Chapter 8

Technical Resolution

The value of a world heritage landscape is ever changing. As a fossil hominid site, the development of Kromdraai Cave is subject to possible future discoveries, in that the cave may produce a treasure of important fossil finds, or may prove to be disappointing. The site has been scientifically analysed to locate the presence of fossils adjacent to the known excavation site, but surrounding areas on Kromdraai farm could possibly still be linked to the identified fossil site.

The development and future of the site is therefore unpredictable, leading to the necessity of the structures to be adaptable and flexible. The need for adaptability, together with the sensitivity of the site itself, leads to the concept of a demountable structure. The technical investigation examines the notion of demountability as a means to design sensitively and provides an approach to designing on fossil hominid world heritage sites.

Relating to the design concept of embracing the archaeological grid and process, the technical concept aims to express the grid throughout the structure.

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8.1 The background to the technical concept

The value of a world heritage landscape is ever changing. As a fossil hominid site, the development of Kromdraai Cave is subject to possible future discoveries, in that the cave may produce a treasure of important fossil finds, or may prove to be disappointing. The site has been scientifically analysed to locate the presence of fossils adjacent to the known excavation site, but surrounding areas on Kromdraai farm could possibly still be linked to the identified fossil site.

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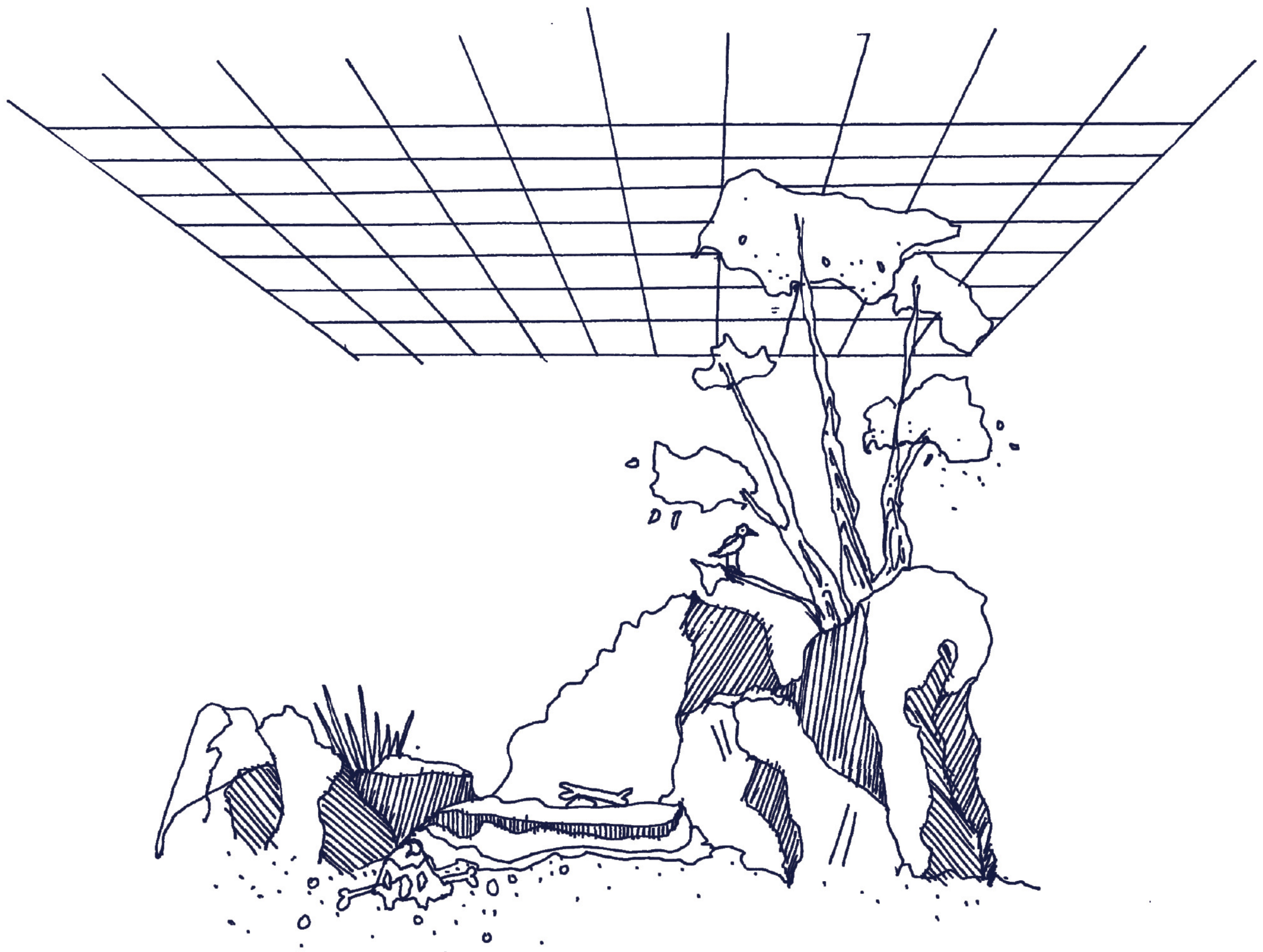


