ARCHITECTURAL \\ TECHNICAL RESEARCH PAPER

TRA-DIGITAL HYBRID

Using digital fabrications to create a hybrid design for developing countries

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// June 2014

ACKNOWLEDGEMENTS

During my research I was greatly aided by my research tutors:

Monique Smit, my architecture tutor, has been a source of knowledge of Indonesian culture and a great guide during our time in Indonesia. Despite us getting lost often in Bandung, this always led to more interesting places.

Marcel Bilow, my building technology tutor, thank you for your endless enthusiasm and great idea's during my graduation project. I experienced Marcels tutoring philosophy as such: there are never any unsolvable problems, only opportunities and improvement. Thank you for seeing the potential of this technology in this project.

Pieter Stoutjesdijk, my research tutor, thank you for all your help in my academic challenges. For completely revising my technical research report on a Sunday night, despite it being three times the required length, and making it so much better. But also for CNC milling my 1:1 model, on material that was less than ideal, and on a CNC mill that was less than cooperative at quite an inopportune time.

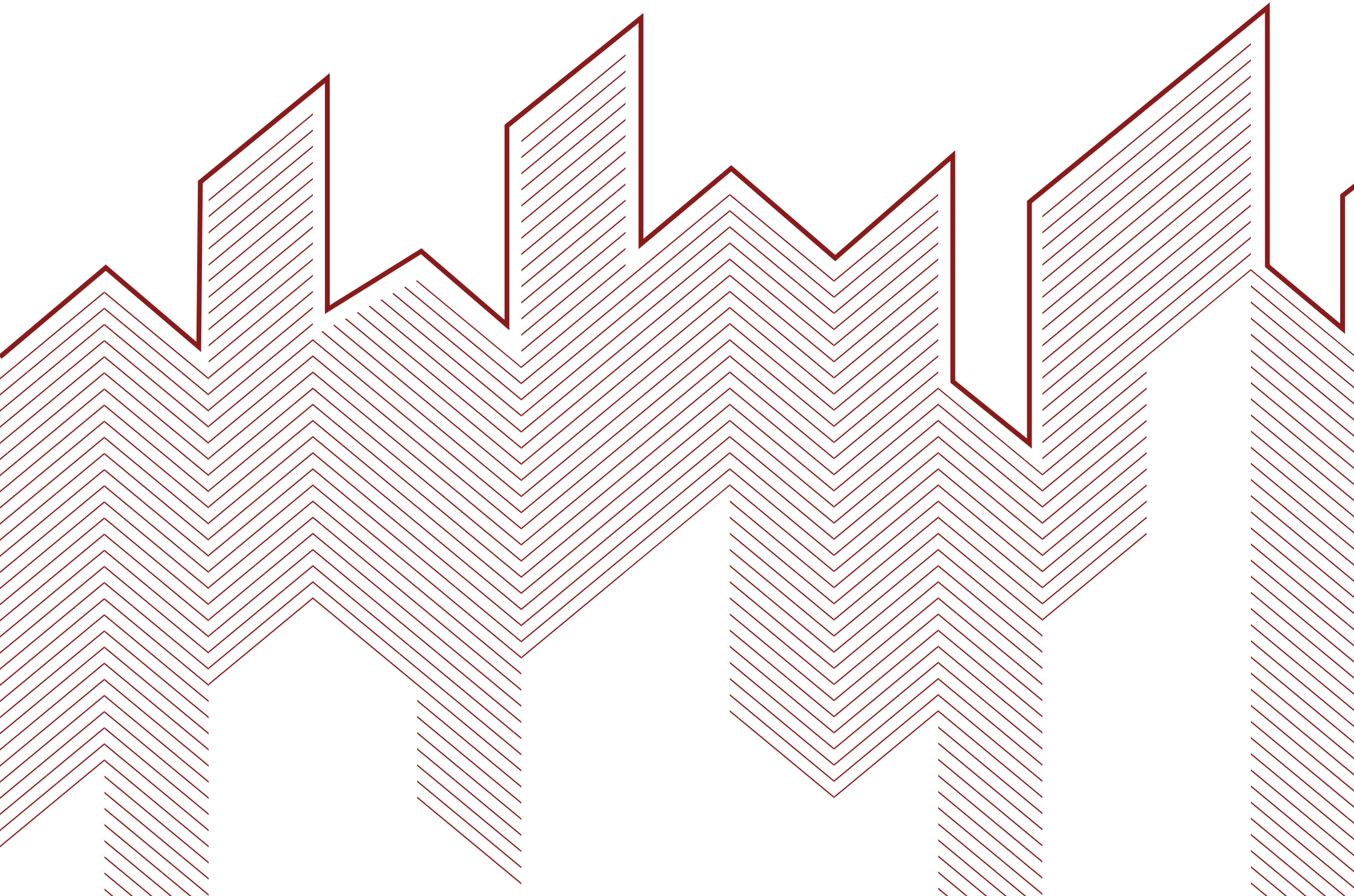
My thanks extends also all the people who supported my research in Bandung Indonesia. In our first trip to Bandung we were greatly helped by Setianingtyas Permatasari (Ayya) an ITB student who volunteered to help us with translating, arranging meetings in Bandung and arranging for her friends Prathito Andy Wisambodhi and Fauzan Wassil to help us in the Kampung.

During my second trip in Bandung I was assisted by Kania Thea Pradipta, an ITB Architecture student, she was a great help in translating and helping me navigate the city of Bandung.

Ramalis Sobandi, a woman of many talents, thank you for connecting me with local architects, showing me local architecture and changing my mind-set on kampungs in Indonesia.

Last but certainly not least I would like to thank KIVI NIRIA for funding my second research trip to Indonesia.

KIVI NIRIA



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  - Housing matrix

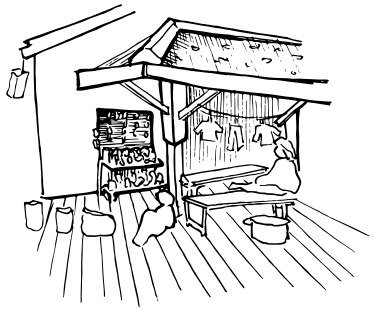
PROBLEMS \\ VALUES KAMPUNG

// PRIORITIZED ACCORDING TO THE DIGITAL RESEARCH

It is quite easy to pick out obvious problems in the kampung, overcrowding and poor quality were the first problems that came to mind when navigating the kampungs. What took slightly longer was to find the strengths of these areas. It requires a very different mind-set to realise there is great value in these area's compared to the western ways of building.
The kampung are a great source of economic activity and know a very tight knit community. They are more than just housing areas. This is very important to take into account when designing for these areas.

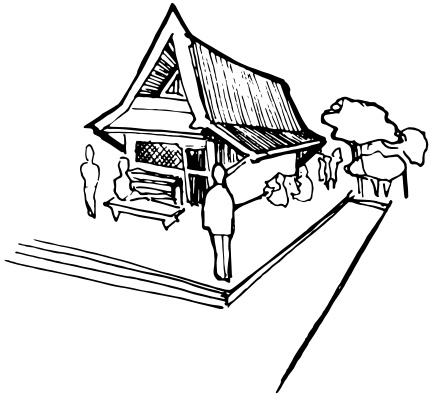
Fig A1.

Fig A1. Visualisation problems Indonesian kampungs (own ill.)
Fig A2. Visualisation most important values Indonesia (own ill.)

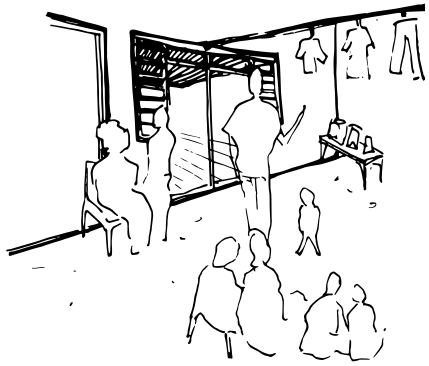


ECONOMIC ACTIVITIES
Workshops
Hairdressers
etc.

FOOD STALLS ATTACHED
TO THE HOUSE



FOOD STALL COMPLEX



COMMUNITY MEETING SPACE
Corridor as a place to
Go, Sit, Meet

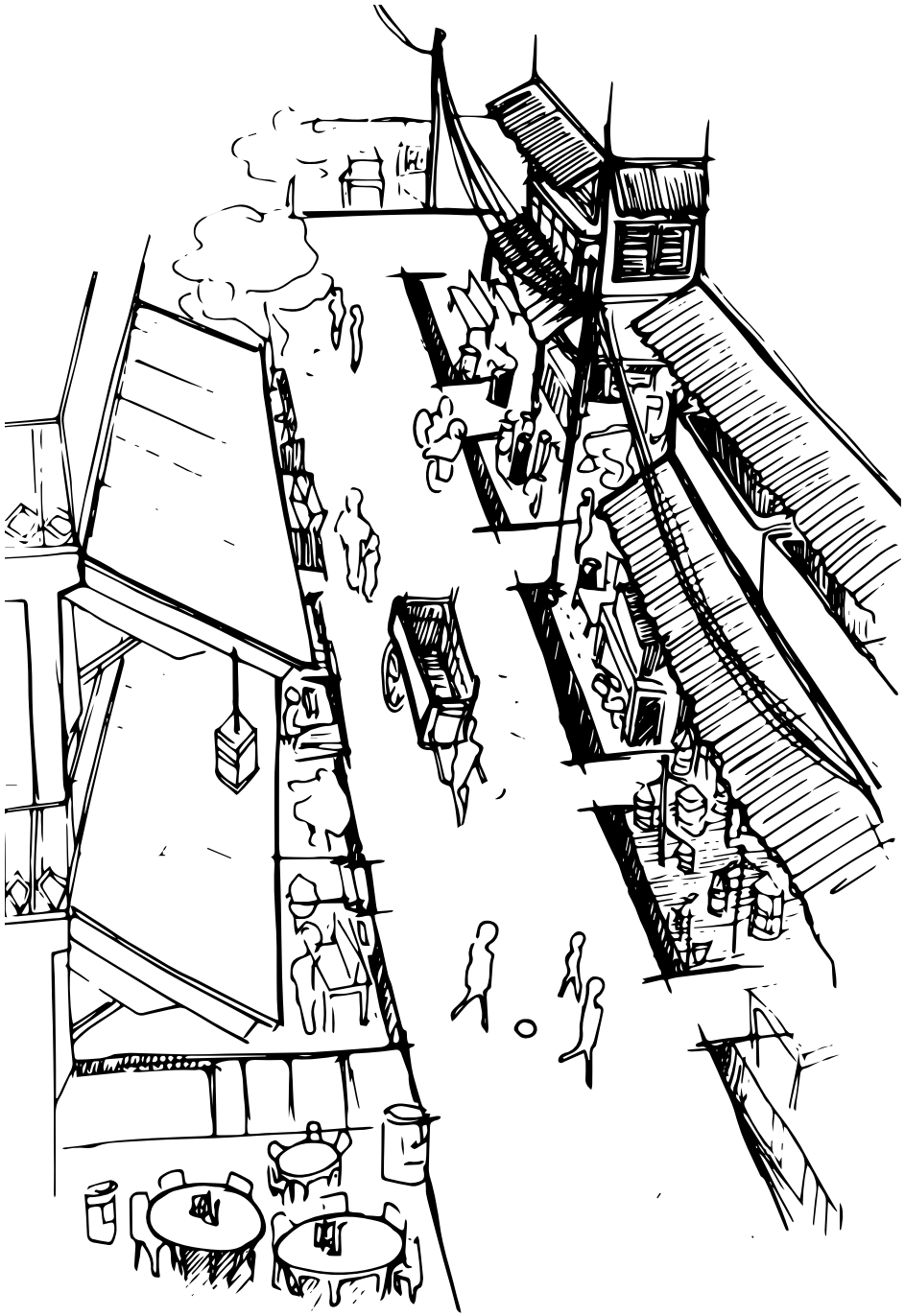


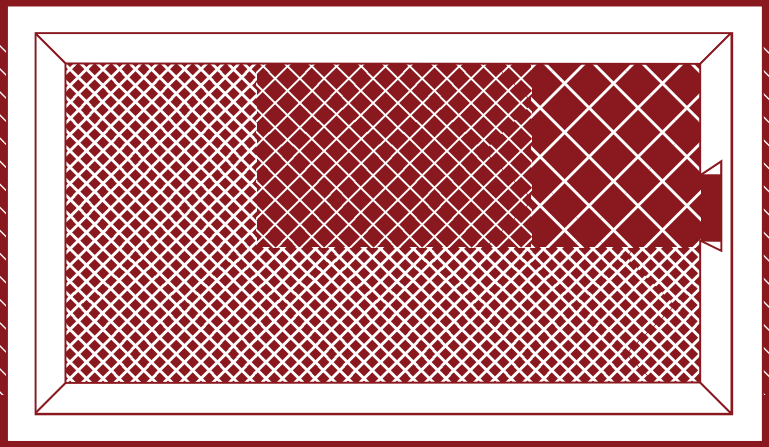
Fig A1.

PRIVACY ZONING

// PRIVACY ZONING AND EXPANSION IMPLICATIONS

The Indonesians know quite a specific zoning system with regards to privacy. During our time in Indonesia it became clear that once you step into the kampung it is similar to stepping into someone's backyard. The very small kampung streets are considered private property. People use this space not only as social meeting space, but also to expand their houses and shops. Almost all houses have some sort of partially covered outside space to hang their laundry, sit with neighboors or be outside when the monsoon hits. The first room in the house is usual the family room with utility spaces further in the back. Bedrooms are either at perpendicular to the living room, when the house is sufficiently broad, but usual the more private rooms like the bedrooms are situated in the back of the house.

Fig A3. Visualisation privacy zoning kampung Indonesia (own ill.)



1. Bedrooms
2. Family room
   Utility spaces
3. Reception room
4. Porch/Balcony
5. Semi-private-public
   inbetween space
6. Street/Walkway

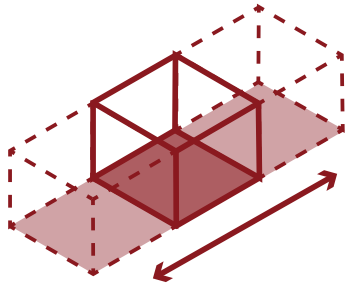
7. Kampung Entrance

INCREMENTAL EXPANSION

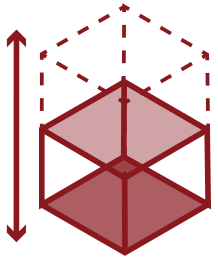
// ARGUMENTATION EXPANSION, VERTICAL & HORIZONTAL

During our time in the kampung it was clear most of the space available was build upon. The Indonesian population had two ways of expanding, vertically and horizontally. The research as visualized on the right is based on the article 'Considerations on Typology of Kampung House (red..)' by Shuji Funo. What was most important for my research was the realization that local building knowledge was often not sufficient for building over two storeys high. The expansion was therefore halted at this level while in the kampung much more building space is needed. This is one of the key elements in my final building system design.

TYPE A - HORIZONTAL EXPANSION



TYPE B - VERTICAL EXPANSION



TYPE C - COMBINATION

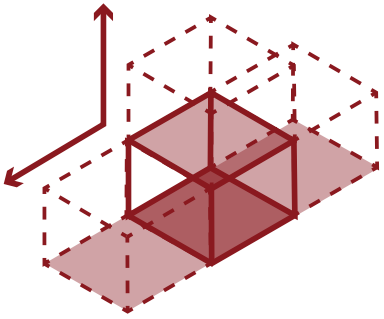
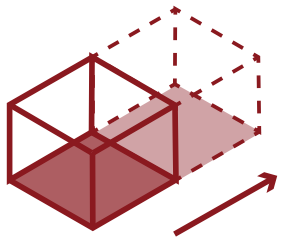


Fig A4. Visualisation incremental expansion methods kampung Indonesia (own ill. based on data from 'Considerations on Typology of Kampung House (red..)' by Shuji Funo)

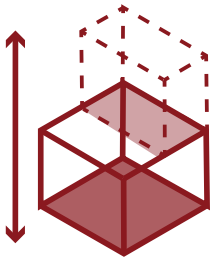
1: FAMILY EXPANSION

A-1



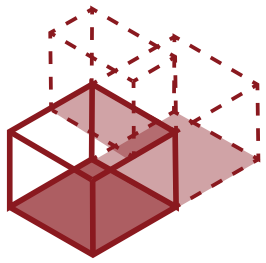
- BACK GARDEN OR TERRACE TRANS FORMED INTO KITCHEN
- ADDITION OF WASHING ROOM
- ADDITION OF TOILETS / SHOWER
- EXPANSION OF THE HOUSE WITH EXTRA BEDROOMS INSIDE AND UTILITY SPACES PLACED FURTHER IN THE BACK

B-1



- EXTRA FLOOR BUILD OFTEN OF WOODEN CONSTRUCTION
- USED FOR:
  EXTRA BEDROOMS
  STORAGE
  LIVING AREA
  BALCONY

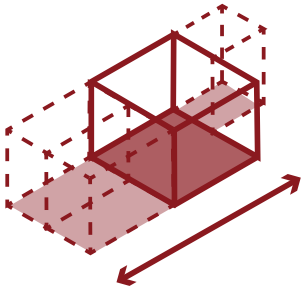
C-1



- EXTENSION OF GUEST AREA
- EXTRA BEDROOMS
- EXTRA DINING ROOM

2: BUSINESS VENTURES

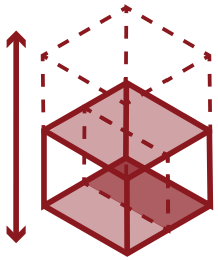
A-2



FRONT EXPANSION:
- WARUNG/TOKO/WARTEL
- HAIRDRESSER
- WORKSHOP
- GARAGE
- STORAGE SPACE

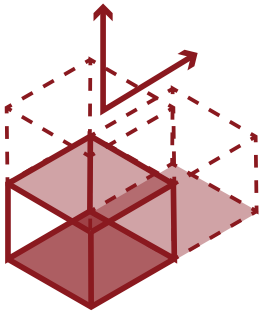
BACK EXPANSION
- RENTAL TOILETS
- RENTAL ROOMS

B-2



- RENTAL ROOMS UPSTAIRS
- PLACEMENT OF BED-ROOMS UPSTAIRS AND NEW SHOP STORE DOWNSTAIRS

C-2

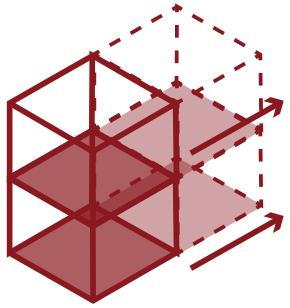


C-1

- RENTAL ROOMS BOTH UPSTAIRS AND DOWN-STAIRS
- RENTAL TOILETS IN THE BACK
- WASHING SPACES RENTAL HOUSING

3: BOTH BUSINESS AS FAMILY EXPANSION

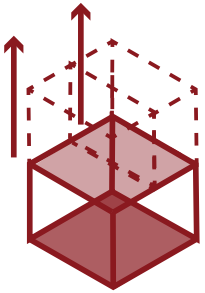
A-3



GROUND FLOOR:
- DINING ROOM
- BEDROOMS
- MORE UTILITY SPACES

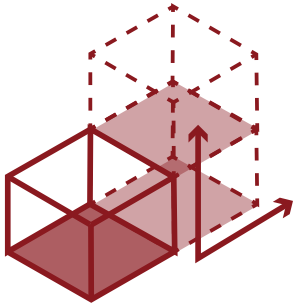
1ST FLOOR
- RENTAL ROOMS
- RENTAL TOILETS

B-3



- RENTAL ROOMS UPSTAIRS, SEPERATE STAIRCASE VIA OUTSIDE
- EXTRA FAMILY BEDROOMS UPSTAIRS

C-3



C-1

GROUND FLOOR:
- DINING ROOM
- BEDROOMS
- MORE UTILITY SPACES
- TOILETS AND BATH-ROOM RENTALS

1ST FLOOR
- RENTAL ROOMS

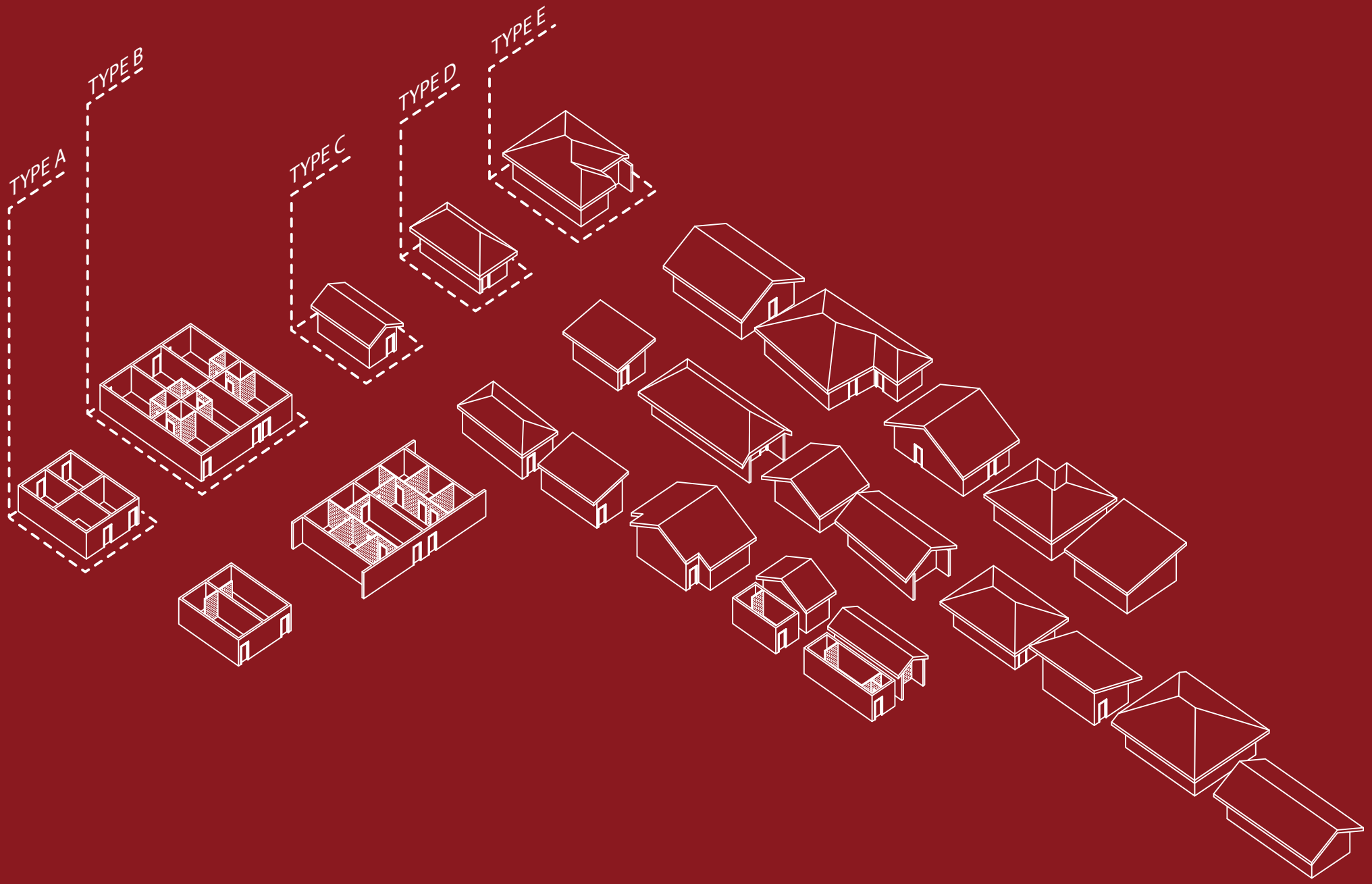
TYPOLOGY KAMPUNG HOUSING

// RESEARCH INTO MOST USED TYPOLOGIES

Both from research in Indonesia, as from articles like that of Shuji Funo: 'Considerations on Typology of Kampung House (red..)' and 'Typology of the Kampung house and its transformations (red..) ' a composition of existing typologies of the Indonesian Kampung was drafted:

- Type A - Apartment blocks with one room, no kitchen or private bathroom. Service areas are shared.
- Type B - Apartment blocks with private service blocks
- Type C - Privately owned housing with only one room and kitchen, service areas like toilets and washing spaces are communal in the kampung
- Type D - Privately owned housing with own kitchen and washing areas, often long and narrow.
- Type E - Family housing with both wide and long floor plans, bedrooms often situated in the side of the house.

