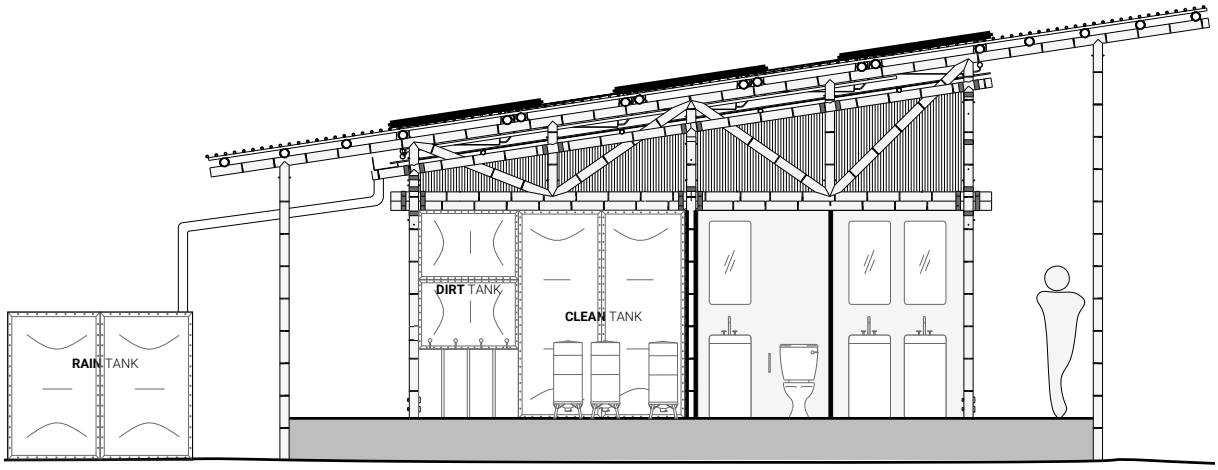


Fig. 26 Central HUB A-A section. Author's graphics.

The central hub has been divided into two separate symmetrical sanitary spaces for men and women, and a technical room (Fig.26). The entrances to the sanitary rooms are located in the front facade. The entrance to the technical room is on the opposite side of the object.