8.1 - The background to the technical concept (Author, 2016).

8.2 SANS 10400

The SANS 10400 guided the technical resolution of the project as a means of achieving the national standards and regulations.

Occupancy and building classification and Design population:

Restaurant and administration block:

- A1 Entertainment and public assembly _ number of fixed seats or 1 person per m2
- C1 Exhibition hall ¬_ 1 person per 10 m2
- F2 Small shop _1 person per 10 m2
- G1 offices _1 person per 15 m2

Laboratories and workshops:

- A3 Places of instruction _1 person per 5m2
- J1 High risk storage _1 person per 50 m2
- J3 Low risk storage _1 person per 50 m2

Archive and library:

- C2 Library _ 1 person per 20 m2

Ventilation:

The total area of an opening shall not be less than 5 %% of the floor area of a room or 0,1 m2 with respect to category E4, H3m H4 or H5 and 0,2m3 in respect of other buildings.

Air requirements for different types of occupancies:

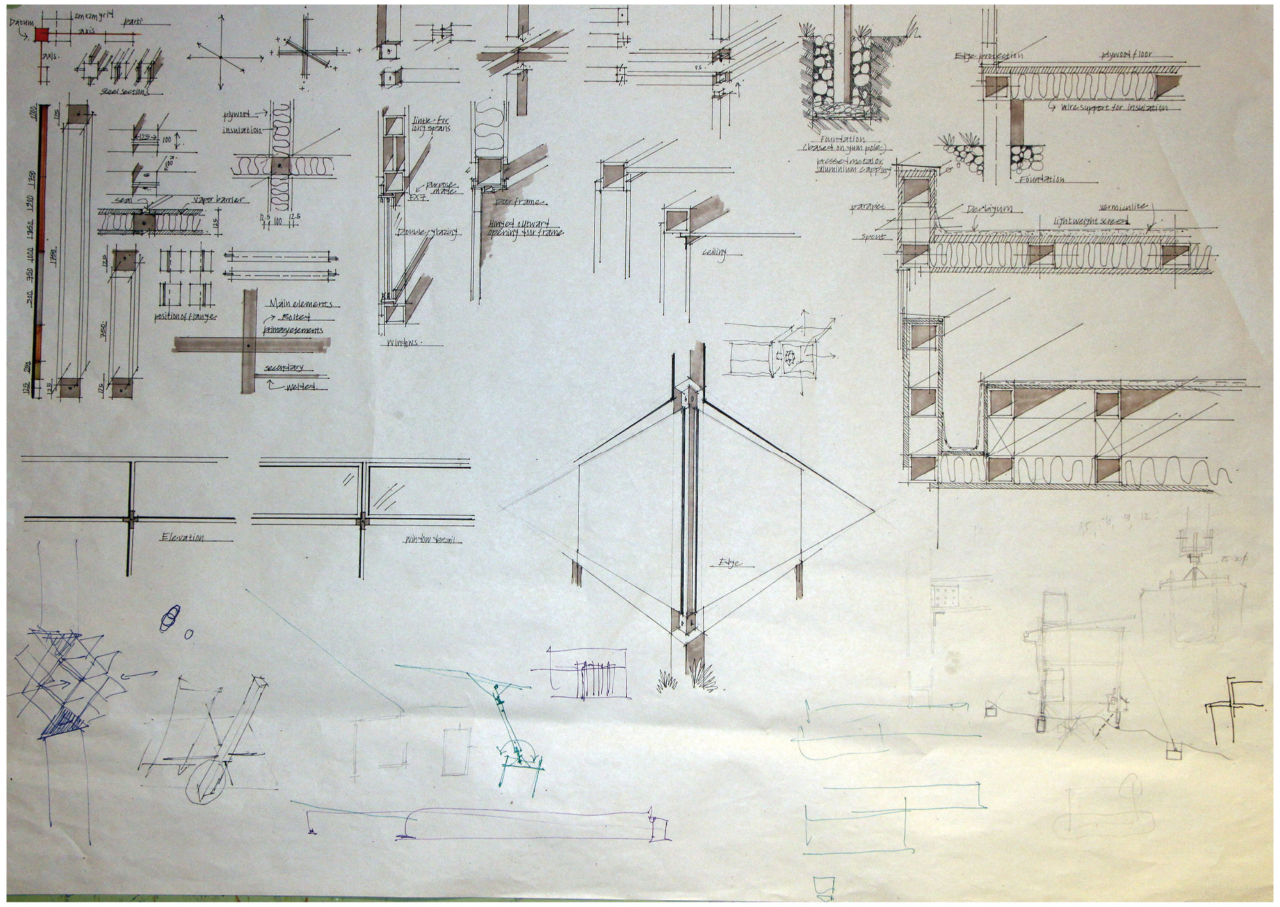
- Public halls: 10 air changes per hour & 7.5 L/s per person
- Educational buildings (classrooms, laboratories and libraries): 2 air changes per hour & 7,5 L/s per person
- Food and eating facilities: 10 air changes per hour & 7,5 L/s per person
- Kitchen: 20 air exchanges per hour & 17,5 L/s per person
- Photographic dark room: 10 L/s per person
- Library: 2 Air exchanges per hour & 7,5 L/s per person
- Offices: 2 Air exchanges per hour & 7,5 L/s per person
- Board rooms: 10 Air exchanges per hour & 10 L/s per person
- Film room: 10 Air exchanges per hour & 7,5 L/s per person
- Ablution facilities: 20 Air exchanges per hour & 20 L/s per person

SANS 10400-P Number of sanitary fixtures to be installed:

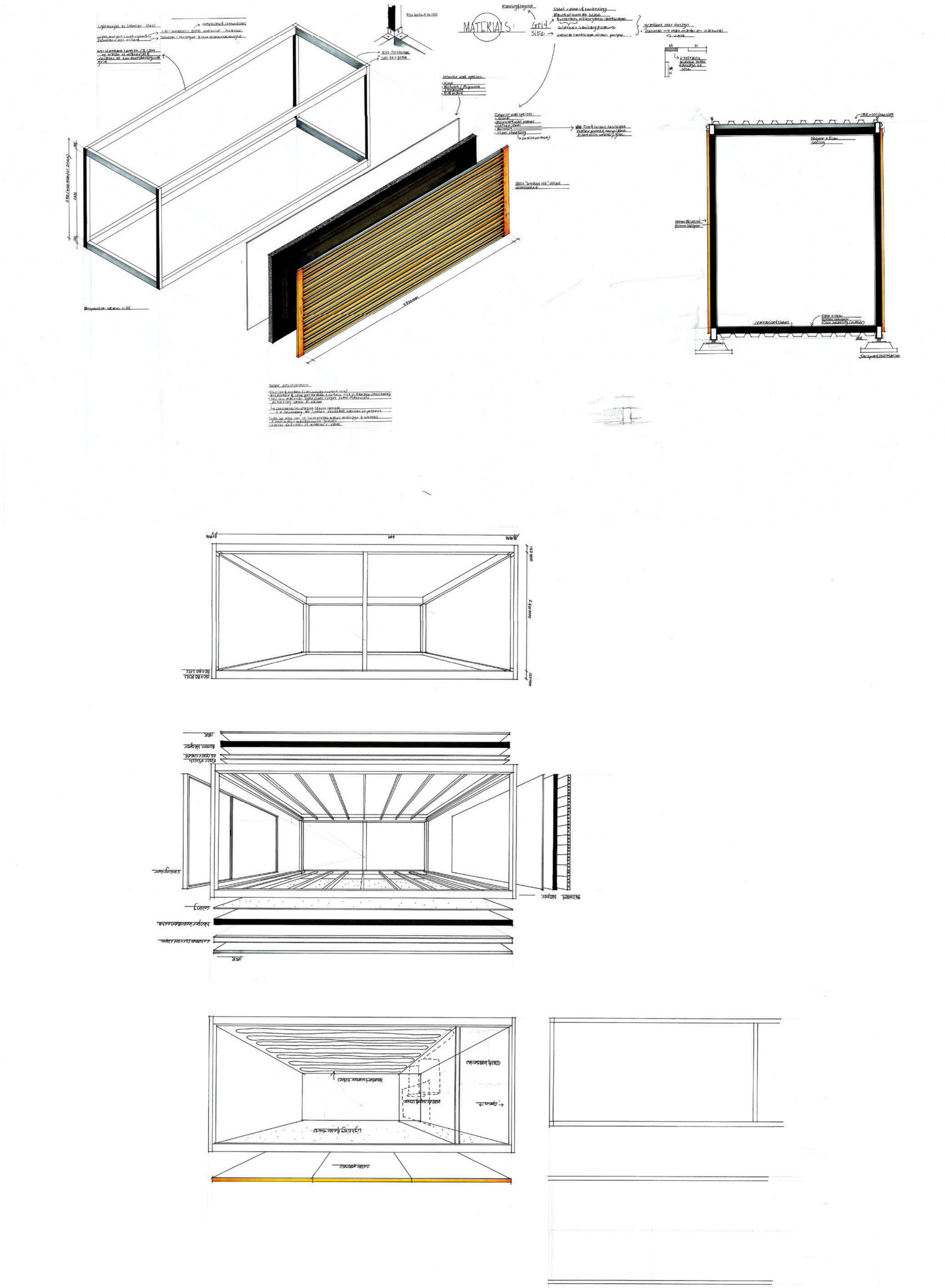
- Laboratories and workshops_ males: 1 toilet pan, 1 urinal, 1 WHB females: 2 toilet pans & 1 WHB
- Restaurant and administration block_ 3 toilet pans, 5 urinal, 4 WHB & Females: 7 toilet pans & 4 WHB
- Archive and library_ 1 toilet pan, 1 urinal, 1 WHB females: 2 toilet pans & 1 WHB