Fig A5. Visualisation typology kampung housing Indonesia (own ill.)


TYPE A
TYPE B
TYPE C
TYPE D
TYPE E

RESEARCH INCOME SHOP OWNERS

// EIGHT SHOP OWNERS INTERVIEWED

For the local community a safer way of building is not high on the list of priorities. It is therefore essential to find a different argumentation to convince them of using a different building system. In my system there are two reasons why they should use this system to (re)build their houses. The first being an emotional one: when build up over two stories high, there is more room for the family, children will not have to be sent away to live in a different kampung, as is now often the case.
The second reason is an econimical one; when there is more space, more money can be earned with the house by turning the ground floor into a shop, workshop or to use the top floors to rent out rooms. The extension of the house would be paid from the revenues of the economic activities. To calculate how long the repayment period would be it was essential to research how big the revenues from shops were.

Fig A6. Photo warung shop Kampung Dago Pojok (own ill.)
Fig A7. Photo's shops & shop owners. kampung Cigondewah & Dago Pojok (own Ill.)


RUNTUT RAWUT SAUYUNAN JAGA LEMBUR BABARENGAN DUDUR
GILA BENERR!
Gratisan dari AXIS emang paling benerr!
Tinggalkan yang lain, pindah ke AXIS sekarang!
Telpon/SMS 500 perak
GRATIS 10.000 SMS/hari
Internetan 1.000 perak
GRATIS 10MB /hari
ke semua operator
Tiap hari tanpa batas waktu
Tiap isi ulang 10.000 perak
GRATIS 10 menit bicara
Terima telpon dari semua operator lain
GRATIS PULSA Rp 100
AXIS

WATER SHOP

// Kampung Dago Pojok
// Ibu Dian (32 y/o)
Family owns water shop
Sels water bottles / gasstoves
Gasstove service
Does not live next to the shop
// Monthly income from shop
IDR 3.000.000

GROCERY SHOP

// Kampung Cigondewah
// Ibu Ai (54 y/o)
She is a widow who inherited the shop from her husband. She supports 6 children + grand-children with the shop and also rents out rooms
// Monthly income from shop
IDR 1.500.000

BIRDS SHOP

// Kampung Dago Pojok
// Pak Pakedi (35 y/o)
House was abandoned, his family fixed it up and has been selling birds there ever since. The family is eight people, two brothers and their family.
// Monthly income from shop
IDR 700.000

GROCERY SHOP

// Kampung Cigondewah
// Ibu Tia (32 y/o)
Family owns grocery store
Lives behind the shop with her husband and two children.
// Monthly income from shop
IDR 1.500.000

ANIMAL STORE

// Kampung Cigondewah
// Pak Ayep (32 y/o)
Rents the shop and does not live there. Has been renting it for 2 years, is supporting his family of four.
// Monthly income from shop
IDR 2.000.000

GROCERY SHOP

// Kampung Dago Pojok
// Ibu Masran (42 y/o)
Owns the house, lives with her family in the back, one husband, wife and four children.
House was bought for 40.000.000
// Monthly income from shop
IDR 2.000.000

GROCERIES SHOP

// Kampung Cigondewah
// Pak Sanjaya (38 y/o)
Family owns grocery store
He has a side business of renting out cars (revenue 1.000.000 p/m)
// Monthly income from shop
IDR 2 / 3.000.000

MATERIALS SHOP

// Kampung Dago Pojok
// Pak Nagreh (32 y/o)
Family owns materials store
// Monthly income from shop
IDR 4.000.000

ELABORATION HOUSE B

// EXPLODED VIEW HOUSE DURING PHASES

In the visuals on the right the economic revenues gained by applying the researched building system are combined with a spatial organisation. As seen in Fig. A16, the first year gaines no extra revenues, the house is simply torn down and replaced by a similar size building, which will serve as foundation for the upper floor to be build upon. In the second year more space is made by adding an extra floor, so a shop can be realised on the ground floor. Revenues made by this shope can be put aside to save up for one extra floor, or if required, two extra floors.
If in total four floors are realised, the total term of repayment will be 10 years. This is taking into account only the revenues earned by the shop and rented spaces in the house. The house will therefore in a sense 'pay for itself'.

Fig. A14
PHASE I // 1ST FLOOR - 'THE RESIDENTIAL'

I.1 Outside living space
I.2 Guest room + Living room
I.3 Bedroom no. 1 (4 m2)
I.4 Bedroom no.2 (4 m2)
I.5 Service area (kitchen + bathroom)

Fig. A15
PHASE II // 2nd FLOOR - 'THE SHOP'

II.1 Semi public/private space
II.2 Porch for shop
II.3 Food shop: revenues IDR 2.000.000 p/m
II.4 Living room/guest area + stairs
II.5 Service area (kitchen + bathroom)
II.6 Private open space - laundry room
II.7 Bedroom no. 1 (12 m2)
II.8 Bedroom no. 2 (7m2)

Fig A16.
PHASE III // 3rd FLOOR - 'THE RENTAL'

III.1 Private entrance rental rooms
III.2 Kitchen area rental rooms
III.3 Rental room no. 1 (7 m2)
III.4 Rental room no. 2 (7 m2)
III.5 Rental room no. 3 (9 m2)
Revenues: 1.750.000 p/m

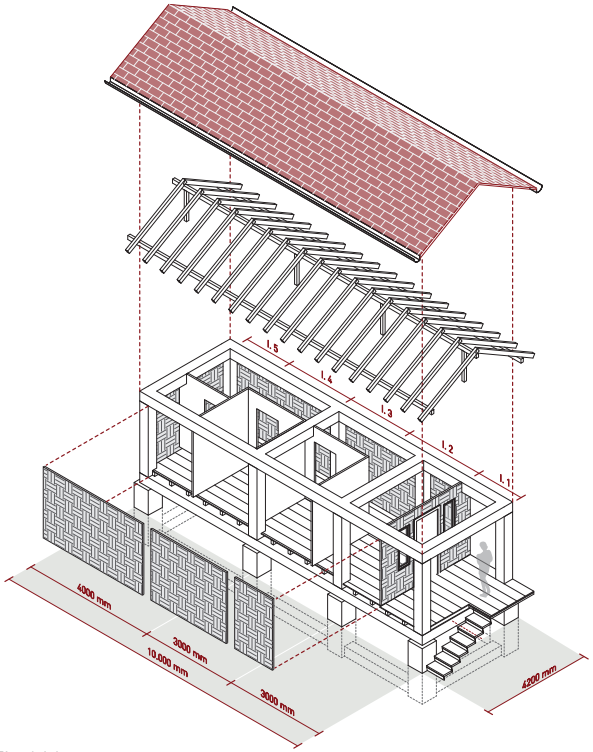


Fig A14.

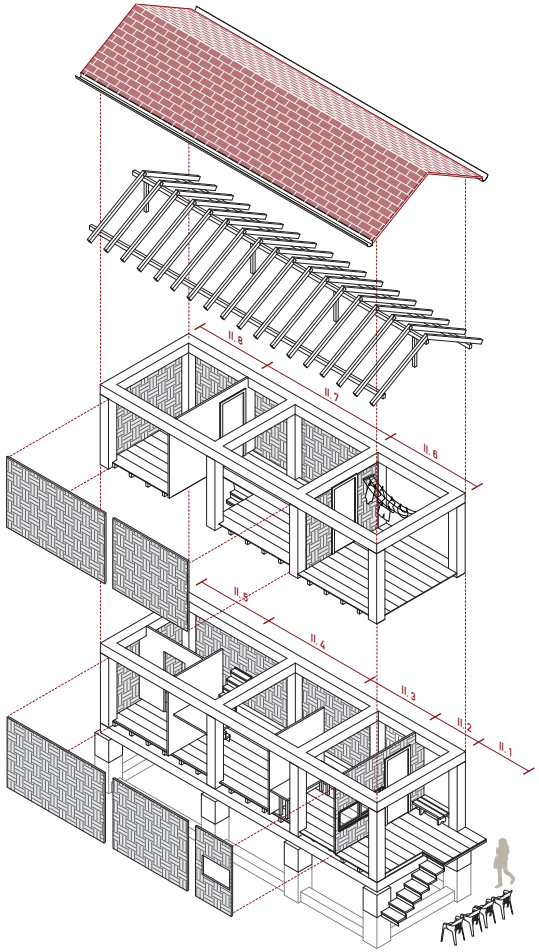


Fig A15.

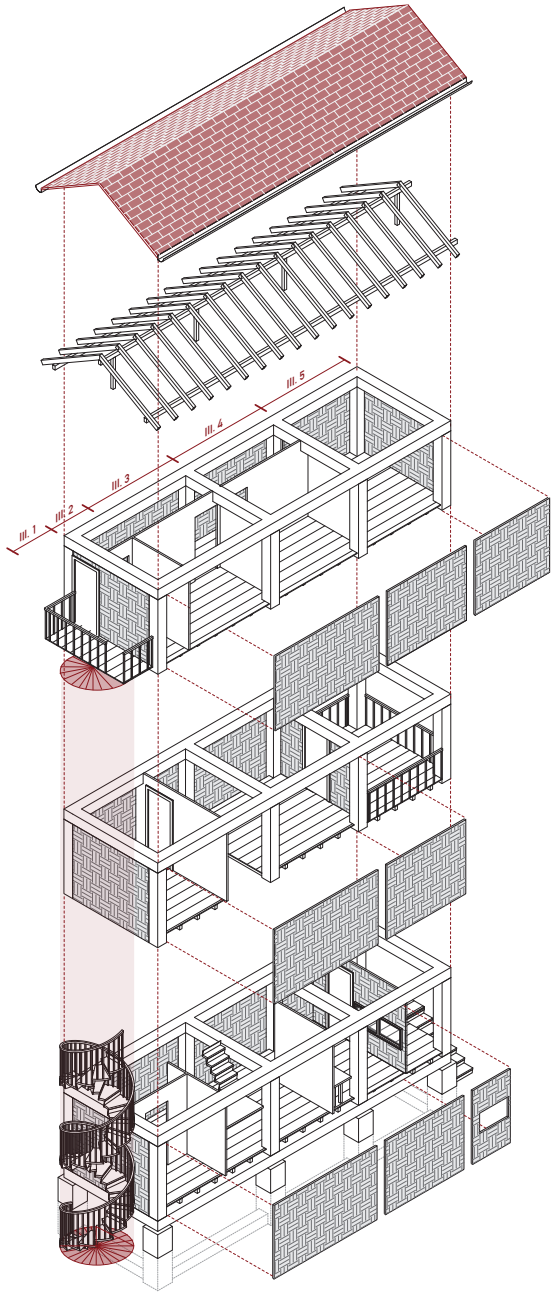


Fig A16.

CATALOGUE EXTERNAL ELEMENTS

// INTEGRATION EXTERNAL ELEMENTS TO BUILDING SYSTEM

In this research a building system for purely the frame of the building was researched. The reasoning here was when there is a very sound frame, the construction imidiately becomes more safe. There are however of course other building elements that make up a house. Facades, roofs, floors and stairs are not always easy to construct. While this is not completely part of the scope of this research, I made a catalogue of possible elements that could be sold within the CNC hub. As seen in Fig. A8 there is one hub in the city of Bandung where the system is rented out. The building system could be made in such a way it would fit perfectly with current roofing systems, facade materials and floor widths. Stairs could also be poored in CNC milled moulds and both windows and doors could be made by CNC milling.

Fig A8. How does it work? (own ill.)
Fig A9. External elements building system (own ill.)
Fig A10. Create your own house recepy (own Ill.)

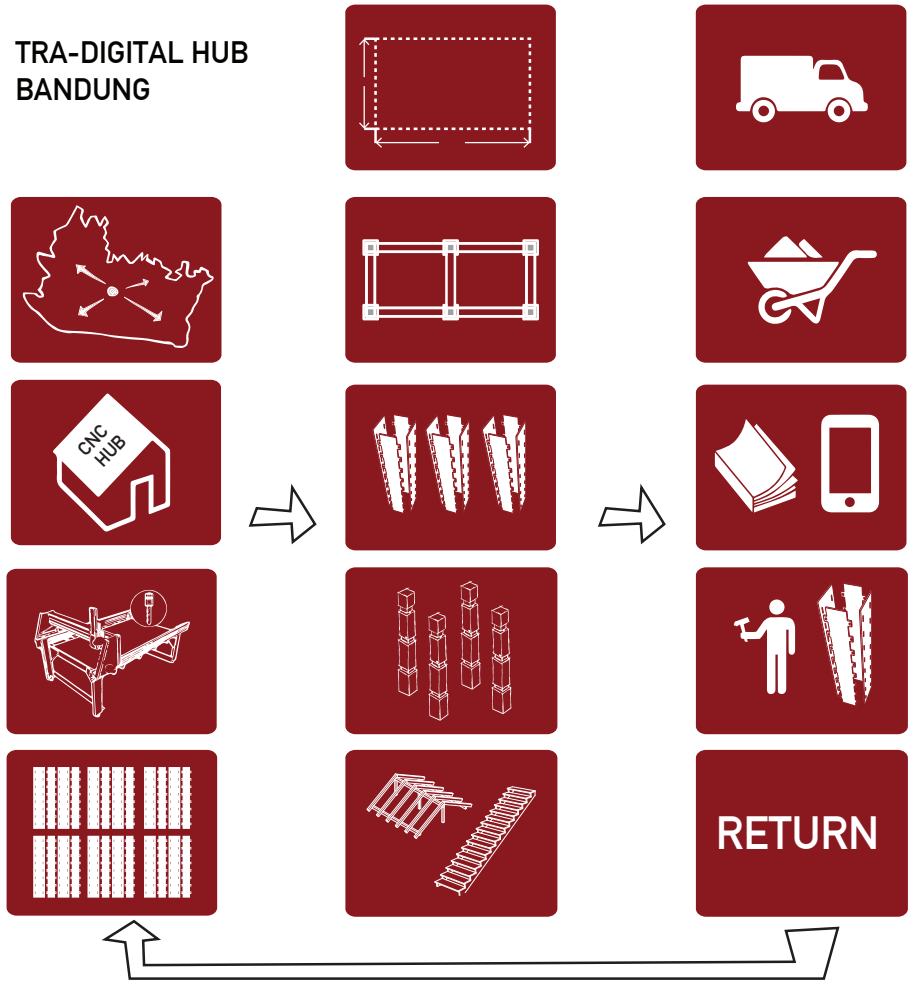


Fig A8.

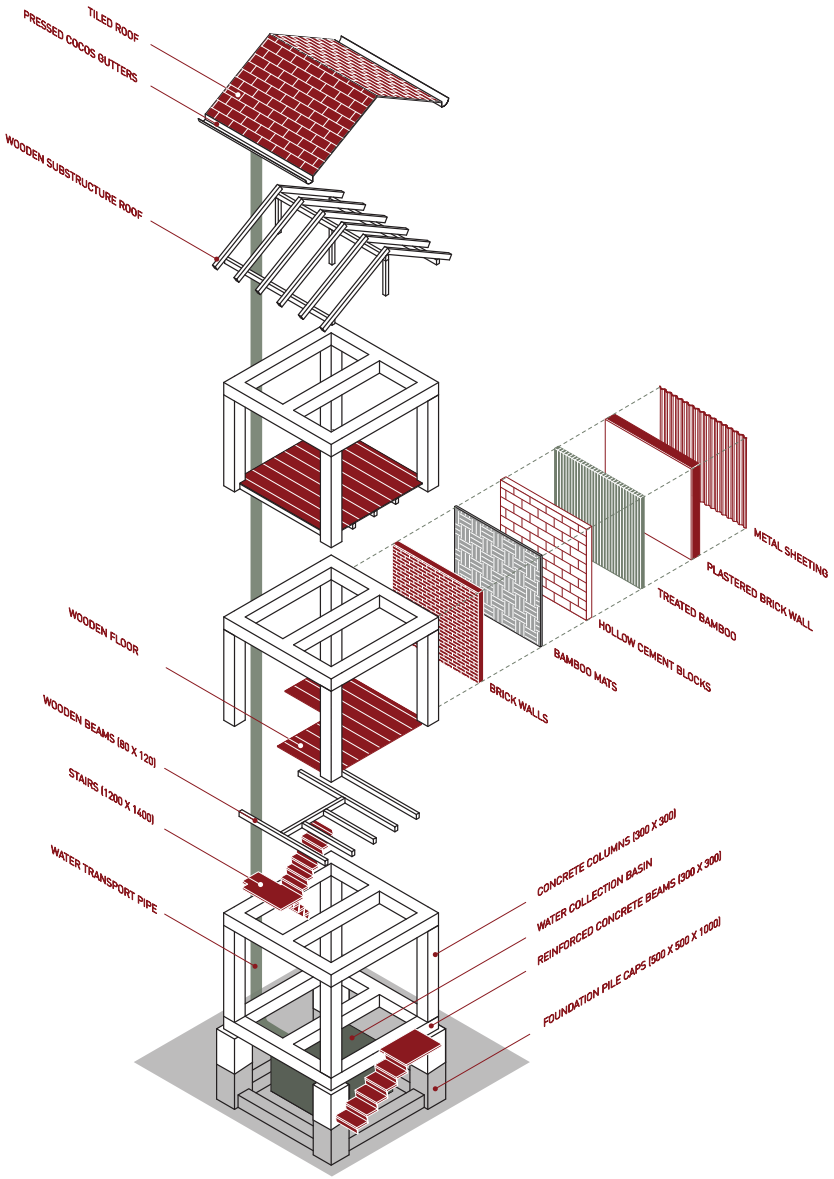


Fig A9.