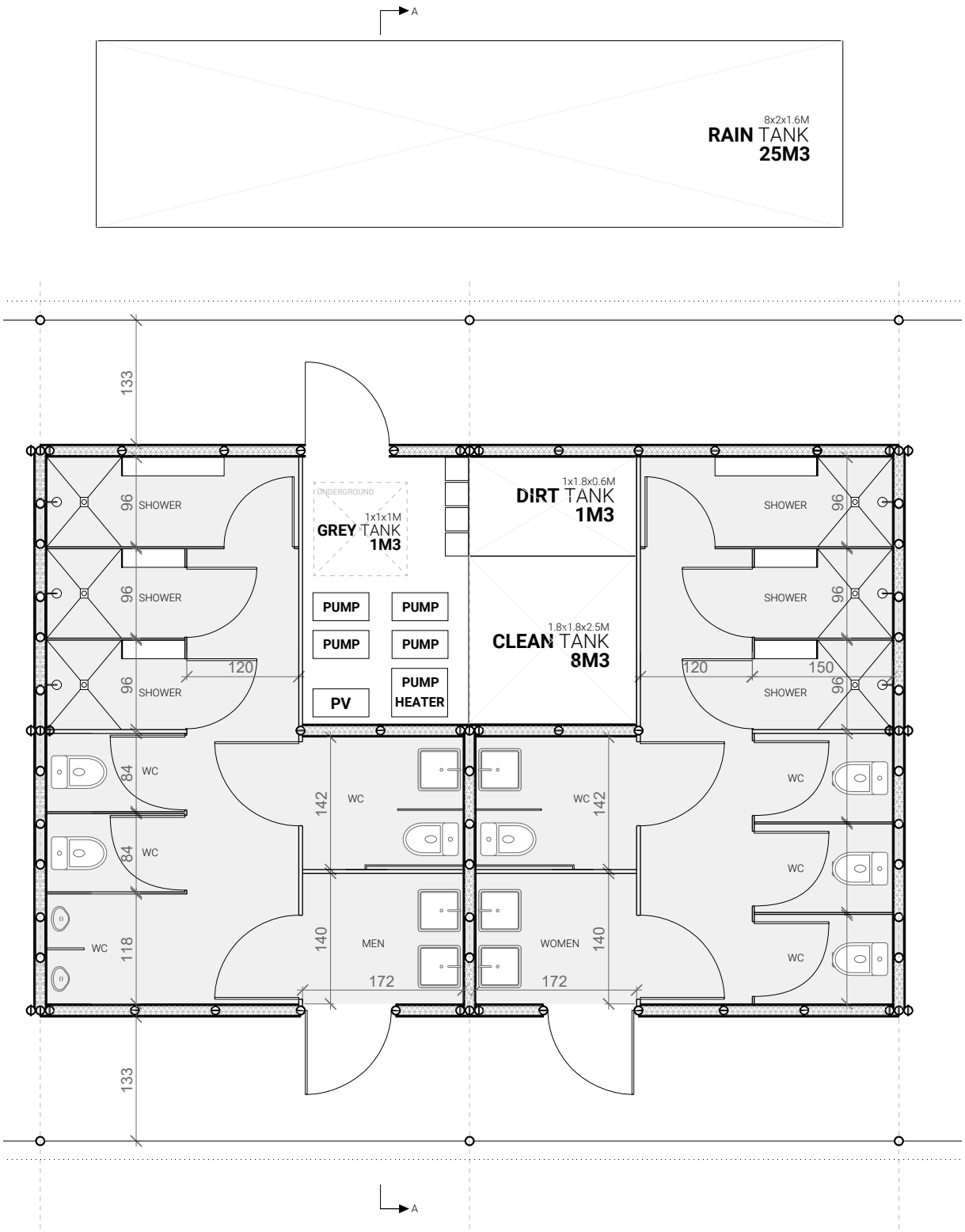


Fig. 27 Central HUB floorplan. Author's graphics.

Water system

Solar-still Unit

The water filtration process takes place in a solar-still system located on the roof of the facility. The minimum production area is based on studied materials and research which can be found in the report document. The size of the installation depends on site climate conditions and the number of people for whom it is designed. In this chapter construction steps of one GFRP unit can be found, as well as, photographic record from mock-up phase.

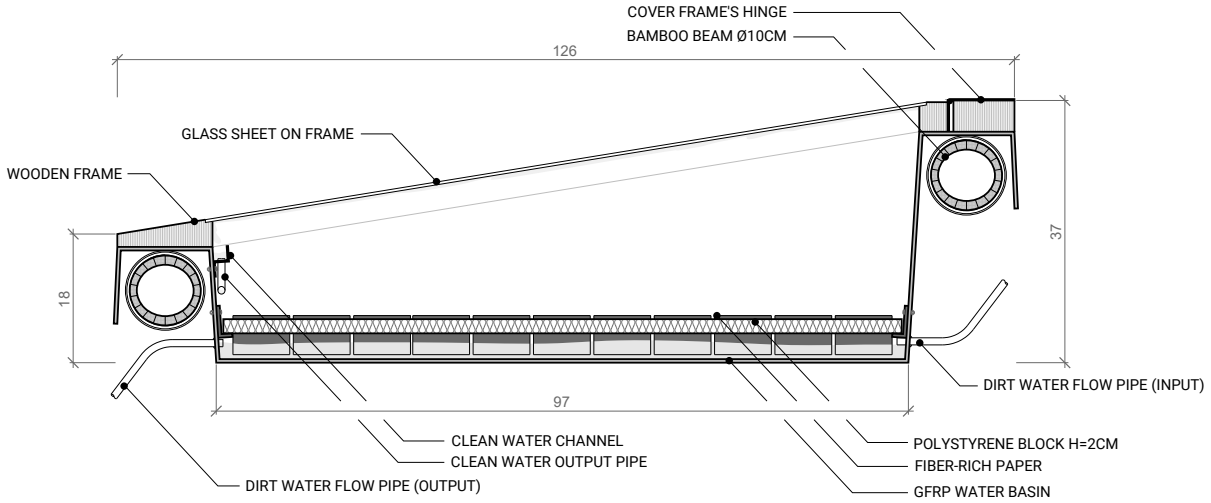


Fig. 28 Solar still unit section. Author's graphics.

Each unit consists of a water basin, polystyrene block with fiber-rich paper, and transparent cover. The total weight of each unit is approximately 40kg.

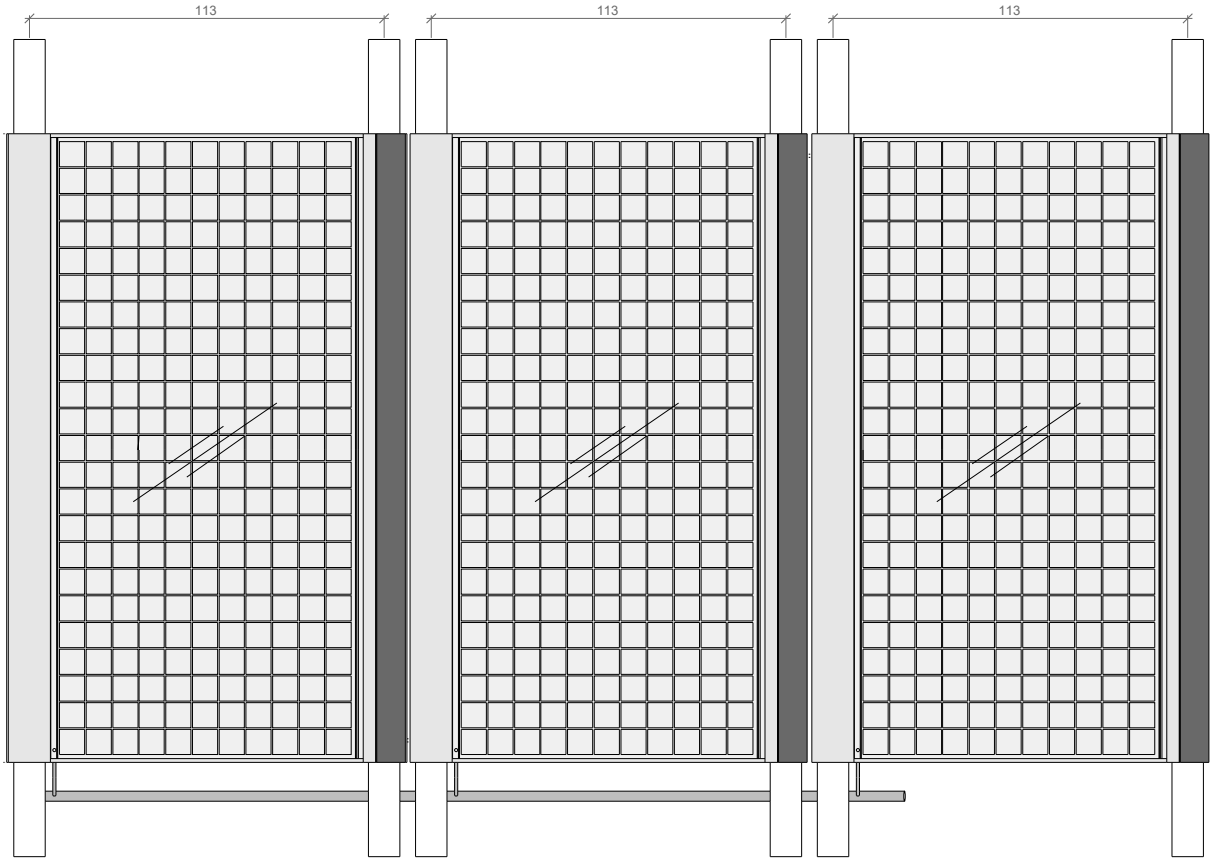


Fig. 30 Solar still unit top view. Author's graphics.

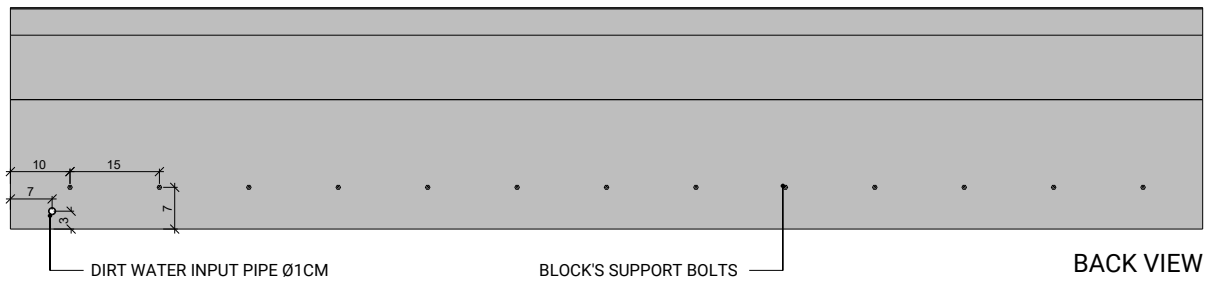


Fig. 29 Solar still unit front and back views. Author's graphics.