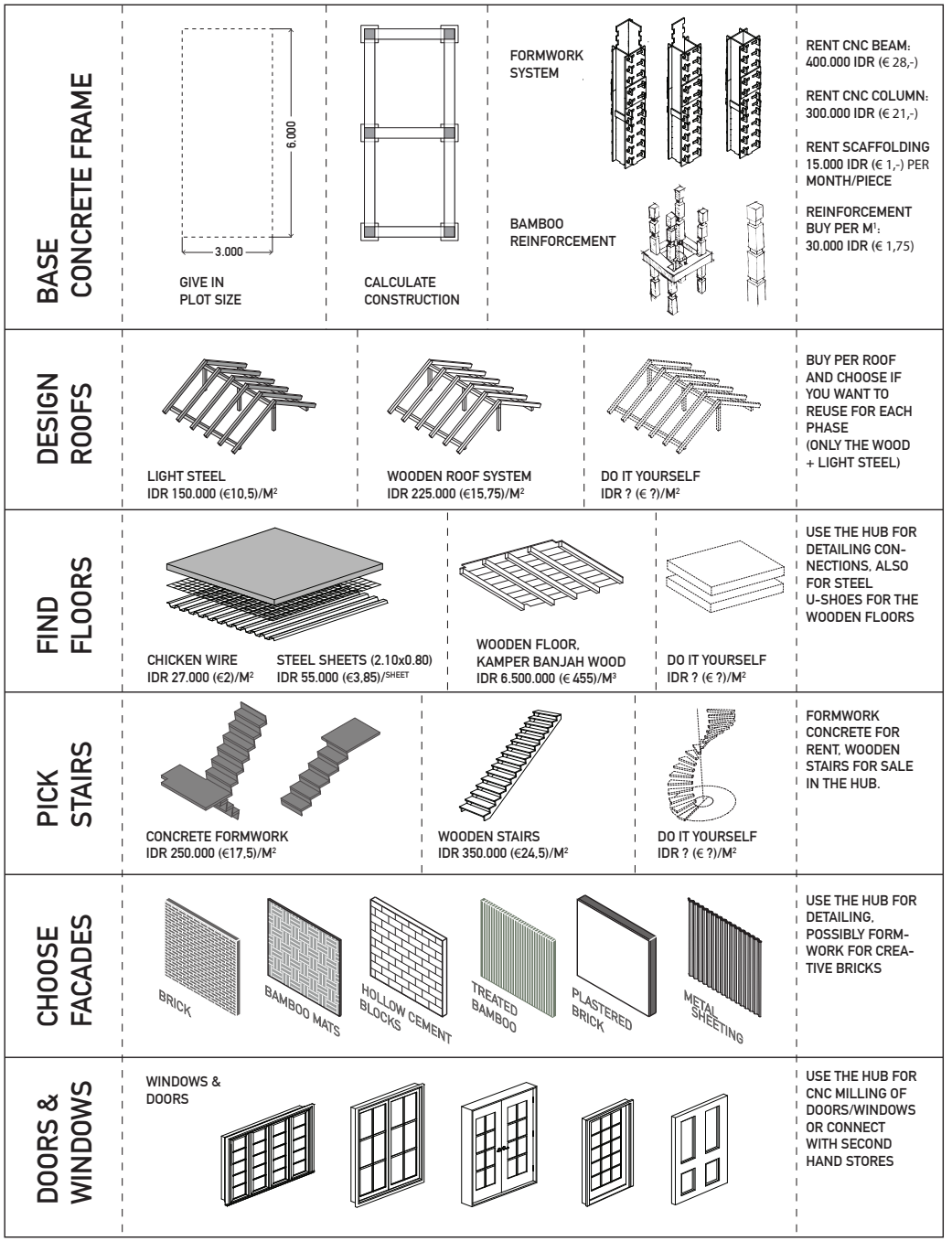
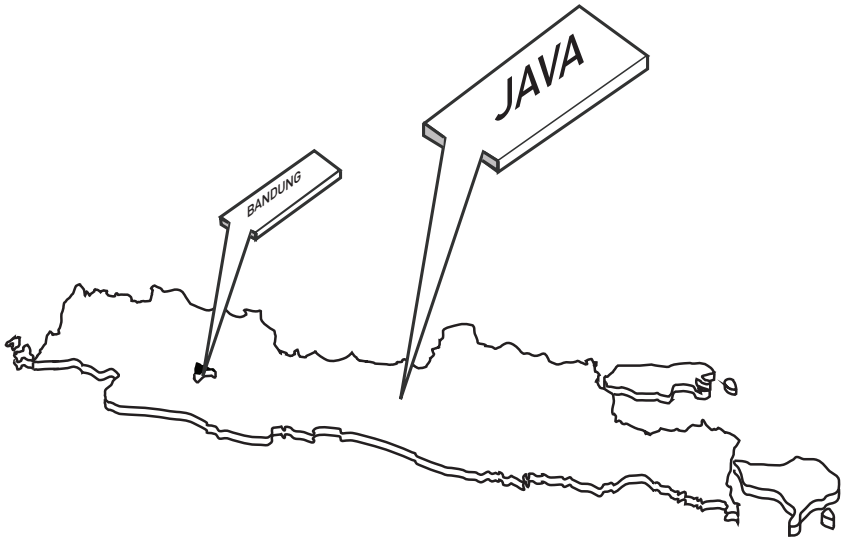


Fig A10.



LOCATION/ARCHITECTURAL INTEGRATION

// RESEARCH INTO MOST USED TYPOLOGIES

The integration of the building system in the local architecture could be done in any place in Bandung. Since the kampung Cigondewah was already chosen by the group of students researching Bandung this was also my chosen location. Within Cigondewah a location was chosen next to the municipal road. Here, five houses were chosen, at random, to analyse. In the housing matrix is shown how much the houses change over time. Each phase of the incremental way of building is shown in the matrix, also the building costs, revenues made by in-house shops and rented rooms, and the calculated repayment period.

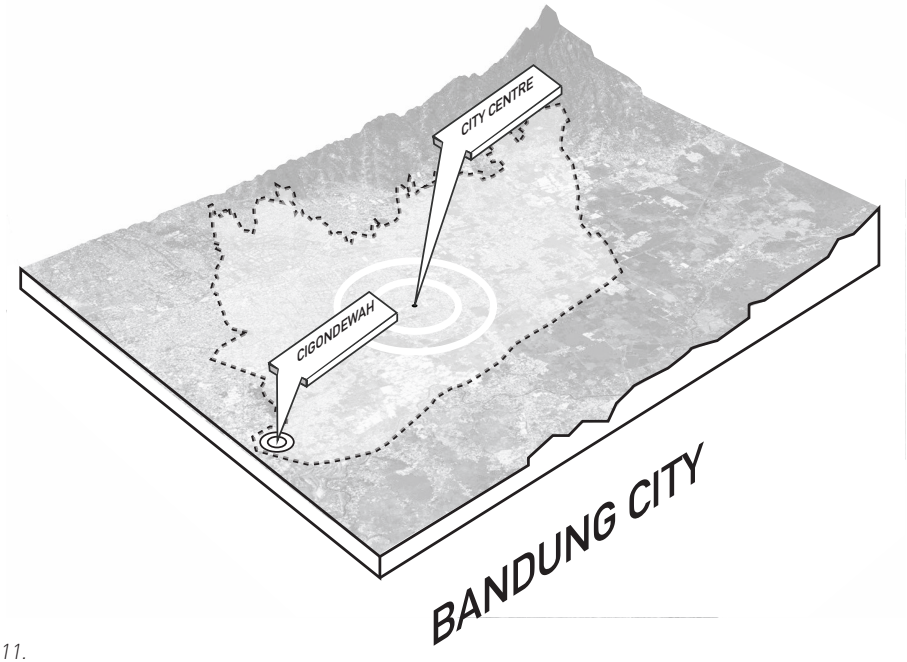
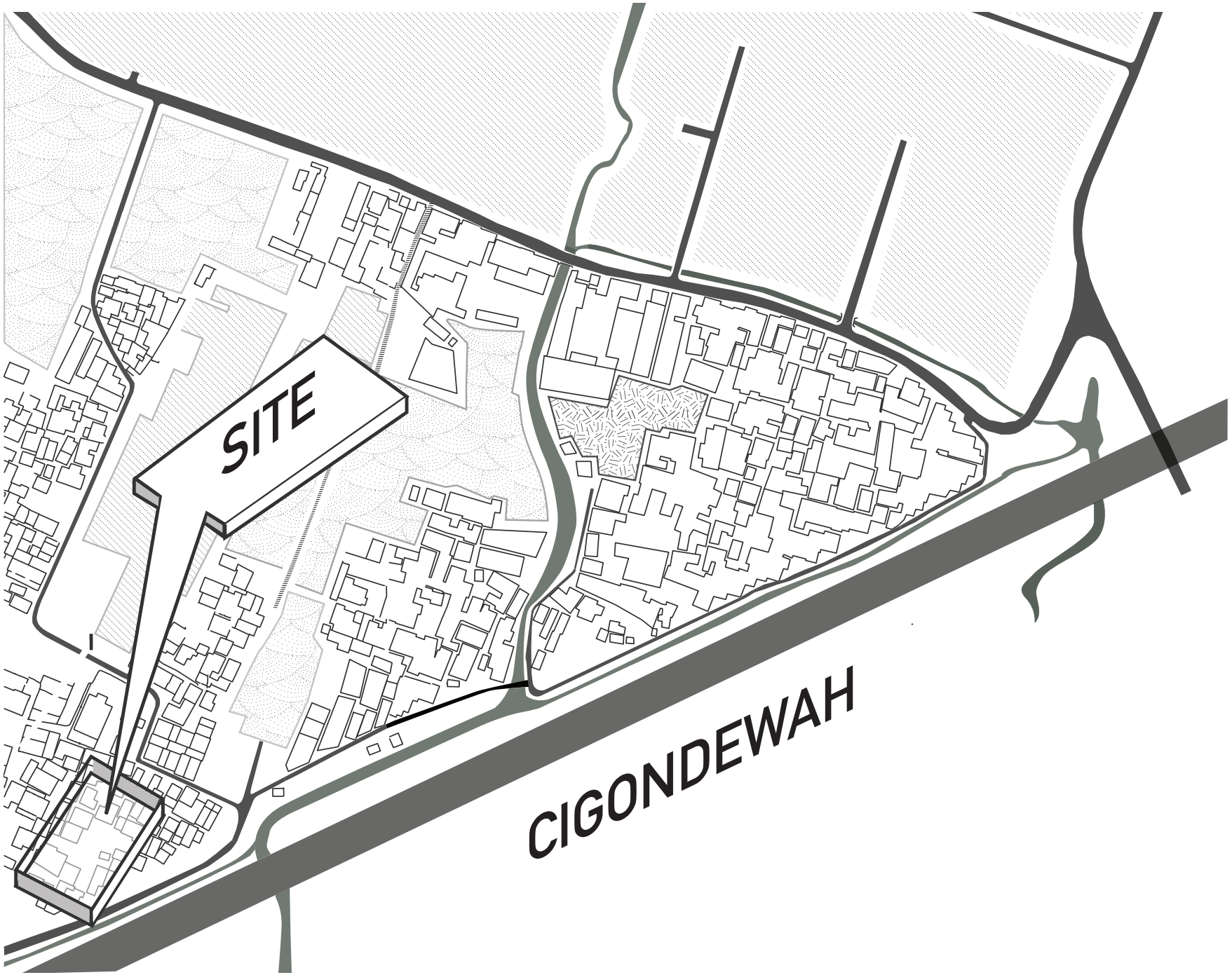


Fig A11.

Fig A11. Chosen location: Java - Bandung - Cigondewah (own ill.)
Fig A12. Chosen site - Chosen site transformed by building system (own ill.)
Fig A13. Housing matrix (own ill.)


SITE
CIGONDEWAH

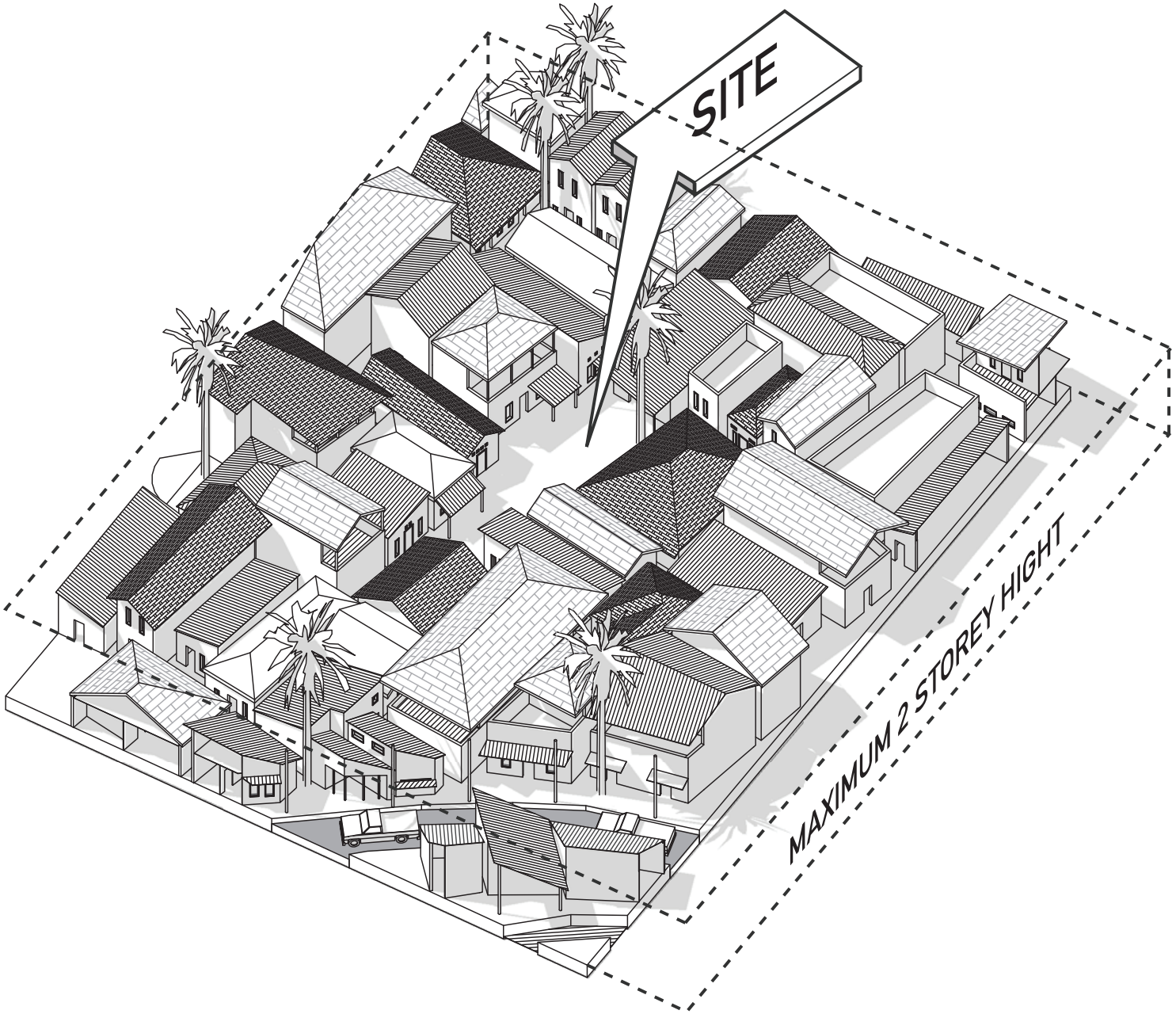


Fig A12.

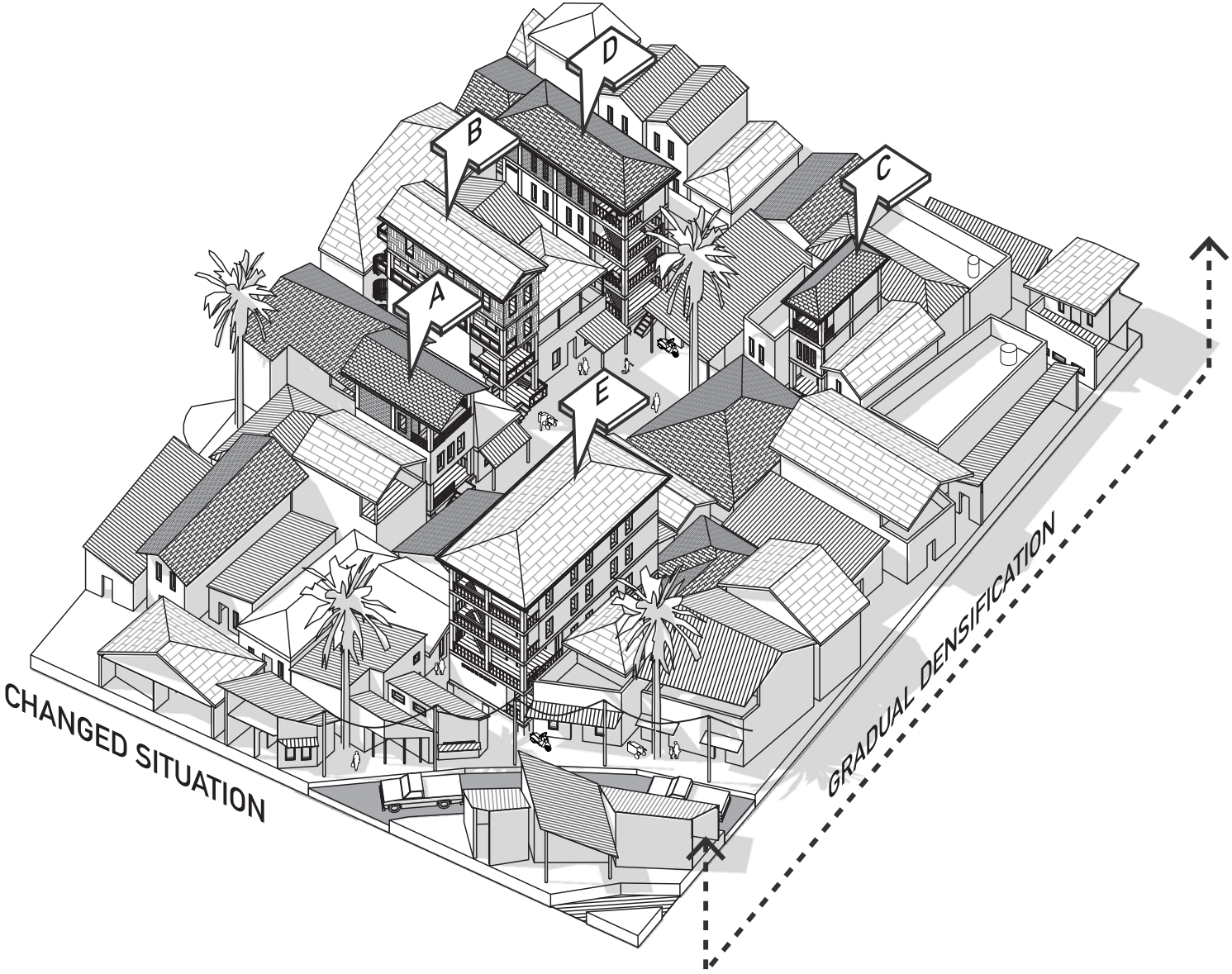


Fig A12.