Water system

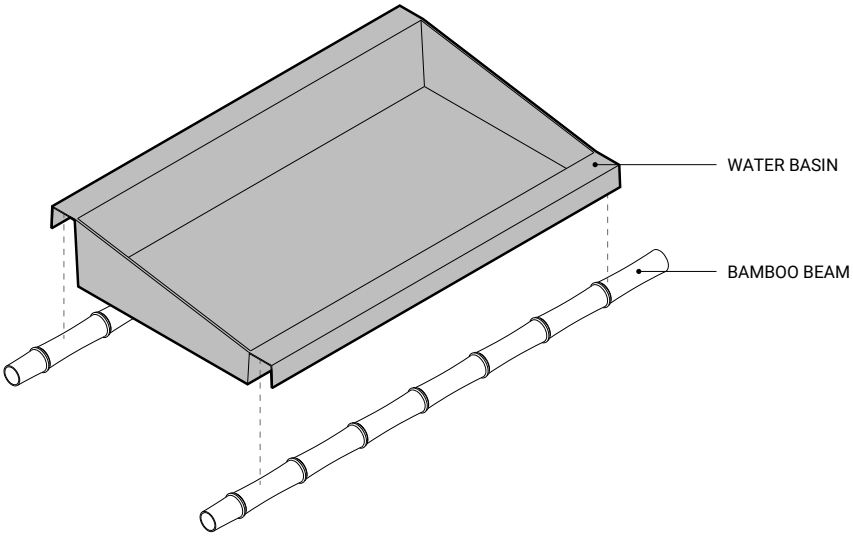


Fig. 32 GFRP water basin. Author's graphics.

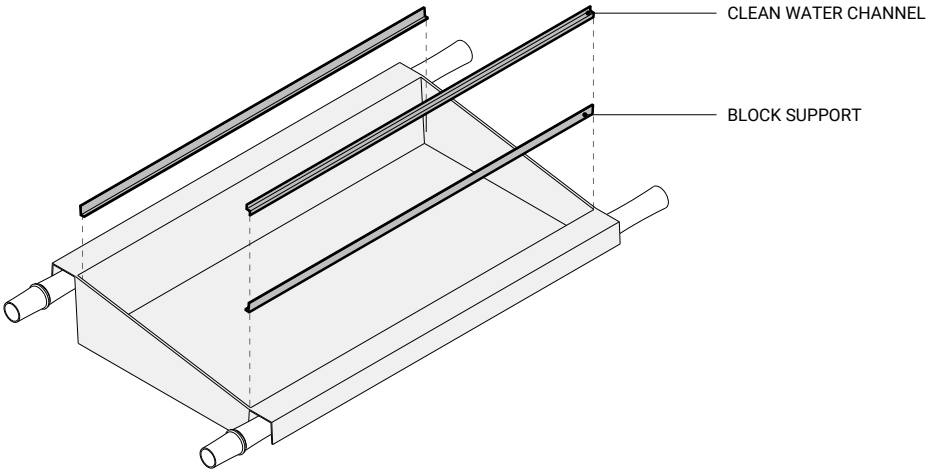


Fig. 31 Block support and clean water profiles. Author's graphics.

1. Make mold for casting GFRP (1-7)
2. Cut fiber glass mat (8-9)
3. Prepare tools and materials (resin) for casting (10)
4. Cast GFRP water basin (11-13)
5. Postprocess cast (sand surface, cut, topcoat) (14-19; 29-30)
6. Cut and attach profiles (23-24)

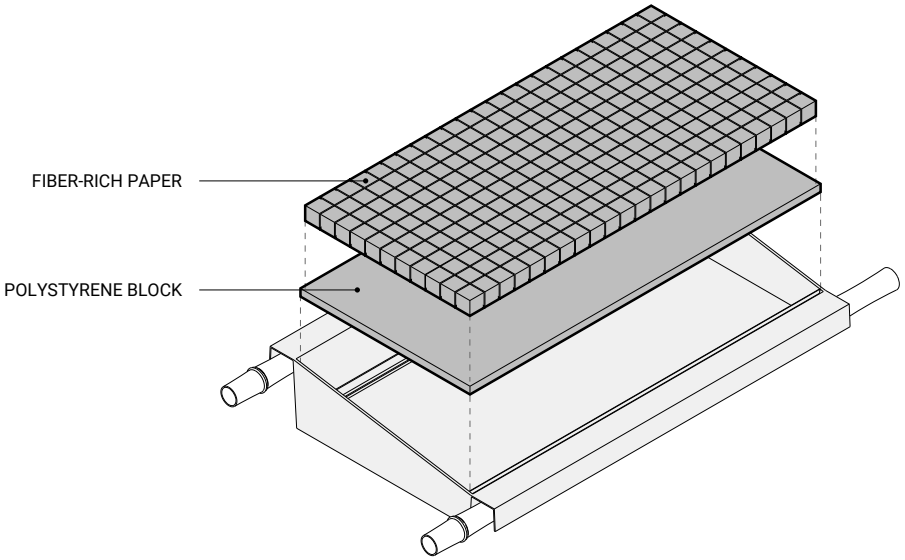


Fig. 33 Polystyrene block with fiber-rich paper. Author's graphics.

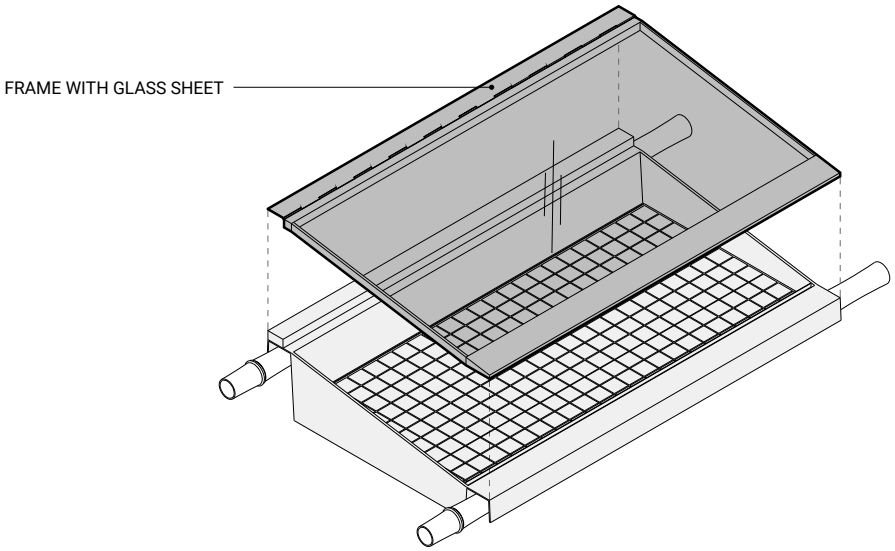


Fig. 34 Transparent cover. Author's graphics.

7. Construct transparent cover with glass (32-33)
8. Glue rubber gasket and connect cover with basin (34-36)
9. Cut polystyrene block (37-38)
10. Cut and dye wipes (39-40)
11. Attach wipes to polystyrene block (41-43)
12. Prepare and attach piping system (20-28)

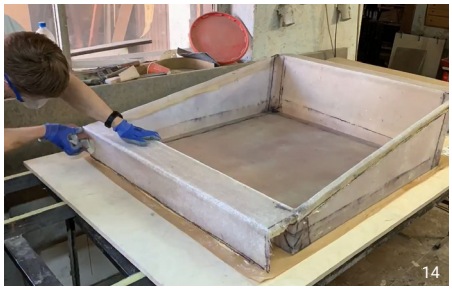
Water system


10


11


12


13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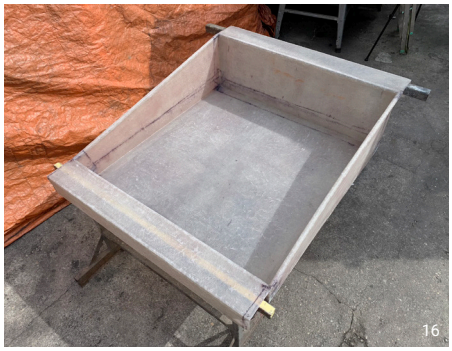
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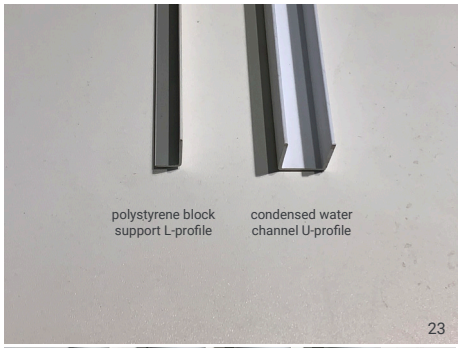
Water system