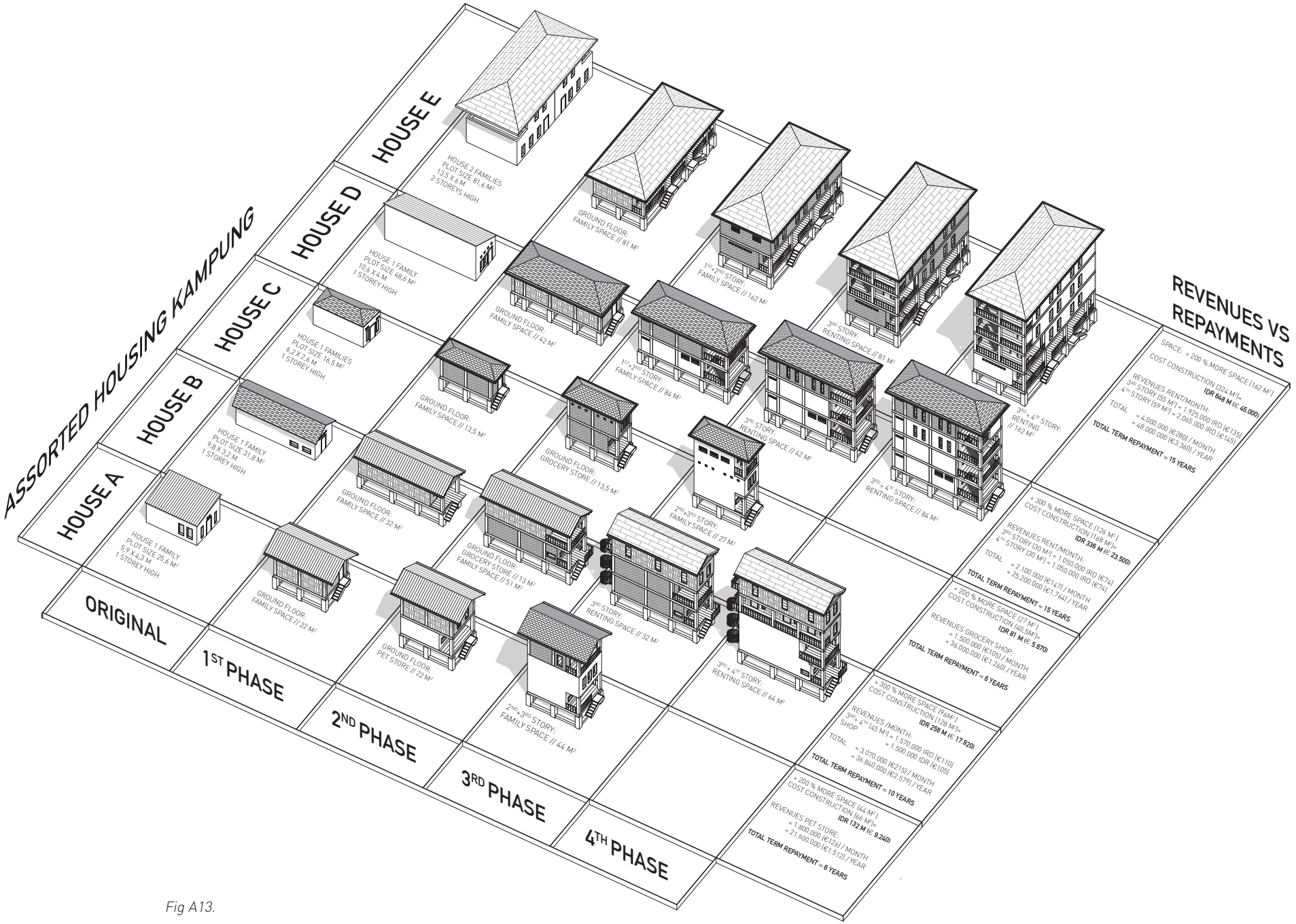
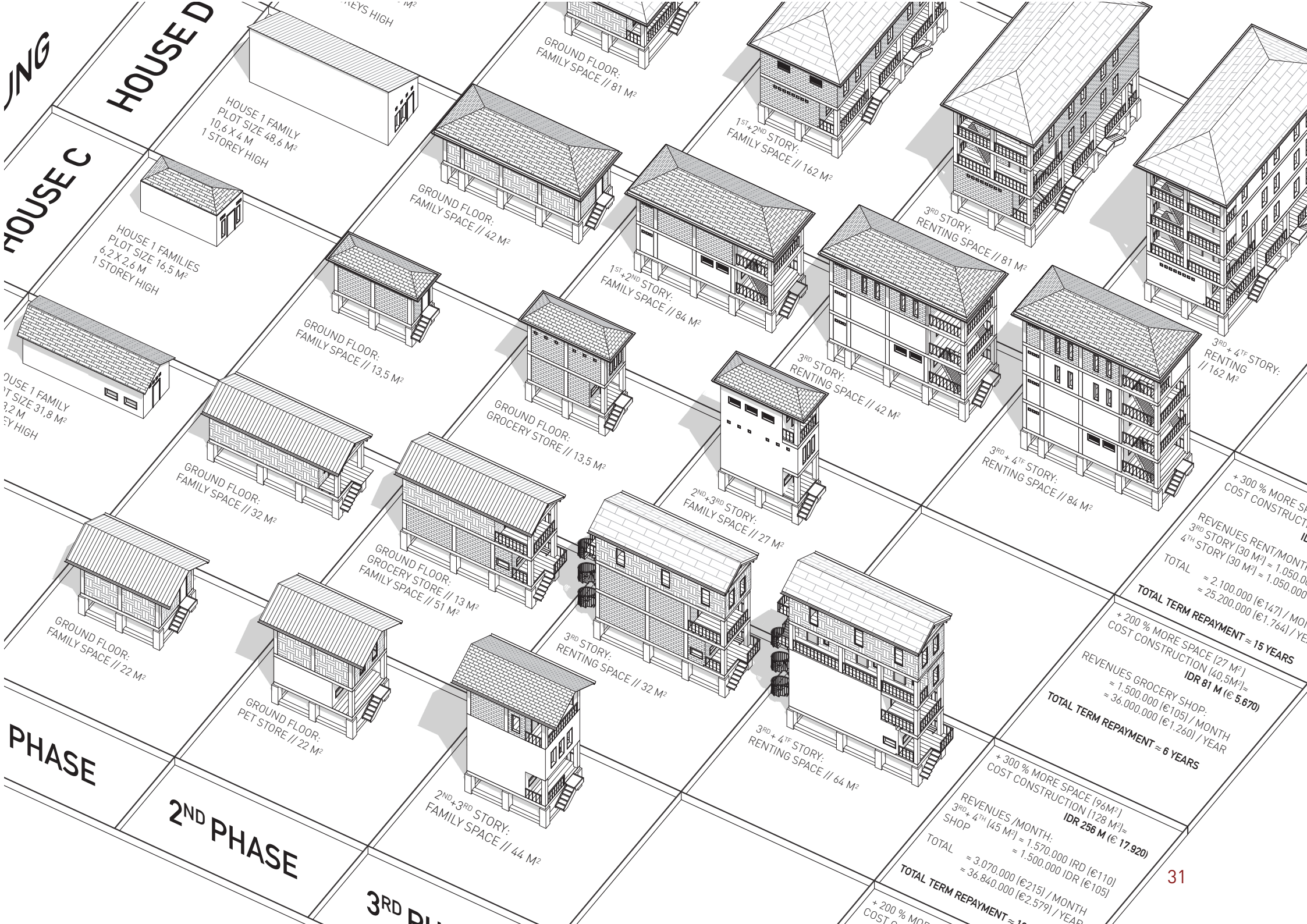
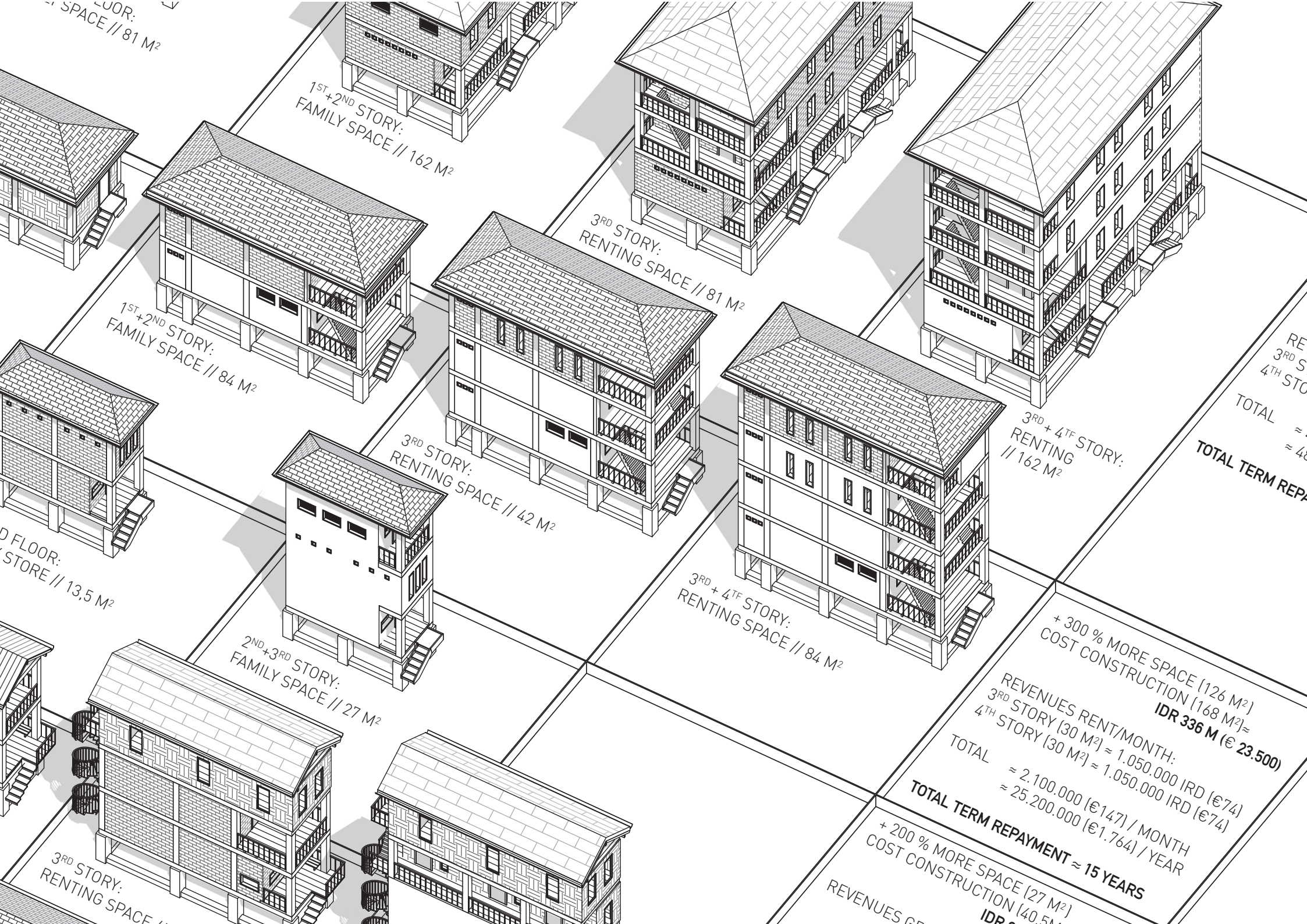
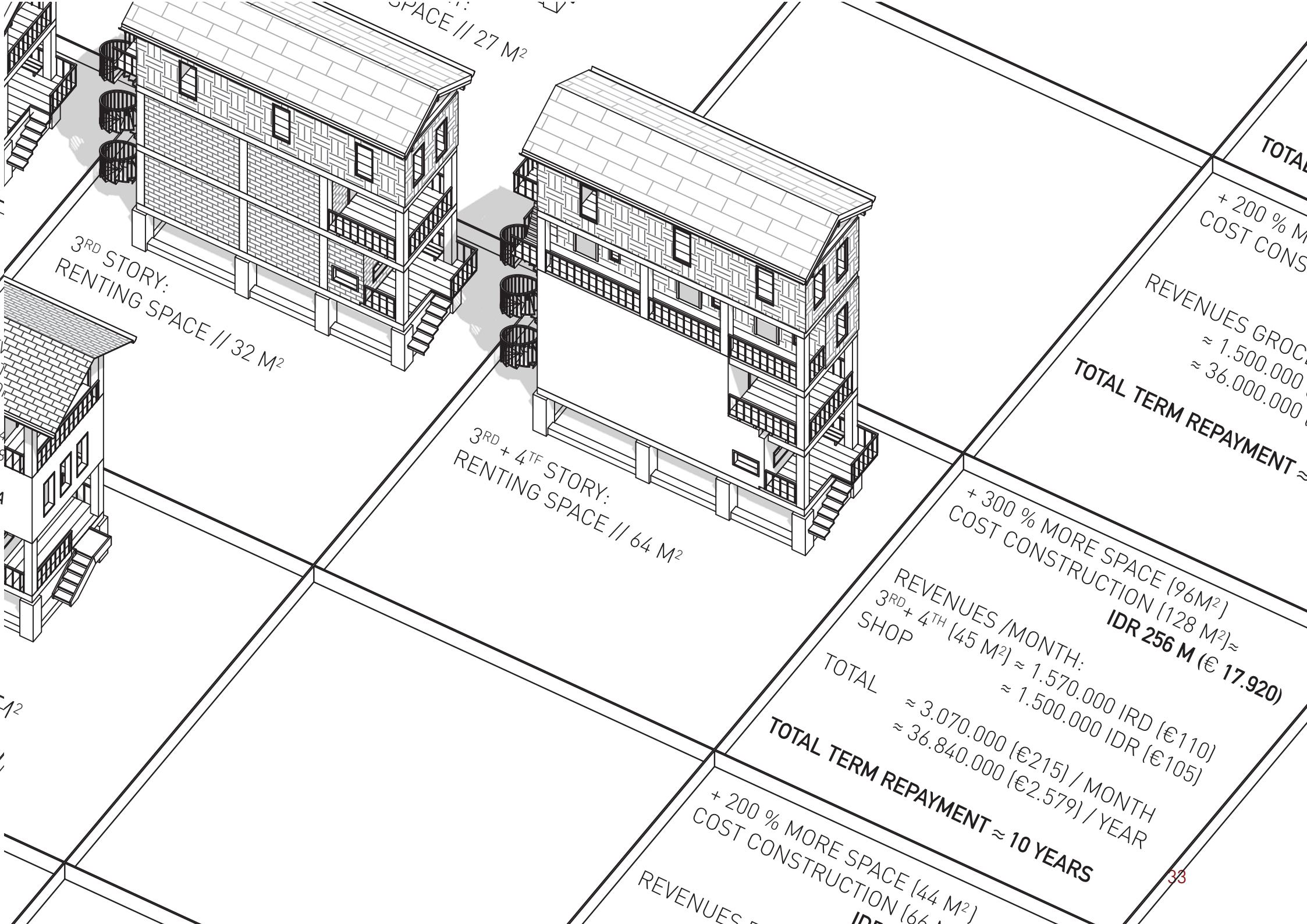

ASSORTED HOUSING KAMPUNG
HOUSE E
HOUSE D
HOUSE C
HOUSE B
HOUSE A
ORIGINAL
1ST PHASE
2ND PHASE
3RD PHASE
4TH PHASE
REVENUES VS REPAYMENTS
HOUSE 2 FAMILIES
PLOT SIZE 81,6 M²
13,5 X 6 M
2 STOREYS HIGH
GROUND FLOOR:
FAMILY SPACE // 81 M²
1ST+2ND STORY:
FAMILY SPACE // 162 M²
HOUSE 1 FAMILY
PLOT SIZE 48,6 M²
10,6 X 4 M
1 STOREY HIGH
GROUND FLOOR:
FAMILY SPACE // 42 M²
1ST+2ND STORY:
FAMILY SPACE // 84 M²
3RD STORY:
RENTING SPACE // 81 M²
HOUSE 1 FAMILIES
PLOT SIZE 16,5 M²
6,2 X 2,6 M
1 STOREY HIGH
GROUND FLOOR:
FAMILY SPACE // 13,5 M²
GROUND FLOOR:
GROCERY STORE // 13,5 M²
2ND+3RD STORY:
FAMILY SPACE // 27 M²
3RD STORY:
RENTING SPACE // 42 M²
3RD + 4TH STORY:
RENTING
// 162 M²
HOUSE 1 FAMILY
PLOT SIZE 31,8 M²
9,8 X 3,2 M
1 STOREY HIGH
GROUND FLOOR:
FAMILY SPACE // 32 M²
GROUND FLOOR:
GROCERY STORE // 13 M²
FAMILY SPACE // 51 M²
3RD STORY:
RENTING SPACE // 32 M²
3RD + 4TH STORY:
RENTING SPACE // 84 M²
HOUSE 1 FAMILY
PLOT SIZE 25,6 M²
5,9 X 4,3 M
1 STOREY HIGH
GROUND FLOOR:
FAMILY SPACE // 22 M²
GROUND FLOOR:
PET STORE // 22 M²
2ND+3RD STORY:
FAMILY SPACE // 44 M²
3RD + 4TH STORY:
RENTING SPACE // 64 M²
SPACE: + 200 % MORE SPACE (162 M²)
COST CONSTRUCTION (324 M²)=
IDR 648 M (€ 45.000)
REVENUES RENT/MONTH:
3RD STORY (85 M²) = 1.925.000 IRD (€135)
4TH STORY (59 M²) = 2.065.000 IRD (€145)
TOTAL = 4.000.000 (€280) / MONTH
= 48.000.000 (€3.360) / YEAR
TOTAL TERM REPAYMENT = 15 YEARS
+ 300 % MORE SPACE (126 M²)
COST CONSTRUCTION (168 M²)=
IDR 336 M (€ 23.500)
REVENUES RENT/MONTH:
3RD STORY (30 M²) = 1.050.000 IRD (€74)
4TH STORY (30 M²) = 1.050.000 IRD (€74)
TOTAL = 2.100.000 (€147) / MONTH
= 25.200.000 (€1.764) / YEAR
TOTAL TERM REPAYMENT = 15 YEARS
+ 300 % MORE SPACE (27 M²)
COST CONSTRUCTION (40,5M²)=
IDR 81 M (€ 5.670)
REVENUES GROCERY SHOP:
= 1.500.000 (€105) / MONTH
= 36.000.000 (€1.260) / YEAR
TOTAL TERM REPAYMENT = 6 YEARS
+ 300 % MORE SPACE (64 M²)
COST CONSTRUCTION (128 M²)=
IDR 256 M (€ 17.920)
REVENUES /MONTH:
3RD + 4TH (145 M²) = 1.570.000 IRD (€110)
SHOP = 1.500.000 IDR (€105)
TOTAL = 3.070.000 (€215) / MONTH
= 36.840.000 (€2.579) / YEAR
TOTAL TERM REPAYMENT = 10 YEARS
+ 200 % MORE SPACE (44 M²)
COST CONSTRUCTION (66 M²)=
IDR 132 M (€ 9.240)
REVENUES PET STORE:
= 1.800.000 (€126) / MONTH
= 21.600.000 (€1.512) / YEAR
TOTAL TERM REPAYMENT = 6 YEARS

Fig A13.


HOUSE D
HOUSE C
HOUSE 1 FAMILY
PLOT SIZE 48,6 M²
10,6 X 4 M
1 STOREY HIGH
HOUSE 1 FAMILIES
PLOT SIZE 16,5 M²
6,2 X 2,6 M
1 STOREY HIGH
GROUND FLOOR:
FAMILY SPACE // 81 M²
GROUND FLOOR:
FAMILY SPACE // 42 M²
1ST+2ND STORY:
FAMILY SPACE // 162 M²
3RD STORY:
RENTING SPACE // 81 M²
GROUND FLOOR:
FAMILY SPACE // 13,5 M²
1ST+2ND STORY:
FAMILY SPACE // 84 M²
3RD STORY:
RENTING SPACE // 42 M²
3RD + 4TF STORY:
RENTING
// 162 M²
GROUND FLOOR:
GROCERY STORE // 13,5 M²
GROUND FLOOR:
FAMILY SPACE // 32 M²
2ND+3RD STORY:
FAMILY SPACE // 27 M²
3RD + 4TF STORY:
RENTING SPACE // 84 M²
GROUND FLOOR:
GROCERY STORE // 13 M²
FAMILY SPACE // 51 M²
GROUND FLOOR:
FAMILY SPACE // 22 M²
3RD STORY:
RENTING SPACE // 32 M²
GROUND FLOOR:
PET STORE // 22 M²
2ND+3RD STORY:
FAMILY SPACE // 44 M²
3RD + 4TF STORY:
RENTING SPACE // 64 M²
+ 300 % MORE SPACE (27 M²)
COST CONSTRUCTION (40,5M²)=
IDR 81 M (€ 5.670)
REVENUES RENT/MONTH:
3RD STORY (30 M²) = 1.050.000
4TH STORY (30 M²) = 1.050.000
TOTAL = 2.100.000 (€147) / MONTH
= 25.200.000 (€1.764) / YEAR
TOTAL TERM REPAYMENT ≈ 15 YEARS
+ 200 % MORE SPACE (27 M²)
COST CONSTRUCTION (40,5M²)=
IDR 81 M (€ 5.670)
REVENUES GROCERY SHOP:
= 1.500.000 (€105) / MONTH
= 36.000.000 (€1.260) / YEAR
TOTAL TERM REPAYMENT ≈ 6 YEARS
+ 300 % MORE SPACE (96M²)
COST CONSTRUCTION (128 M²)=
IDR 256 M (€ 17.920)
REVENUES /MONTH:
3RD + 4TH (45 M²) = 1.570.000 IRD (€110)
SHOP = 1.500.000 IDR (€105)
TOTAL = 3.070.000 (€215) / MONTH
= 36.840.000 (€2.579) / YEAR
TOTAL TERM REPAYMENT ≈ 12
2ND PHASE
3RD PHASE


SPACE // 81 M²
1ST+2ND STORY:
FAMILY SPACE // 162 M²
3RD STORY:
RENTING SPACE // 81 M²
1ST+2ND STORY:
FAMILY SPACE // 84 M²
3RD STORY:
RENTING SPACE // 42 M²
3RD + 4TF STORY:
RENTING
// 162 M²
D FLOOR:
STORE // 13,5 M²
2ND+3RD STORY:
FAMILY SPACE // 27 M²
3RD + 4TF STORY:
RENTING SPACE // 84 M²
3RD STORY:
RENTING SPACE
+ 300 % MORE SPACE (126 M²)
COST CONSTRUCTION (168 M²)≈
IDR 336 M (€ 23.500)
REVENUES RENT/MONTH:
3RD STORY (30 M²) ≈ 1.050.000 IRD (€74)
4TH STORY (30 M²) ≈ 1.050.000 IRD (€74)
TOTAL ≈ 2.100.000 (€147) / MONTH
≈ 25.200.000 (€1.764) / YEAR
TOTAL TERM REPAYMENT ≈ 15 YEARS
+ 200 % MORE SPACE (27 M²)
COST CONSTRUCTION (40,5M
REVENUES GE
IDR
TOTAL TERM REPA


SPACE // 27 M2
3RD STORY:
RENTING SPACE // 32 M2
3RD + 4TF STORY:
RENTING SPACE // 64 M2
+ 200 % M
COST CONS
REVENUES GROC
≈ 1.500.000
≈ 36.000.000
TOTAL TERM REPAYMENT ≈
+ 300 % MORE SPACE (96M2)
COST CONSTRUCTION (128 M2)≈
IDR 256 M (€ 17.920)
REVENUES /MONTH:
3RD + 4TH (45 M2) ≈ 1.570.000 IRD (€110)
SHOP ≈ 1.500.000 IDR (€105)
TOTAL ≈ 3.070.000 (€215) / MONTH
≈ 36.840.000 (€2.579) / YEAR
TOTAL TERM REPAYMENT ≈ 10 YEARS
+ 200 % MORE SPACE (44 M2)
COST CONSTRUCTION (66
REVENUES

B. RESEARCH INCREMENTAL BUILDING SYSTEM

+ INTERVIEWS CONSTRUCTION TEAMS KAMPUNG
+ COST CALCULATION SYSTEM FORMWORK
+ DESIGN SYSTEM FORMWORK
  - How does it work
  - CNC milled elements
  - Cost calculation matrix

INTERVIEWS CONSTRUCTION TEAMS

// PROFESSIONAL / SEMI-PROFESSIONAL / INFORMAL

For the second research trip to Indonesia the goal was to visit as much construction sites as possible to asses not only local building knowledge, but also research specific questions like: how to transport material in the kampung, what is the structure of a building team, what are the price of building cost per m2, are there any kind of roof systems in the kampung, prices of building material and so forth.

Many of these questions were answered in interviews with construction leaders like Pak Nana, but also by interviewing Pak Apep, the foremen of local architect Ramalis Sobandi. With him I discussed specifically my building system and incorporated his tips and worries into my final design.

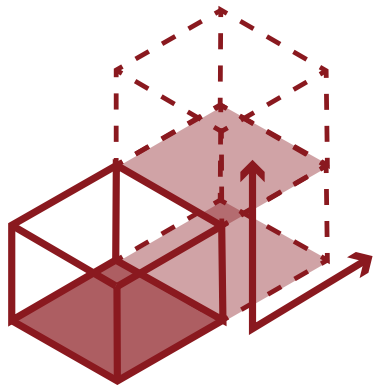
//	Pak Nana (45 y/o)	Leader construction (foreman)
//	Construction site	Kampung Dago Pojok
//	Project	Student housing (4 floors with atrium)

PROFESSIONAL CONSTRUCTION SITE


DUNHILL
DISCOVER
MILD
FINE TASTE
SADULUR
22B
218

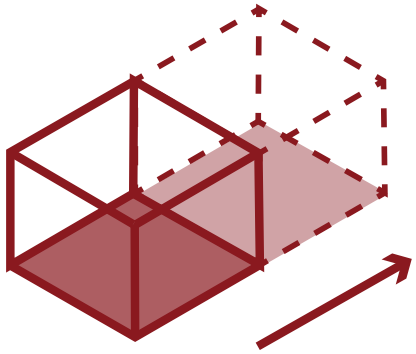
// Pak Iwan (32 y/o) Carpenter (one of three)
// Construction site Kampung Dago Pojok
// Project Extension house (2 floors)

SEMI - PROFESSIONAL CONSTRUCTION SITE



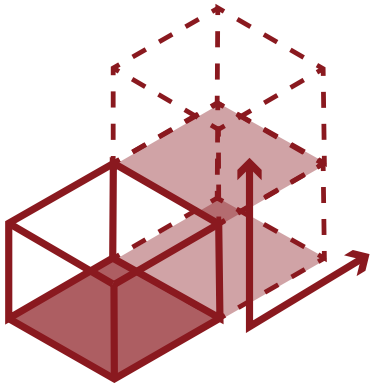
// Pak Thito (18 y/o) Son of owner
// Construction site Kampung Dago Pojok
// Project Extention house

INFORMAL CONSTRUCTION SITE

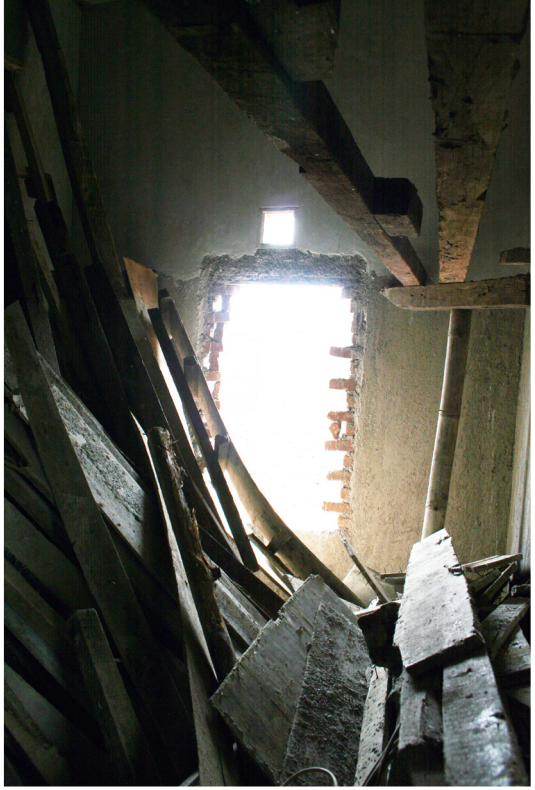


// Pak Isun (56 y/o) Construction worker (one of 3)
// Construction site Cigondewah
// Project Build new house behind existing house

SEMI-PROFESSIONAL CONSTRUCTION SITE

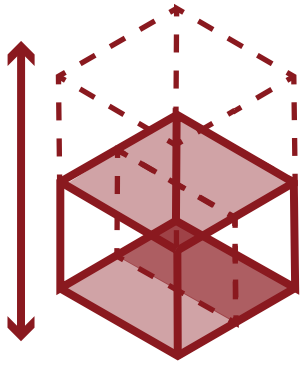



11 m
DENAH LANTAI 1
RUANG SAMU LANTAI 1
KAMAR TIDUR
KAMAR TIDUR
RUANGAN IBU
6.10 m



// Pak Mamat (45 y/o) Brother of owner (bank clerk)
// Construction site Kampung Cigondewah
// Project Extention house to two floors

INFORMAL CONSTRUCTION SITE

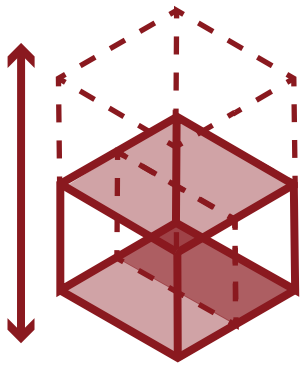


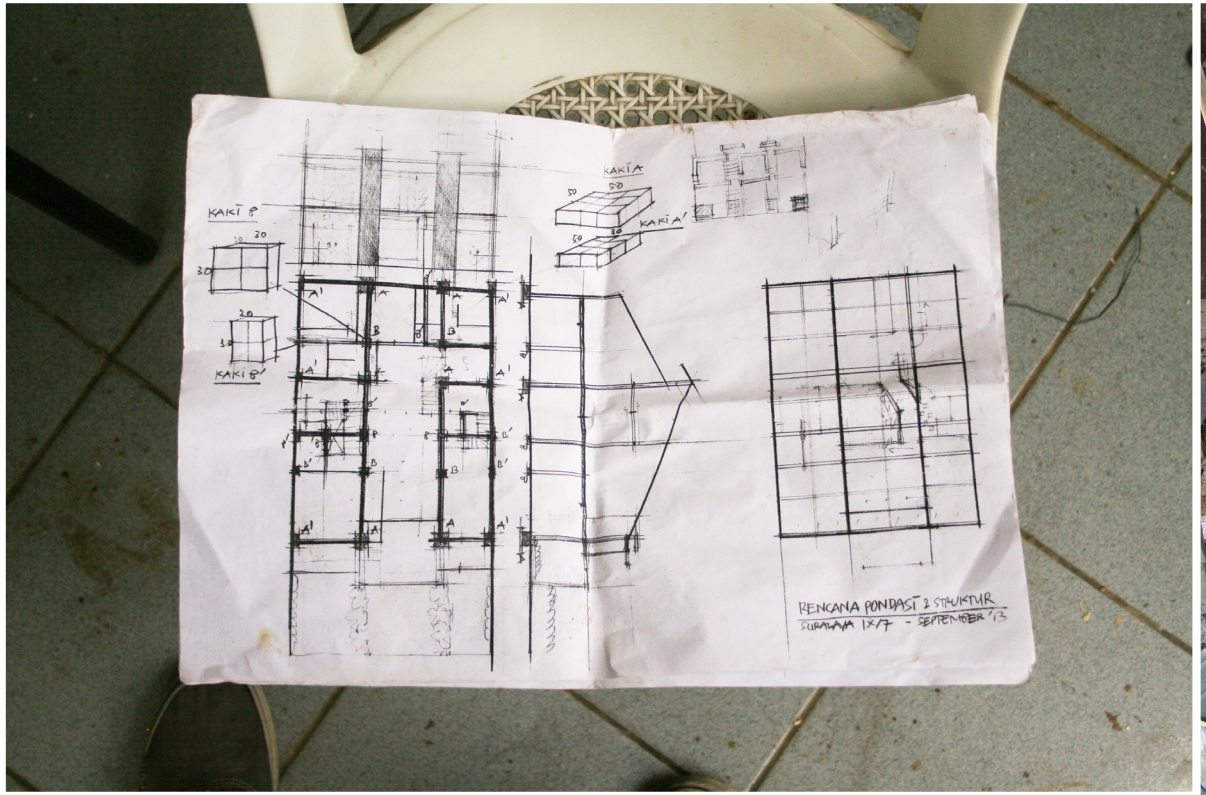




// Pak Omar (43 y/o) Construction leader (foreman)
// Construction site Kampung Braga
// Project Extention house to two floors

SEMI-PROFESSIONAL CONSTRUCTION SITE




KAKI A
KAKI A'
KAKI B
KAKI B'
RENCANA PONDASI & STRUKTUR
SURABAYA 15/7 - SEPTEMBER '13

COST CALCULATION SYSTEM FORMWORK

The cost calculation for the formwork consists of the sum of the following factors:

- Material cost formwork
- Maintenence cost CNC mill
- Costs milling (electricity + labour)
- Rent CNC hub
- Labour workers CNC hub

Because certain factors are unsure I had to make a rough estimation for some of these factors and make some assumptions for the other.
For the startup of the CNC hub I assume some government help is given by funding the labour costs, maintenence of the CNC mill and overhead costs of the CNC hub. This leaves the costs for the material to be paid in terms by renting out the CNC milled formwork to possible house owners. Current building practice in Indonesia is to use Albasia wood, also known as Kaso. This wood is the cheapest option in Indonesia, after use it is sold to garbage companies to be burned. Slightly better wood: Dolken is used for crossbracing the scaffolding of the formwork. When in good condition this wood is sold to furniture makers, or when in bad conditions it is sold together with the Albasia to be burned.

A quick comparison of the three materials available for milling the system-formwork shows that cocosboard (by Goodhout) is the best option. Not only is it very sustainable; it uses local cocos husk waste material to press high quality board material, but it can also compete price-wise. Betonplex is very strong and has a surface suited for multiple usage but can not compete price-wise. Moso Bamboo boards is a very sustainable material, but has a rather poreus surface and is therefore less suited for multiple usage, unless it is coated thoroughly.

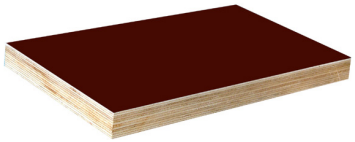
MATERIALS FORMWORK INDONESIA

// ALBASIA / KASO

Local Indonesian formwork
Unknown Kn/m^2
€ 210,- per m^3
15.000 IDR/m^2 (5 mm board)
Reusability = 1 times, burned after

// COCONUT HUSK BOARD (CHB)

+/- 5.000 Kn/m^2
€ 10,- per plaat (1.2 x 2.4 x 0.05 m)
50.000 IDR/M^2
Boards of 1.20 x 2.40 m
Reusability = 5 times



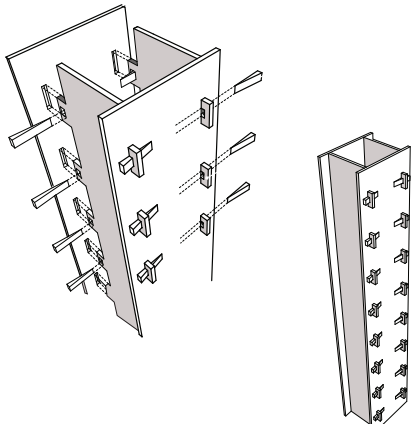
// BETONPLEX

+/- 4.500 Kn/m^2
€ 39,- per plaat (1.2 x 2.4 x 0.18 m)
190.000 IDR/m^2
Boards of 1.20 x 2.40 m
Reusability = 3-5 times

// MOSO BAMBOO

unknown Kn/m^2
€ 39,- per plaat (1.2 x 2.4 x 0.18 m)
190.000 IDR/m^2
Boards of 1.20 x 2.40 m
Reusability = 3-5 times

CALCULATION MATERIAL FORMWORK - COCONUT HUSK BOARD (CHB)

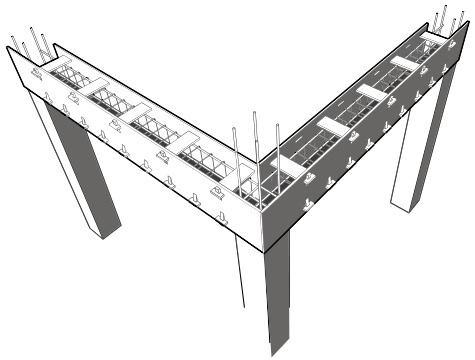


FORMWORK COLUMN

3,8 m^2 needed + 5% lost material = 4 m^2 material needed

4 m^2 x 50.000 = 200.000 IDR/colom
The column can be reused five times so the cost per column per time rented is:
200.000 / 5 = **40.000 IDR**

Material for a similar sized column using Albasia wood is 60.000 IDR.



FORMWORK BEAM (3 M GRID)

5 m^2 needed + 5% lost material = 5,3 m^2 material needed

5.3 m^2 x 50.000 = 265.000 IDR/beam
The 3 m beam can be reused five times so the cost per beam per time rented is:
265.000 / 5 = **53.000 IDR**

Material for a similar sized beam using Albasia wood is 80.000 IDR.

DESIGN SYSTEM FORMWORK

The formwork system was designed in a way that it could provide for most orthogonal floorplan shapes of the kampung. While the columns were always 2.5 m, the length of the beams varies from 2.5 until 4.5. When a longer beam is needed, for example 5 meters long, an extra column is placed in between and two shorter beams are combined.
As seen in Fig. B2 the columns determine what kind of corner is poored in concrete, L, T and + shaped corners could provide for all connections neccary.
On the next page is shown not only the exploded view of the CNC milled beams and columns, but also the recepy for the milled elements to send to the CNC mill. Everything in grey is neccesary for the milled element, everything in white can be considered extra stock.

Fig B1. Variable length beams formwork system (own ill.)
Fig B2 Variable shapes columns formwork system, dependend on corner shape (own ill.)
Fig B3. Shape formwork system, 3 x3 x 2.5 measured (own ill.)

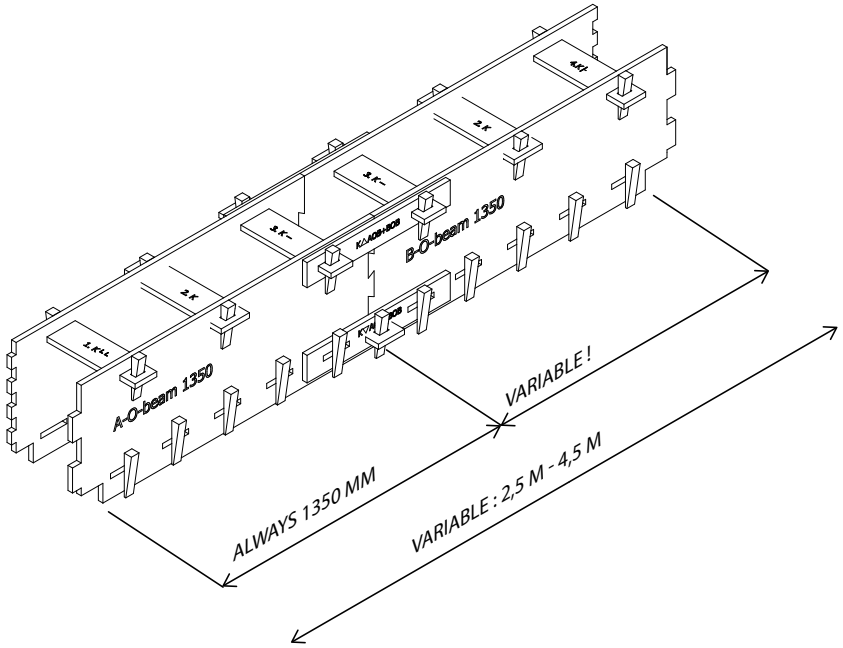


Fig B1.

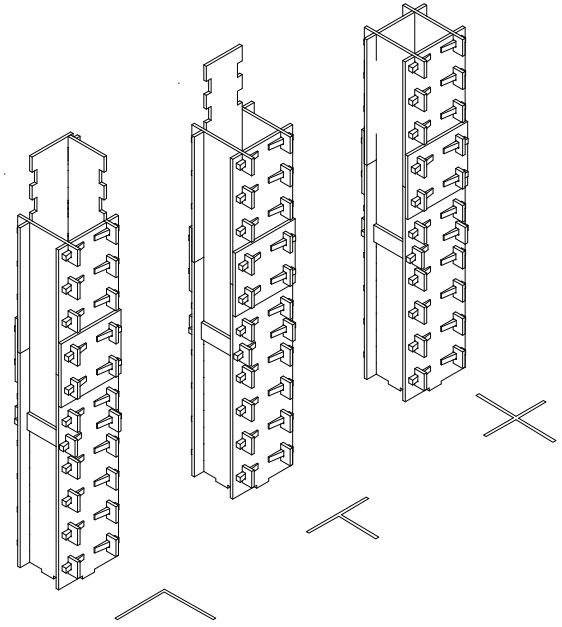


Fig B2.

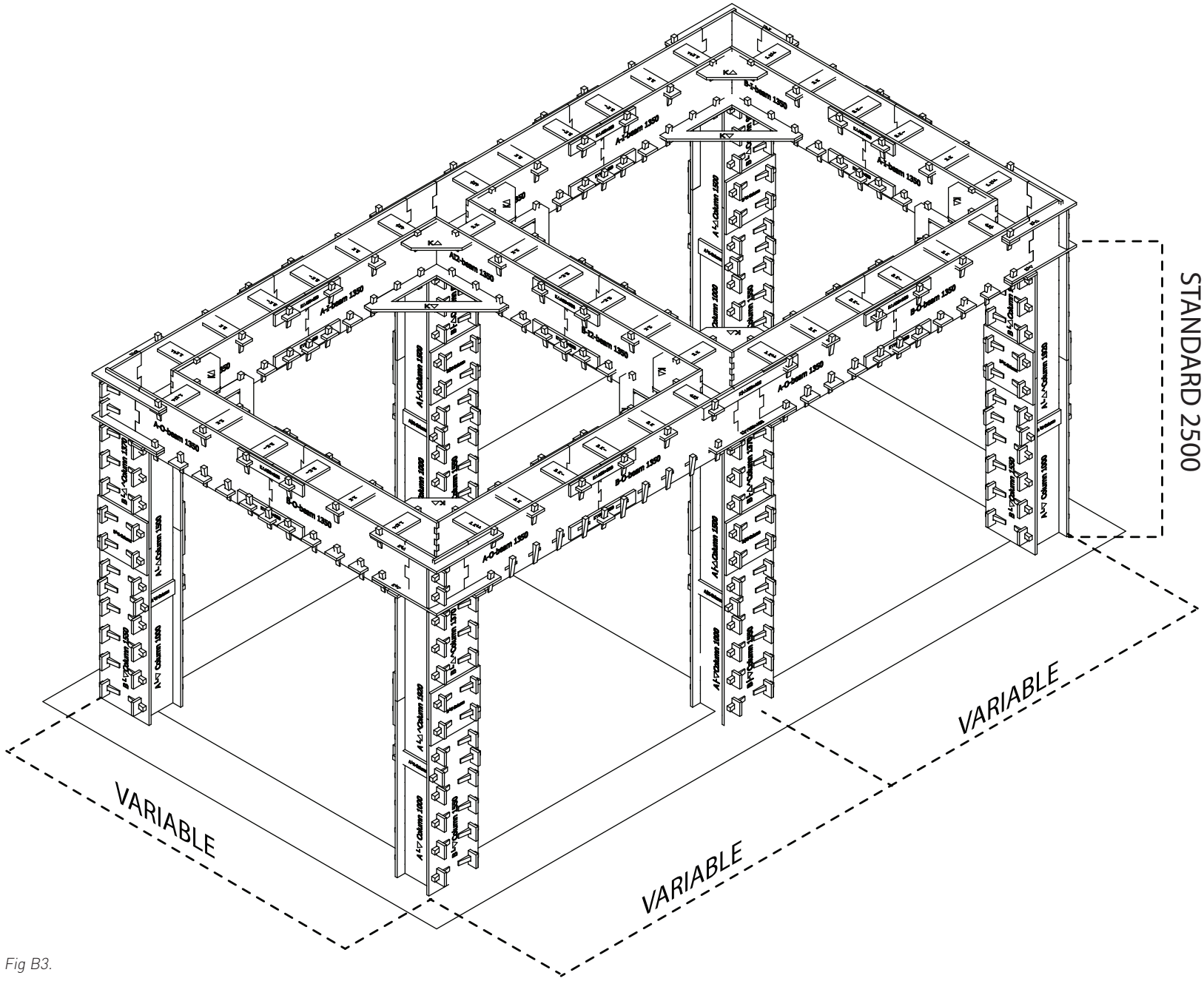


Fig B3.

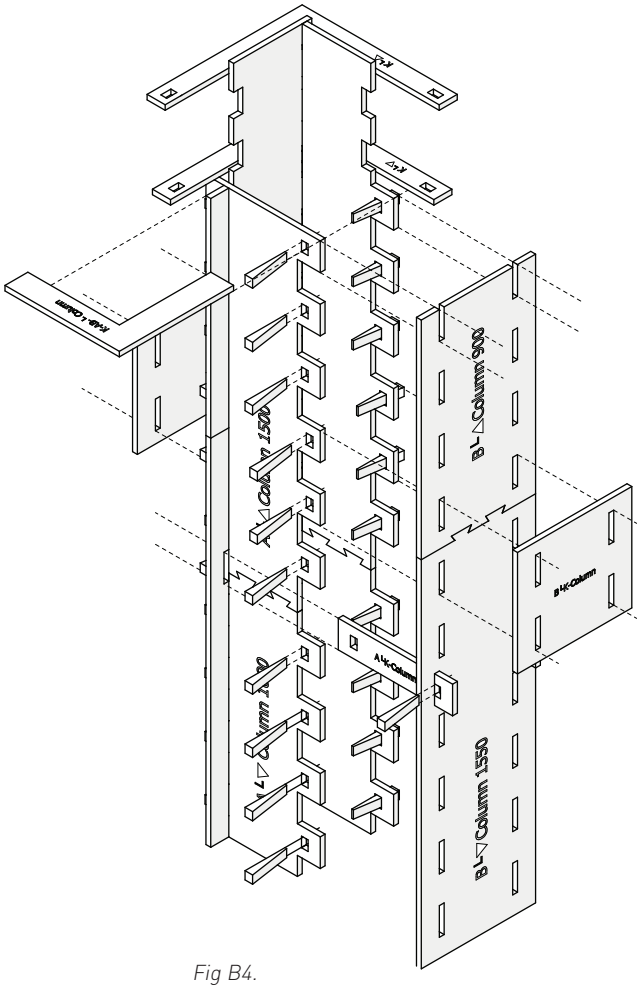


Fig B4.