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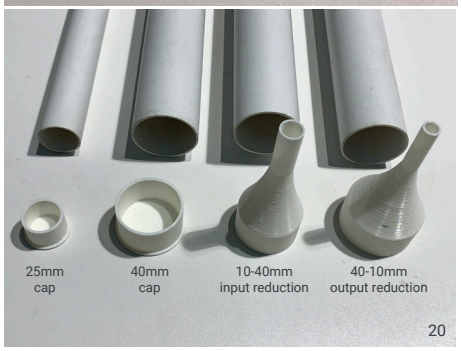

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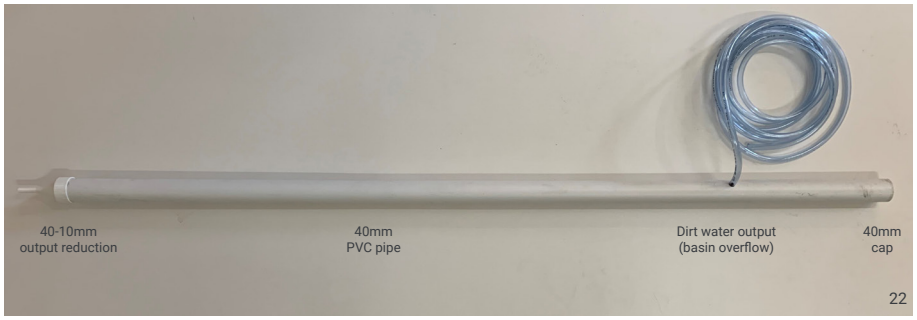

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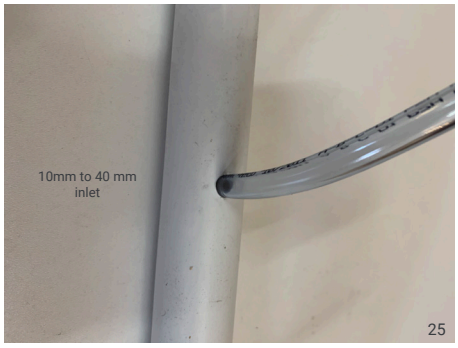

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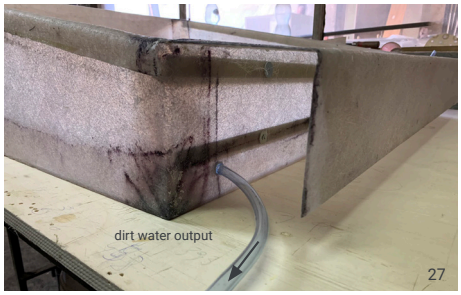

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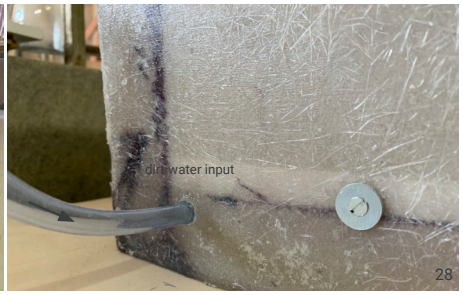

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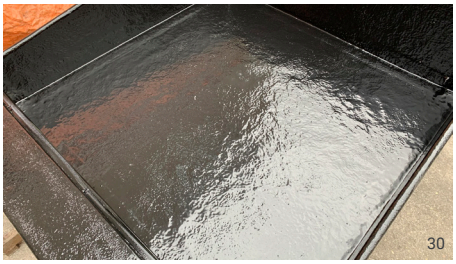
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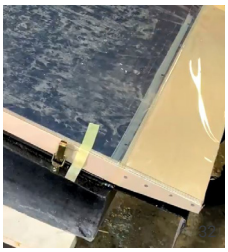
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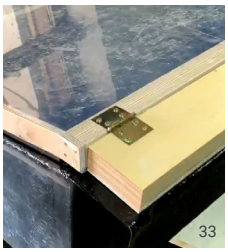
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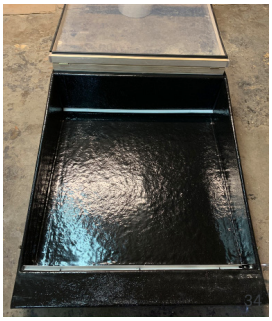
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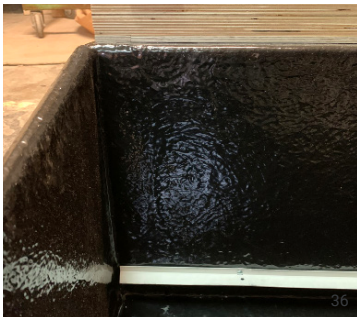
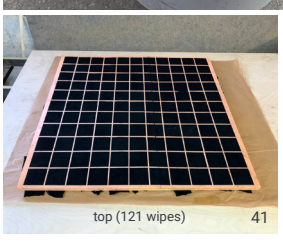

36


37

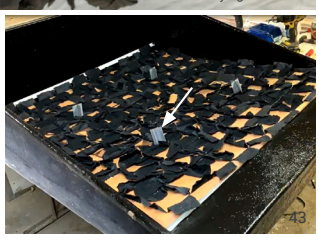

38


coating 39


drying 40


top (121 wipes) 41


bottom (121 wipes) 42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Water System

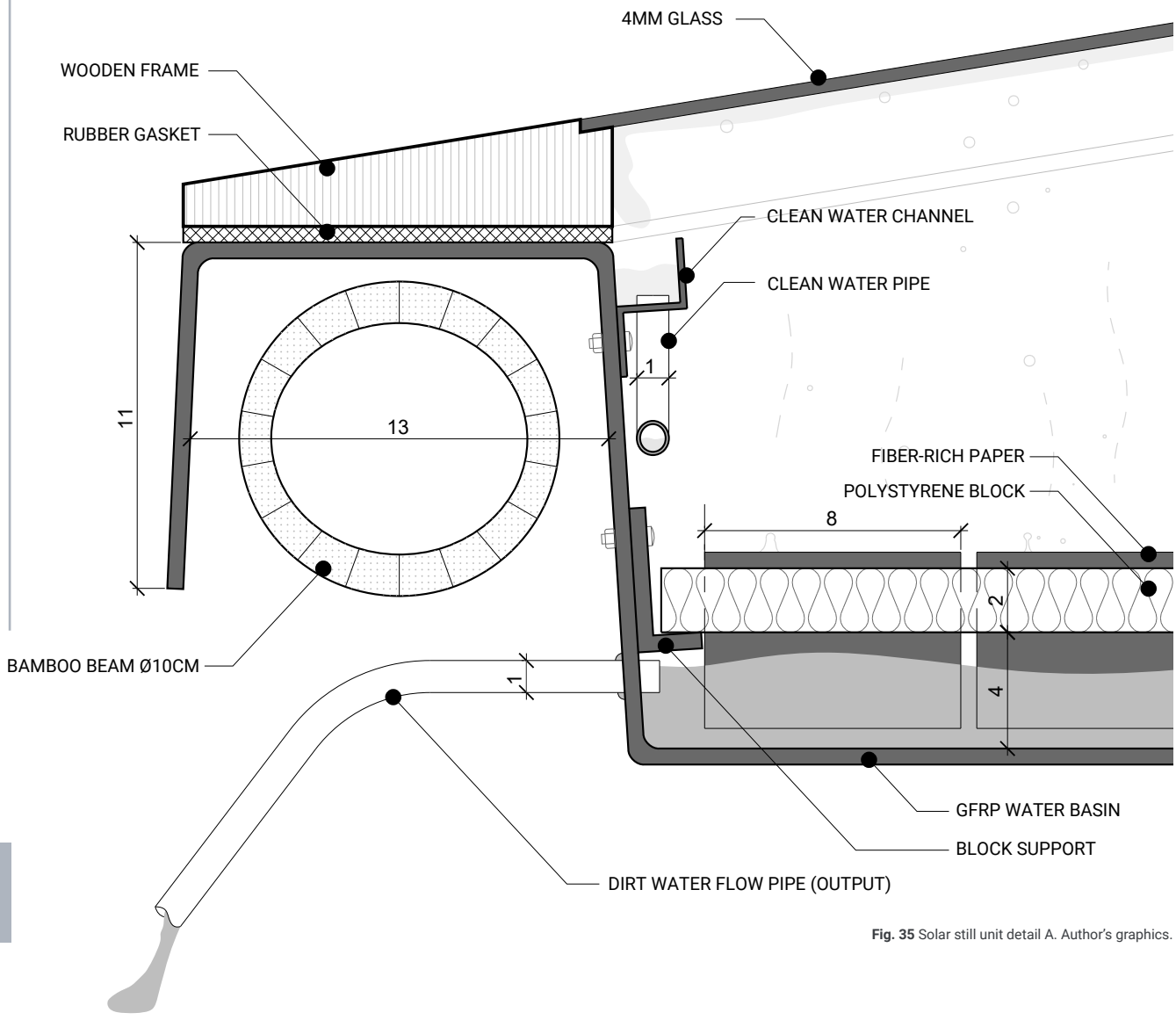

Fig. 35 Solar still unit detail A. Author's graphics.