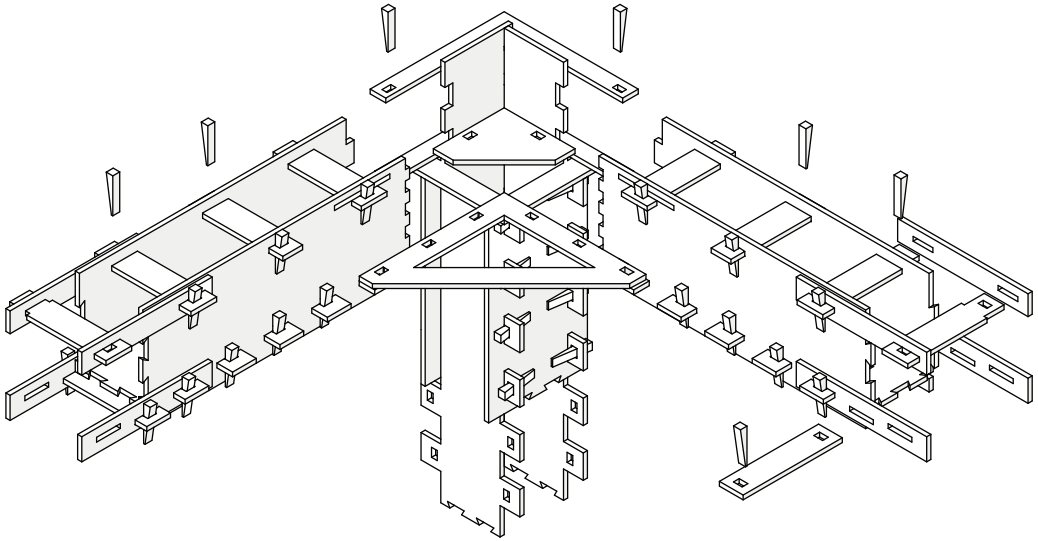
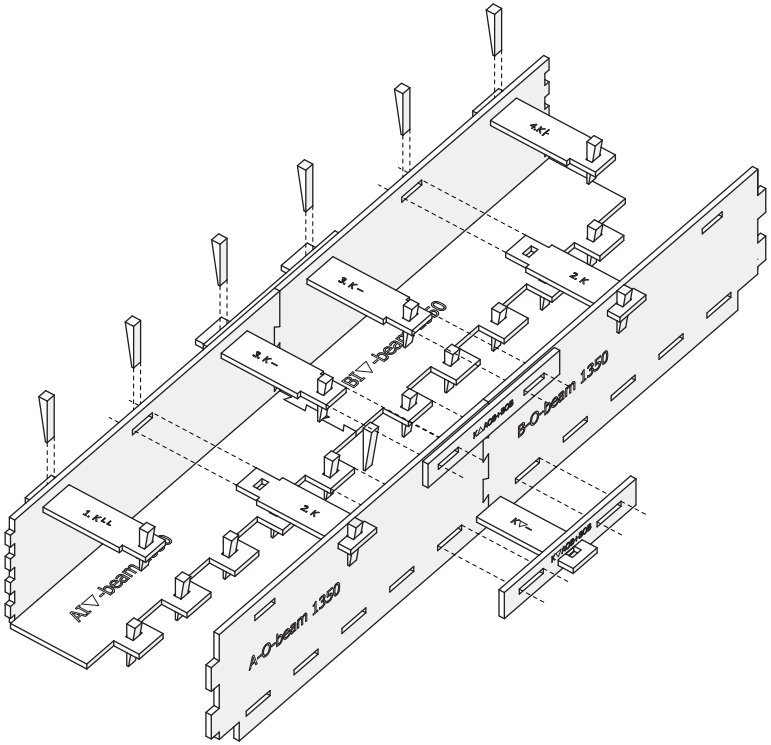


Fig B5.



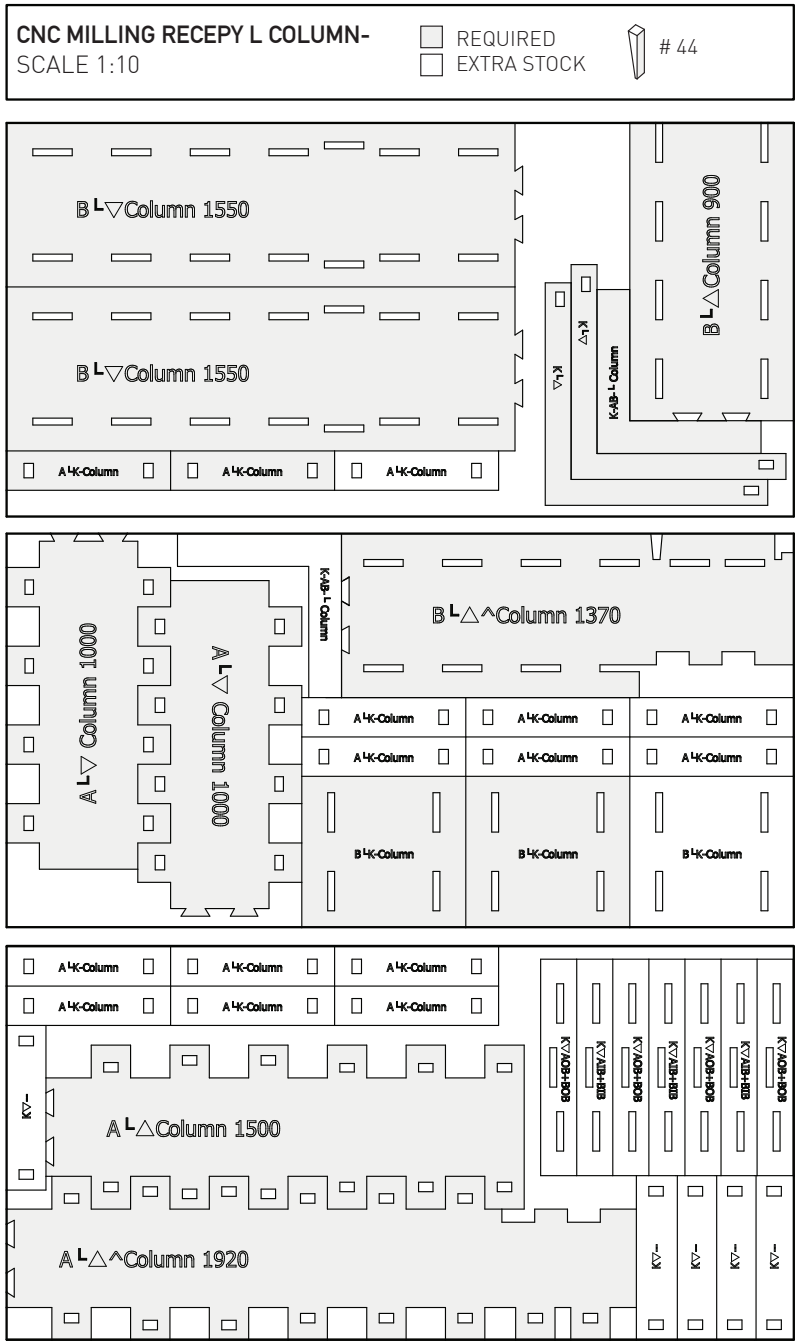

CNC MILLING RECEPY L COLUMN-
SCALE 1:10
REQUIRED
EXTRA STOCK
44
B L▽Column 1550
B L▽Column 1550
B L△Column 900
K-AB-L Column
A L▽ Column 1000
A L▽ Column 1000
B L△^Column 1370
A L△Column 1500
A L△^Column 1920

Fig B7.

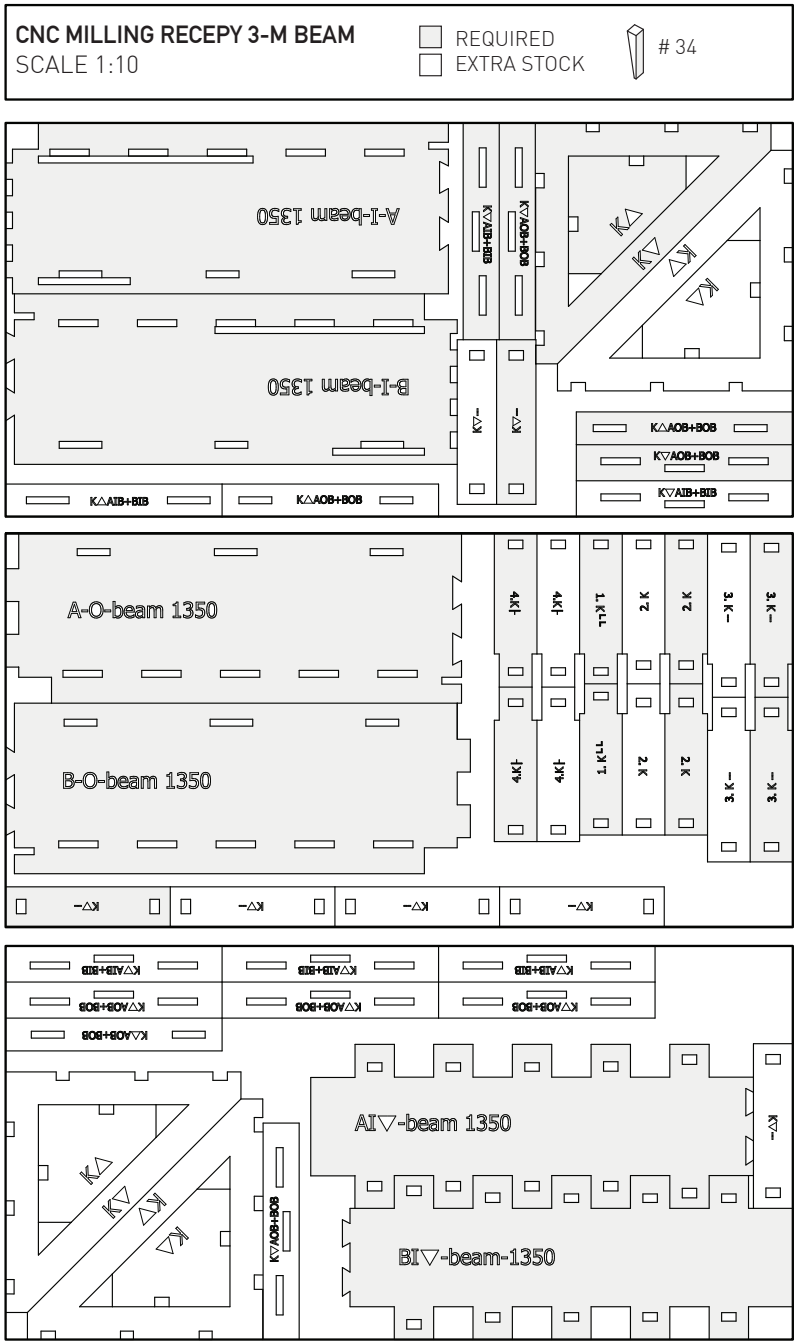

CNC MILLING RECEPY 3-M BEAM
SCALE 1:10
REQUIRED
EXTRA STOCK
34
A-I-beam 1350
B-I-beam 1350
A-O-beam 1350
B-O-beam 1350
AI▽-beam 1350
BI▽-beam-1350

Fig B8.

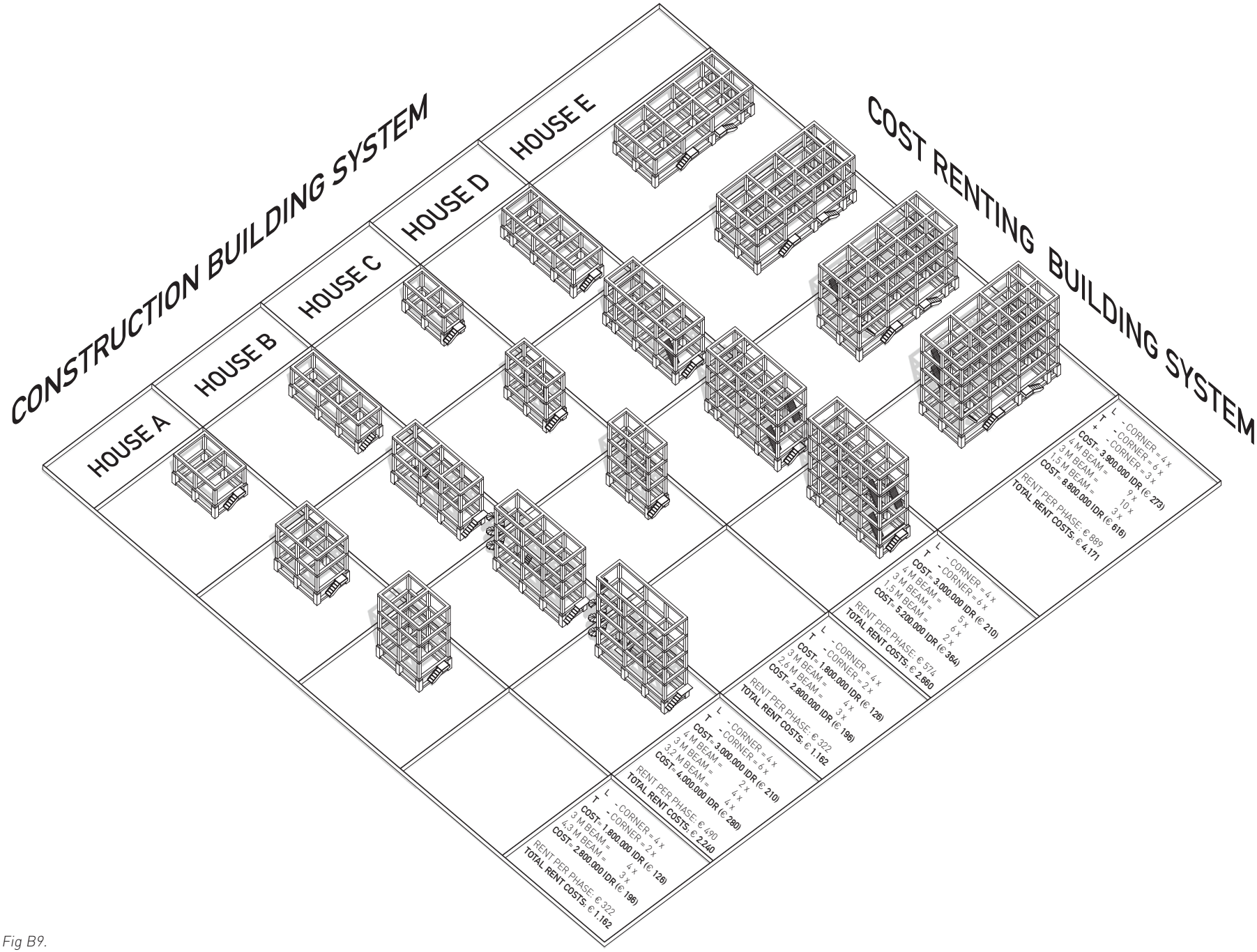
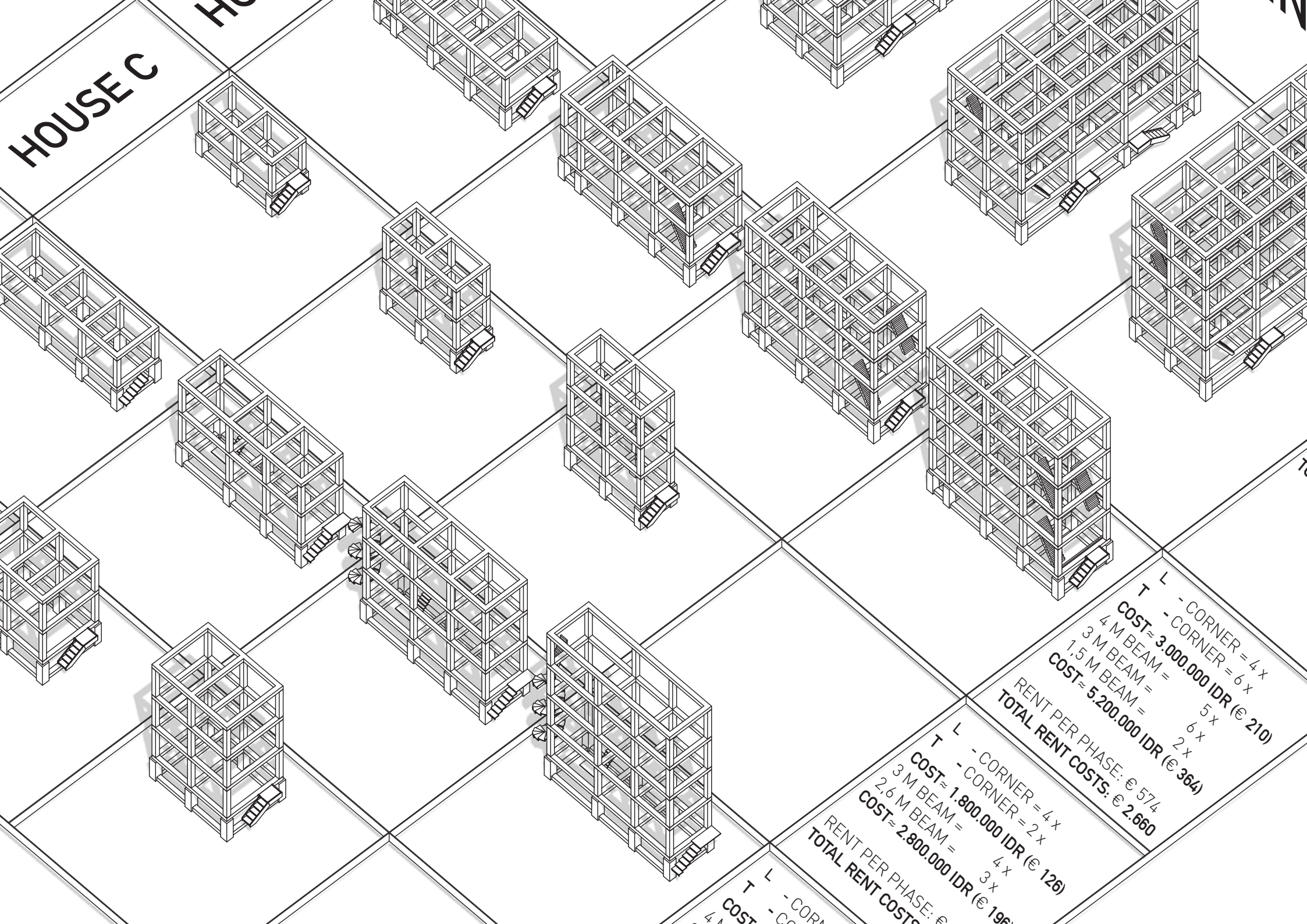

CONSTRUCTION BUILDING SYSTEM
HOUSE A
HOUSE B
HOUSE C
HOUSE D
HOUSE E
COST RENTING BUILDING SYSTEM
L - CORNER = 4 x
T - CORNER = 6 x
+ - CORNER = 3 x
4 M BEAM = 9 x
3 M BEAM = 10 x
1.5 M BEAM = 3 x
COST= 3.900.000 IDR (€ 273)
RENT PER PHASE: € 889
COST= 8.800.000 IDR (€ 616)
TOTAL RENT COSTS: € 4.171
L - CORNER = 4 x
T - CORNER = 6 x
4 M BEAM = 5 x
3 M BEAM = 6 x
1.5 M BEAM = 2 x
COST= 3.000.000 IDR (€ 210)
RENT PER PHASE: € 574
COST= 5.200.000 IDR (€ 364)
TOTAL RENT COSTS: € 2.660
L - CORNER = 4 x
T - CORNER = 2 x
3 M BEAM = 4 x
2.6 M BEAM = 3 x
COST= 1.800.000 IDR (€ 126)
RENT PER PHASE: € 322
COST= 2.800.000 IDR (€ 196)
TOTAL RENT COSTS: € 1.162
L - CORNER = 4 x
T - CORNER = 6 x
4 M BEAM = 2 x
3 M BEAM = 4 x
3,2 M BEAM = 4 x
COST= 3.000.000 IDR (€ 210)
RENT PER PHASE: € 490
COST= 4.000.000 IDR (€ 280)
TOTAL RENT COSTS: € 2.240
L - CORNER = 4 x
T - CORNER = 2 x
3 M BEAM = 4 x
4,3 M BEAM = 3 x
COST= 1.800.000 IDR (€ 126)
RENT PER PHASE: € 322
COST= 2.800.000 IDR (€ 196)
TOTAL RENT COSTS: € 1.162

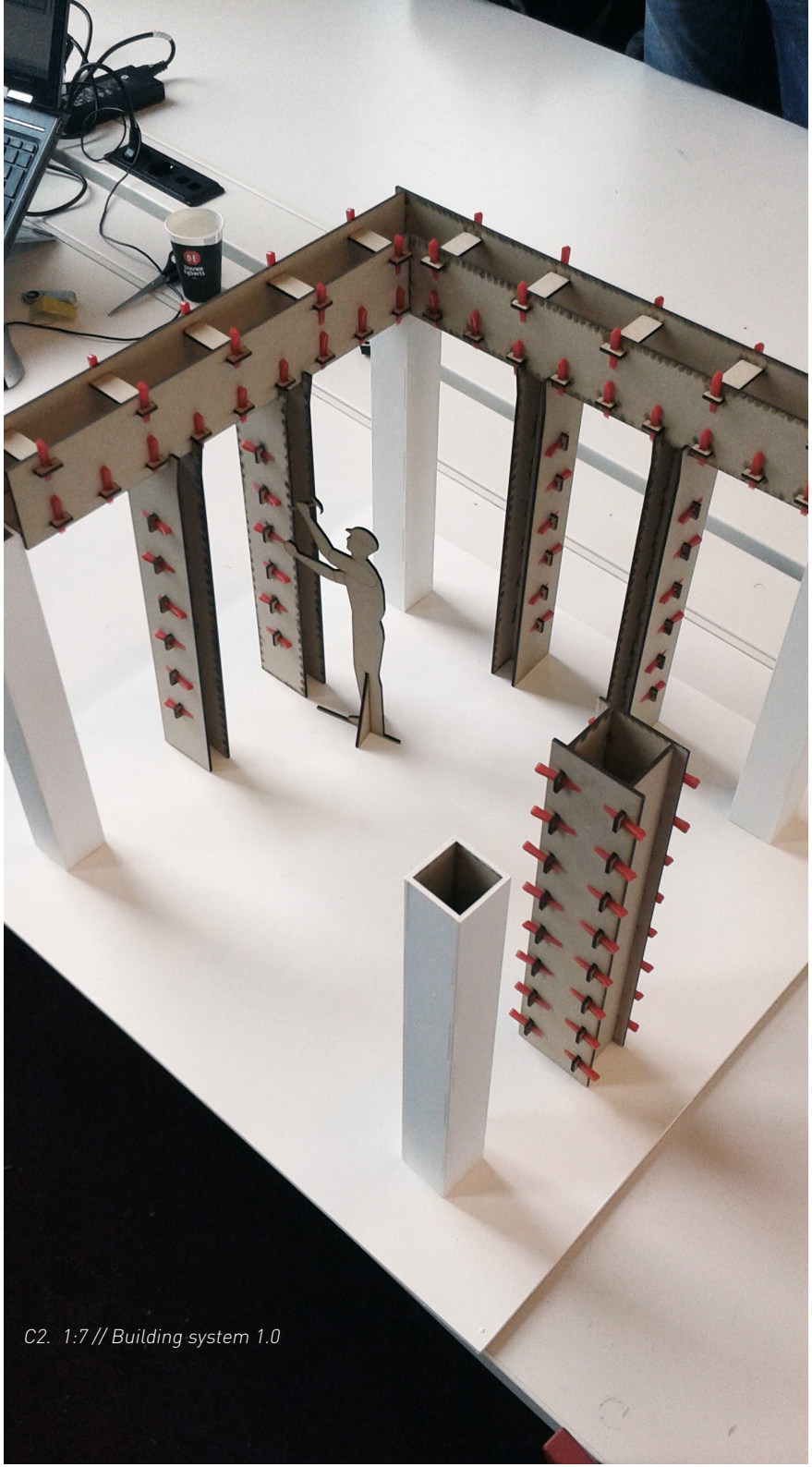
Fig B9.