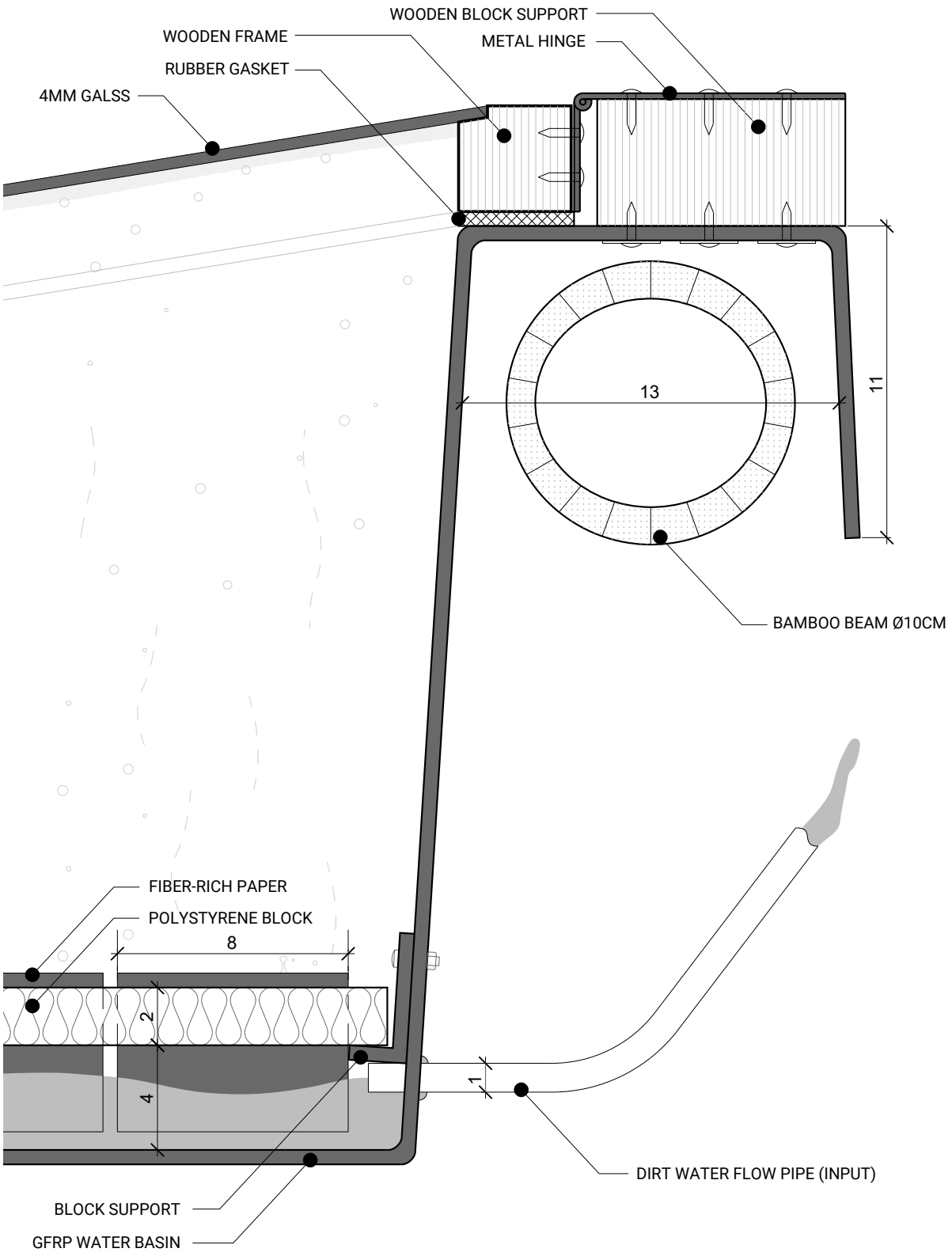

Fig. 36 Solar still unit detail B. Author's graphics.

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