HOUSE C
L - CORNER = 4 x
T - CORNER = 6 x
COST ≈ 3.000.000 IDR (€ 210)
4 M BEAM = 5 x
3 M BEAM = 6 x
1,5 M BEAM = 2 x
COST ≈ 5.200.000 IDR (€ 364)
RENT PER PHASE: € 574
TOTAL RENT COSTS: € 2.660
L - CORNER = 4 x
T - CORNER = 2 x
COST ≈ 1.800.000 IDR (€ 126)
3 M BEAM = 4 x
2,6 M BEAM = 3 x
COST ≈ 2.800.000 IDR (€ 196)
RENT PER PHASE: €
TOTAL RENT COSTS

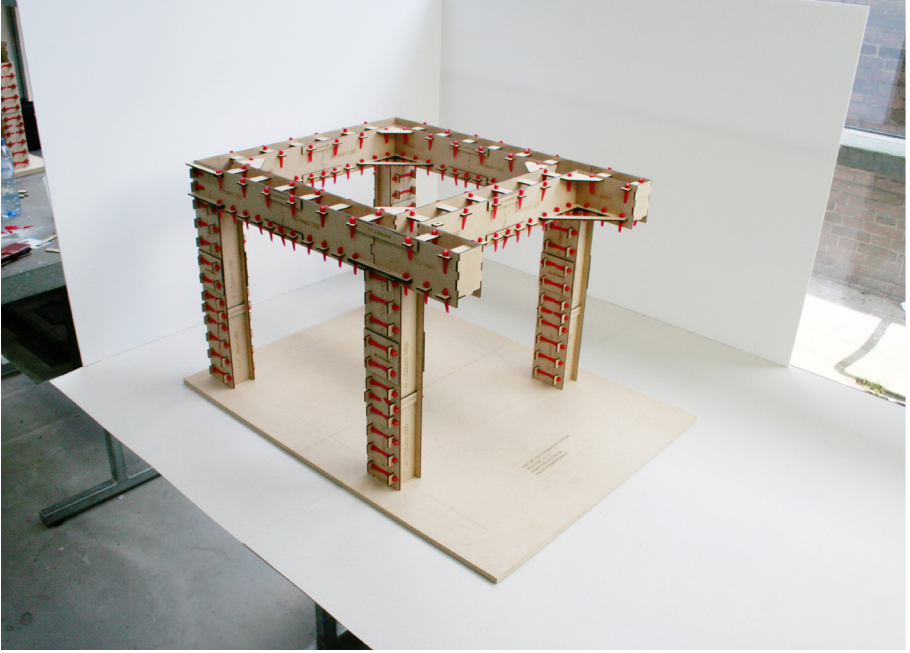
C. MODEL MAKING

+ 1:1
+ 1:7
+ 1:50
+ 1:100

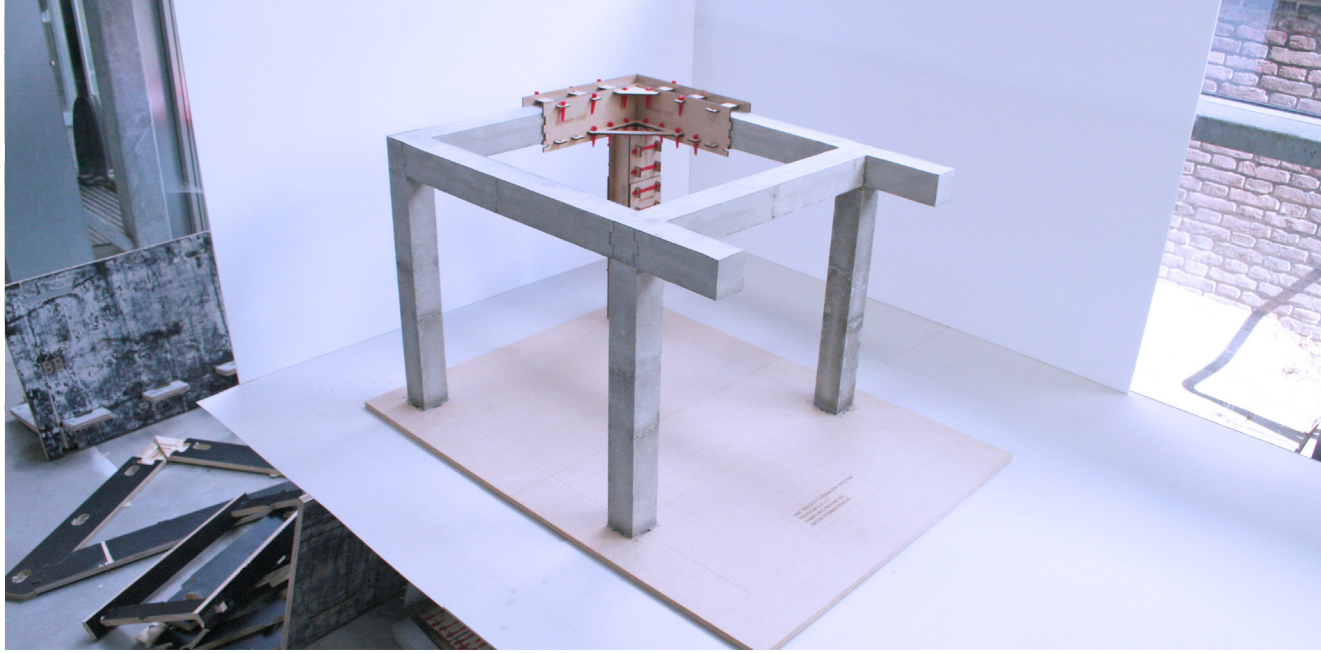
C1. 1:50 // Travel model



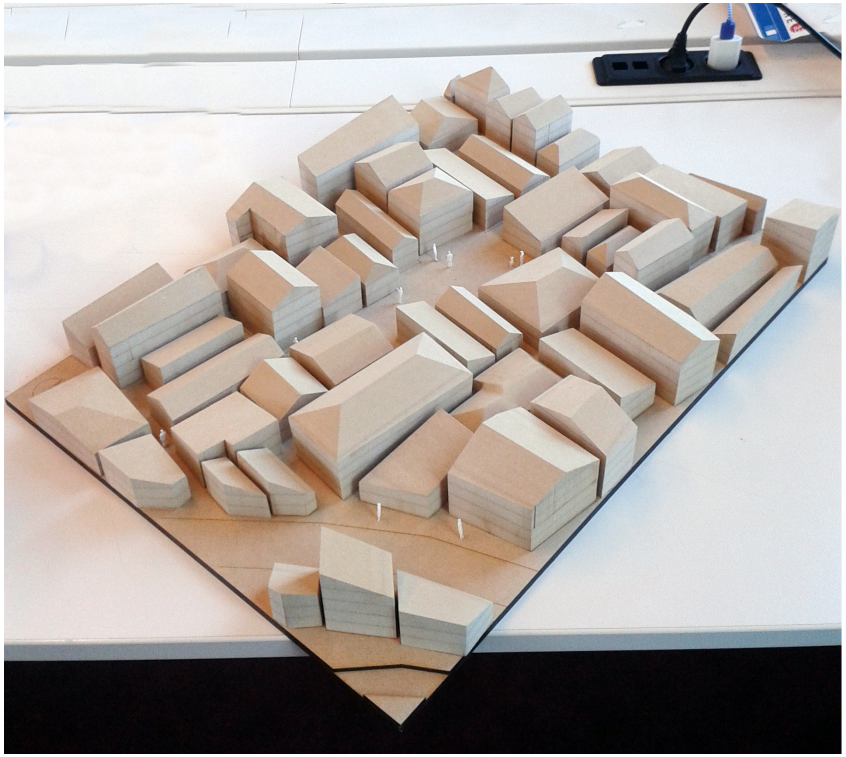
C2. 1:7 // Building system 1.0



C3. 1:7 // Building system

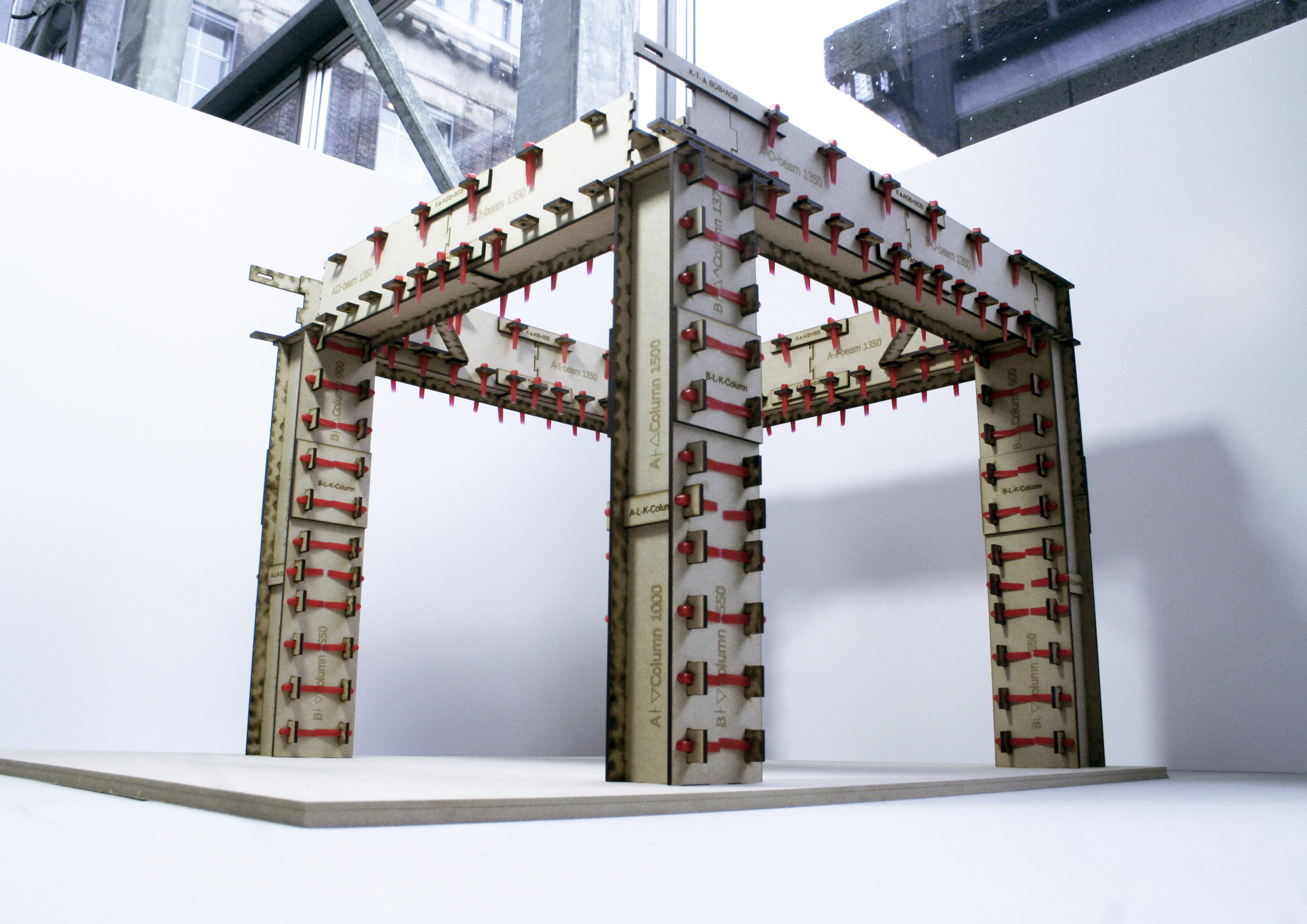


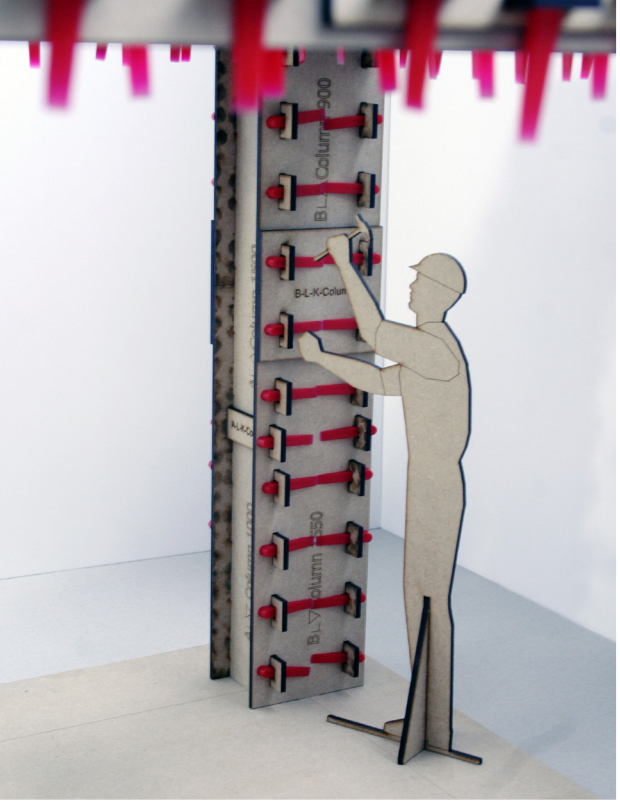
C4. 1:7 // Building system - poored result

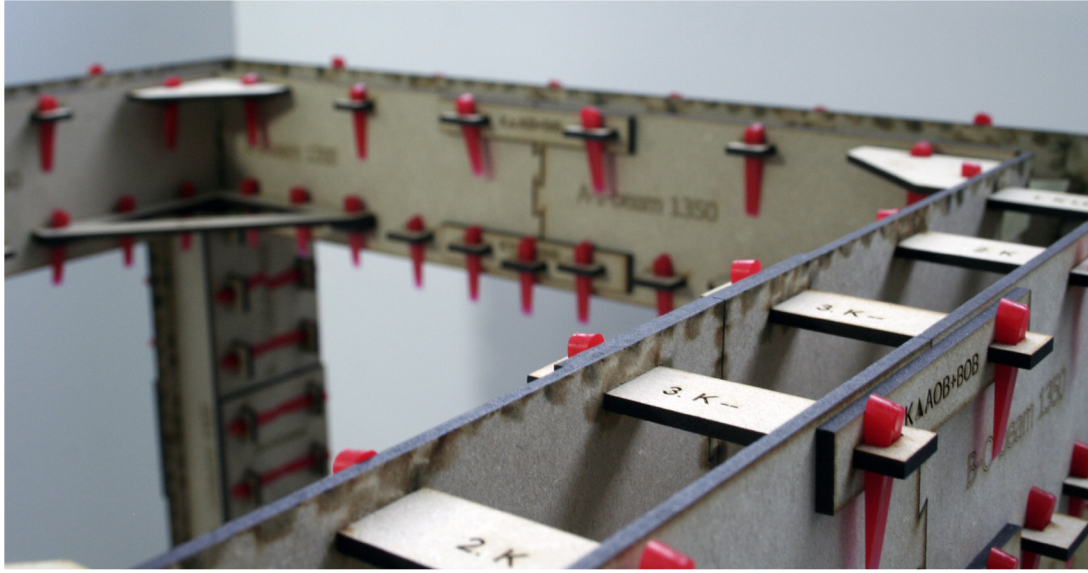


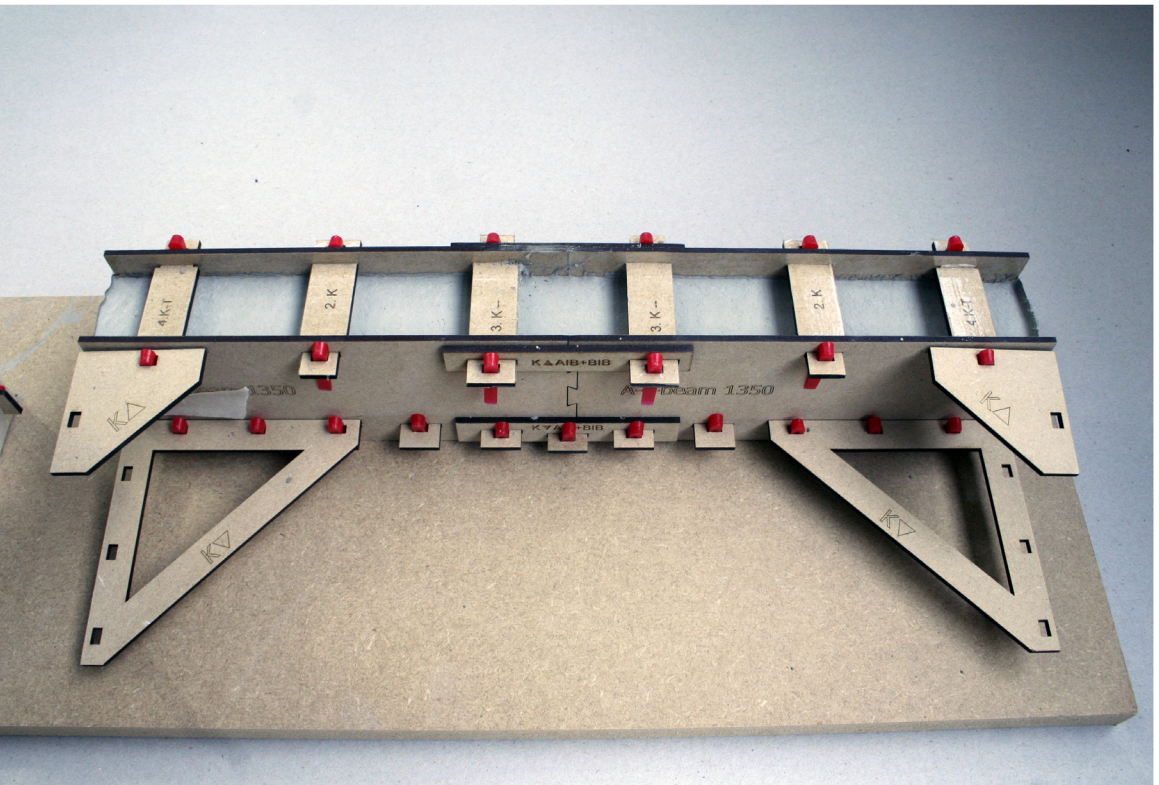
C5. 1:100 // Location model kampung Cigondewah

C6. 1:1 // Building system - corner detail on

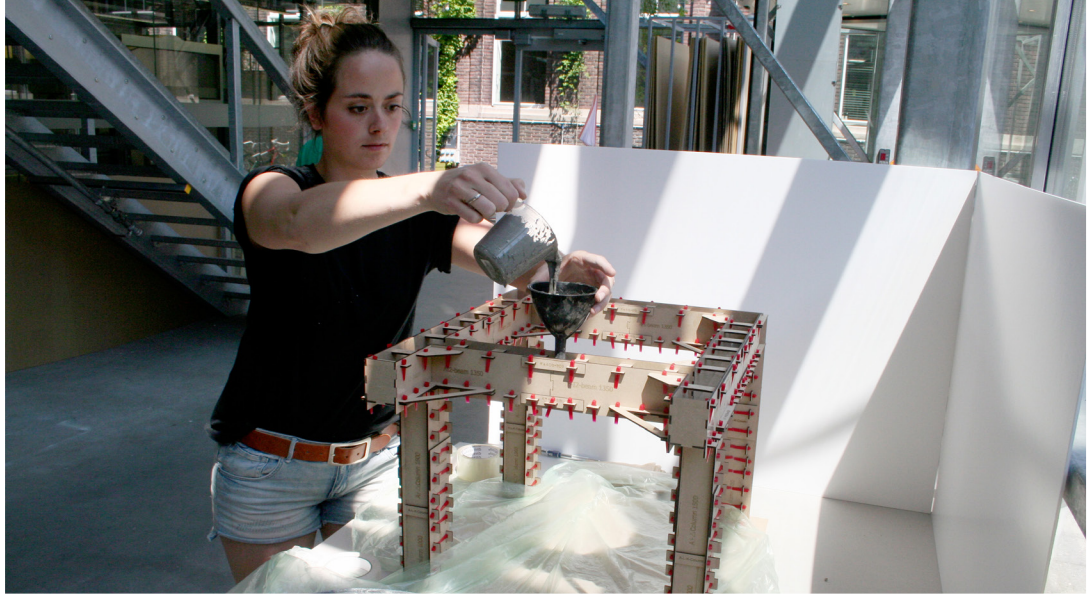

K-T-A BOB+AOB
A-O-beam 1350
A2-beam 1350
A-I-beam 1350
B-L-K-Column
A-L-K-Colun
B-L-K-Column


B-L-K-Colum
B-L-Column 900
B-L-Column 1350

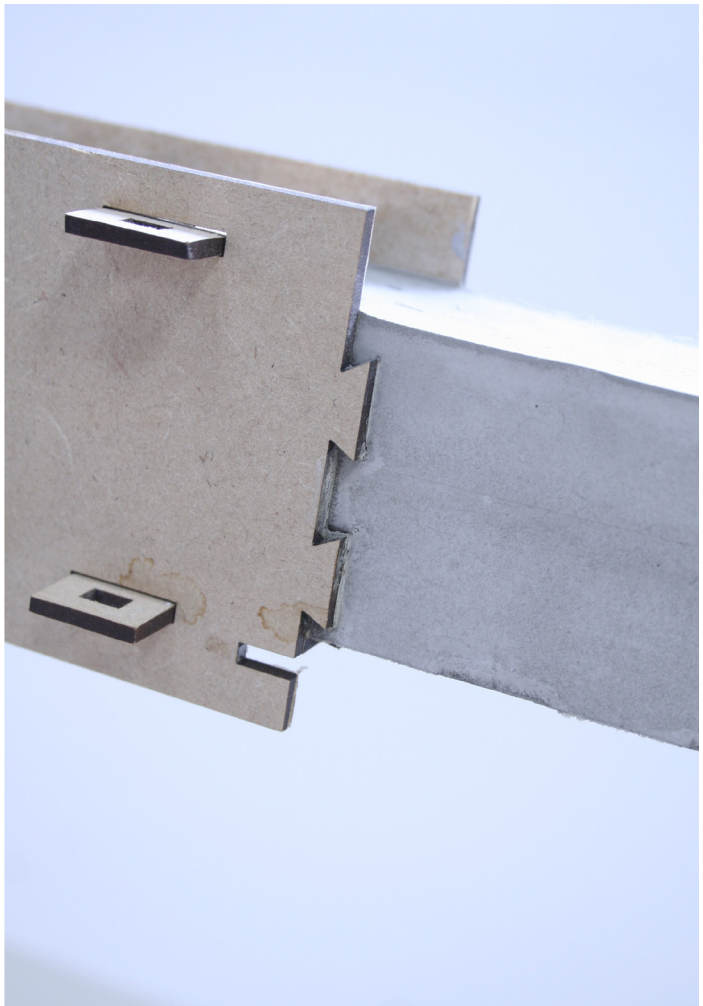

A-O-beam 1350
3. K–
2 K

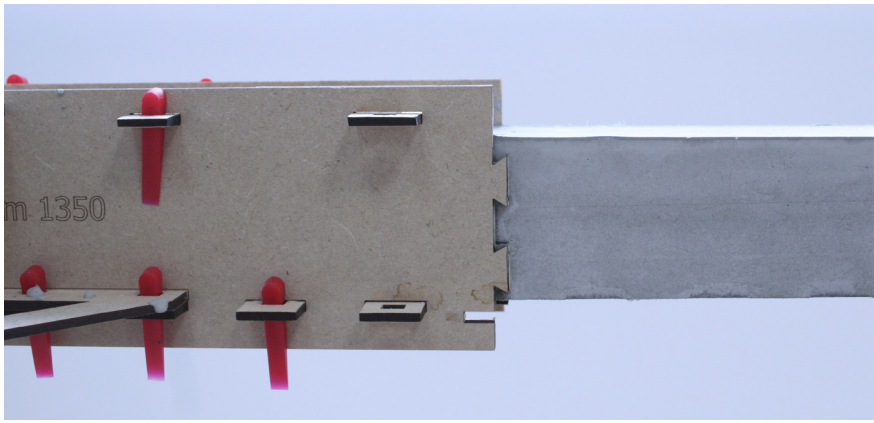

4 K-T
2 K
3. K–
3. K–
2 K
4 K-T
K▲AIB+BIB
A-O-beam 1350

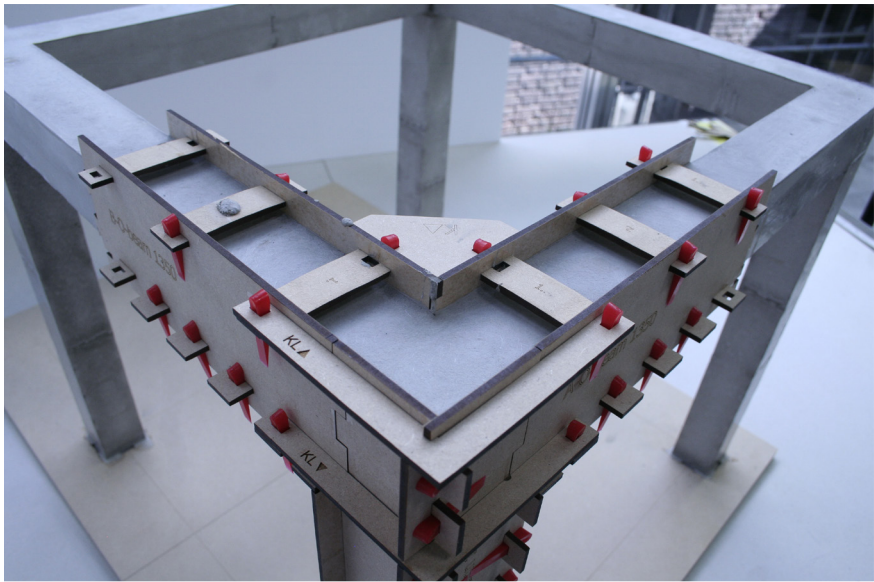

A-O-beam 1350

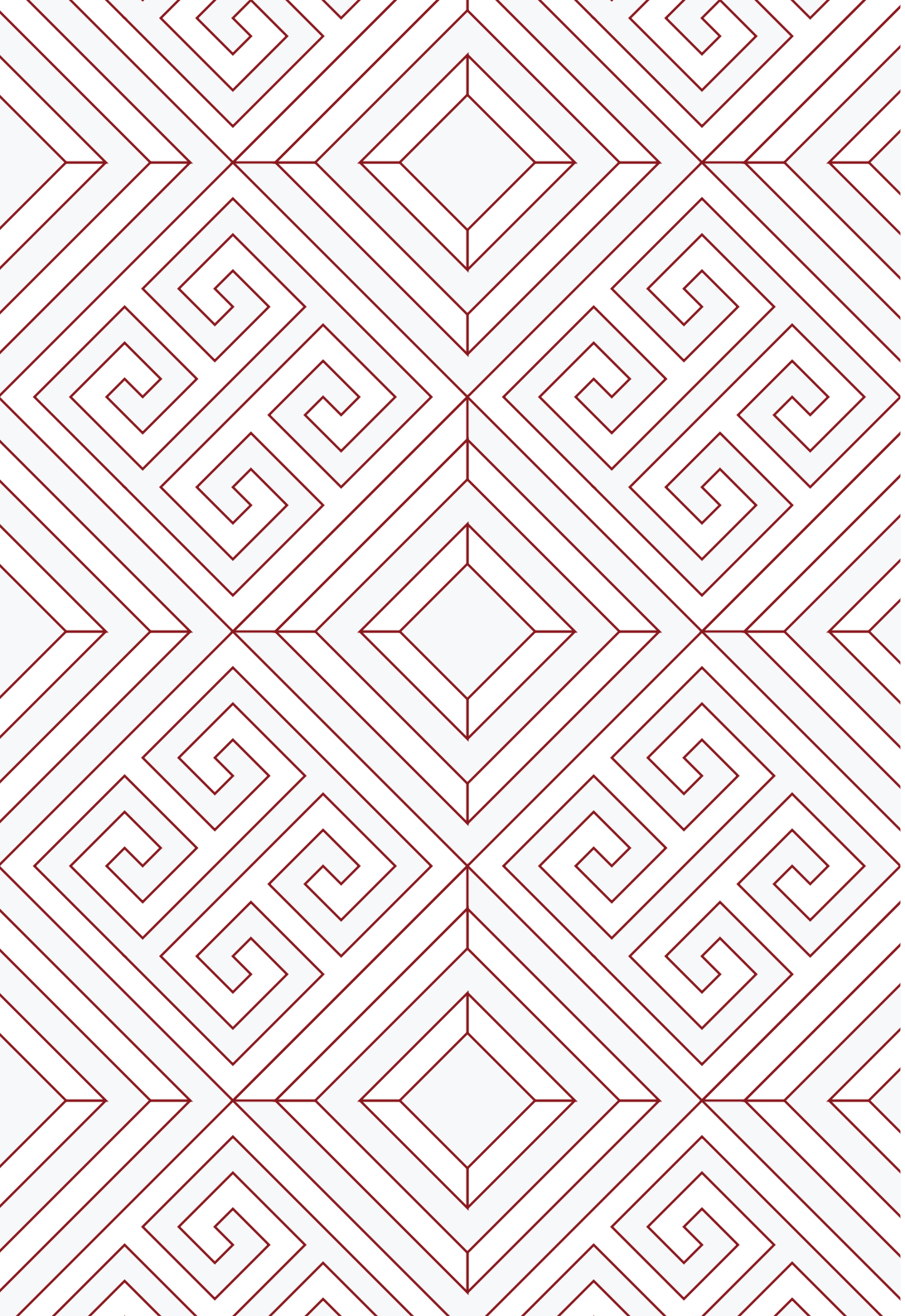


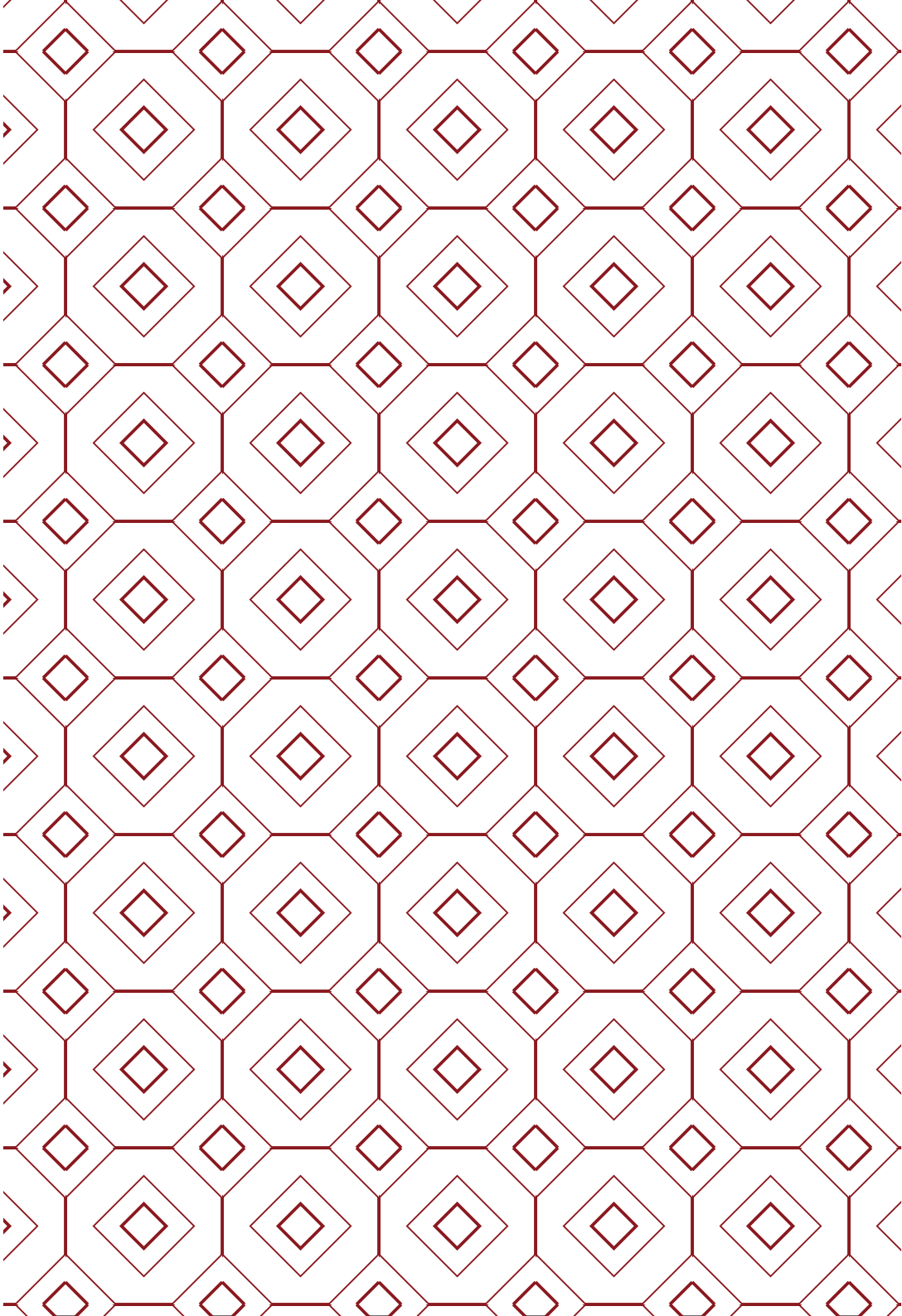

A-I-beam 1350

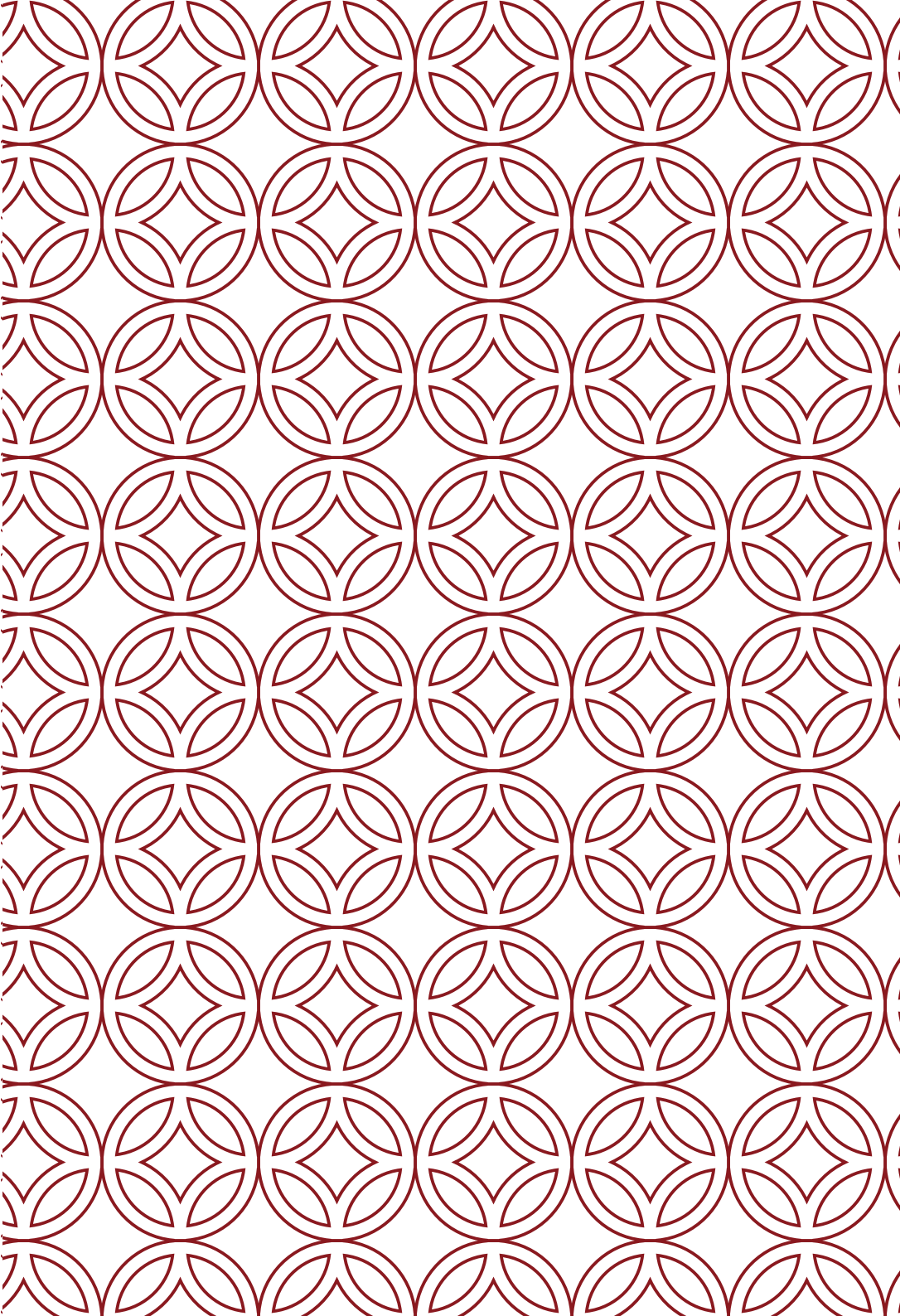
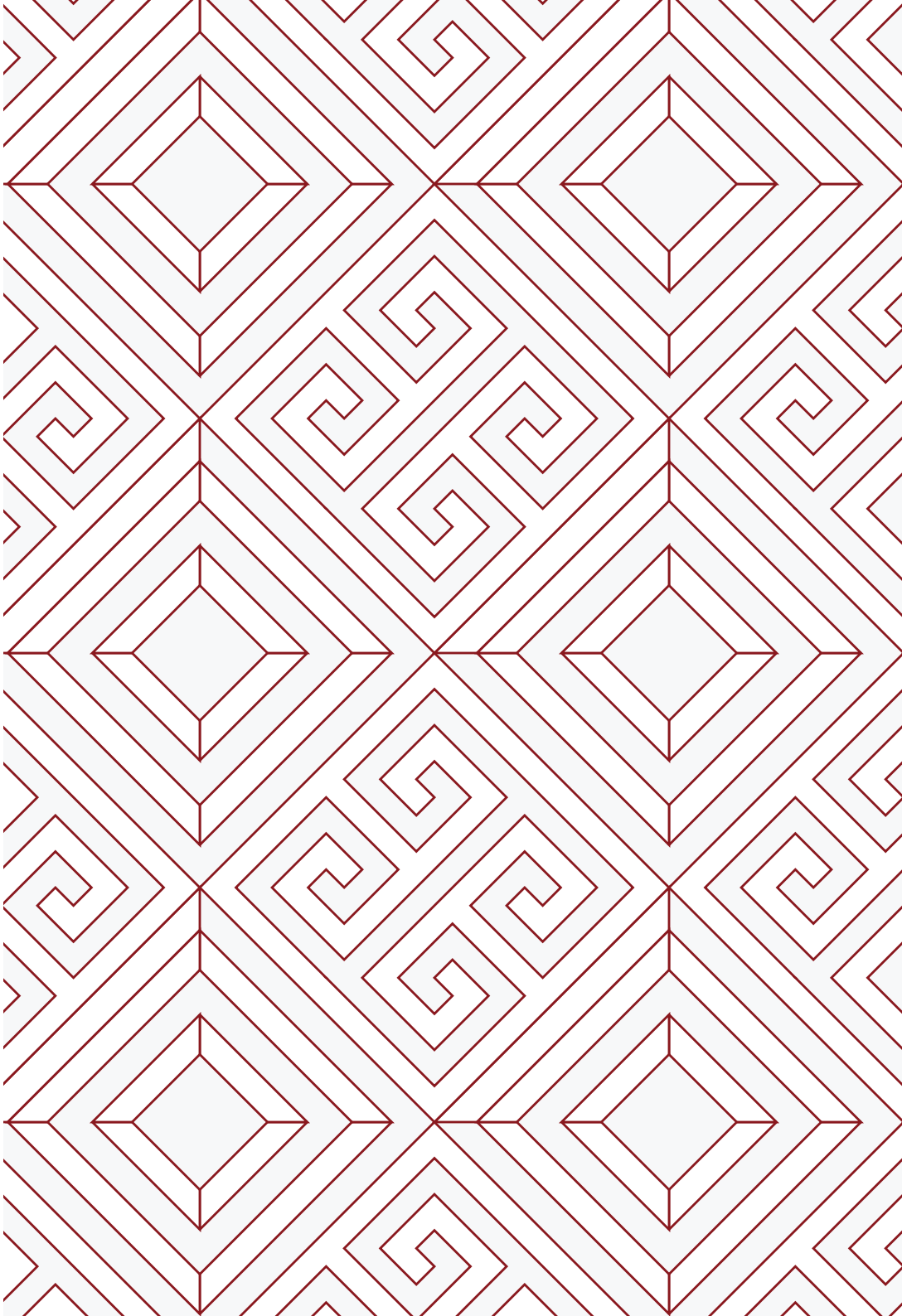



m 1350







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