8.3 Iterations and process

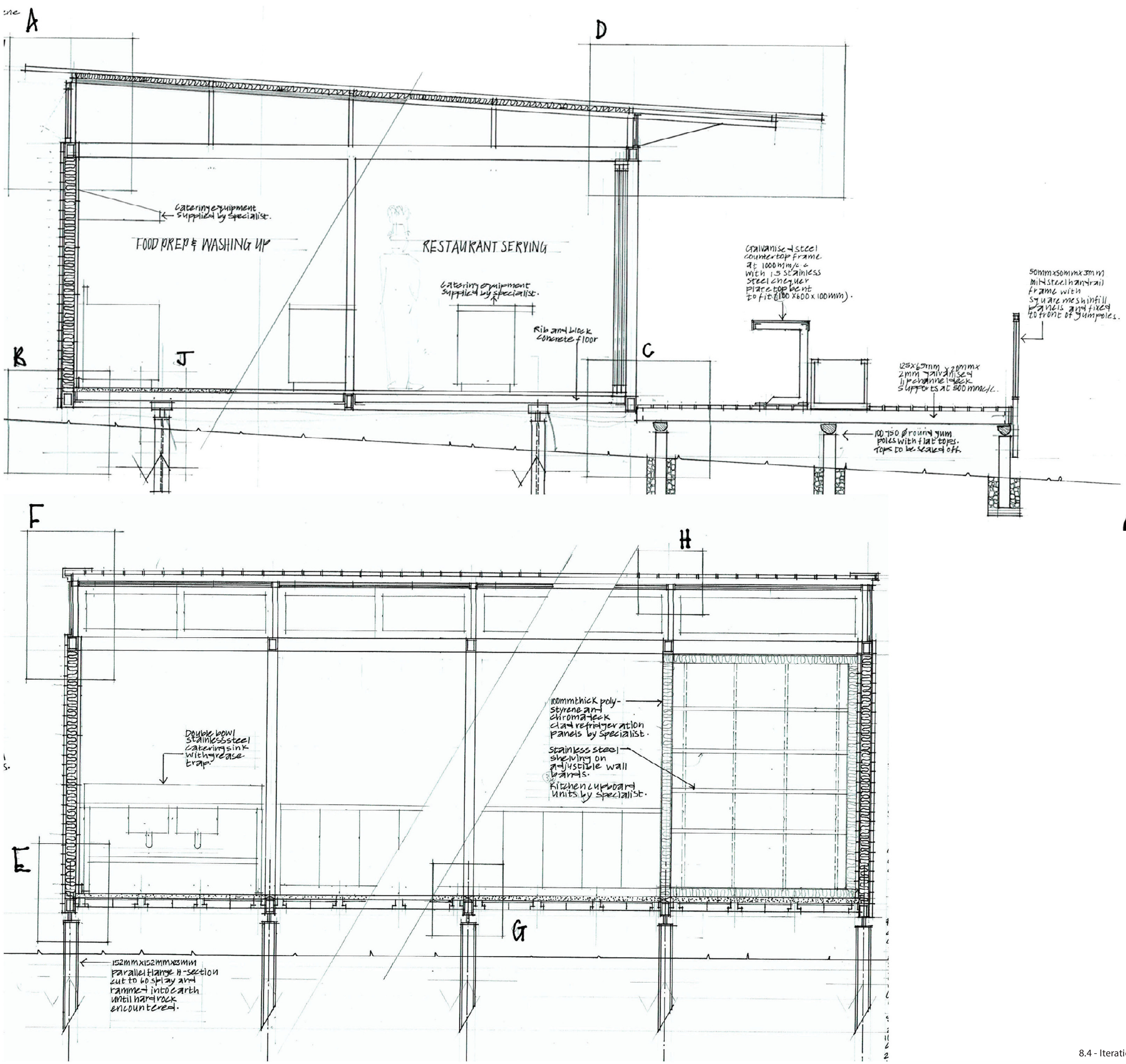
The Kromdraai iteration process contained four investigations, the first being a modular system, the second a prefabricated system, the third a kit-assembly system and the fourth a refinement of the kit assembly system. The design of a modular system with bolted connections consisted of too many connections and problematic edges, with changes in levels being difficult to resolve. A prefabricated system would limit disruption to the site, but proved to waste materials and resulted in a non-contextual resolution. The final iteration, the kit assembly, allowed for all components to be constructed off site and bolted together on site, with minimum material wastage and allowing for adaptability and demountability.



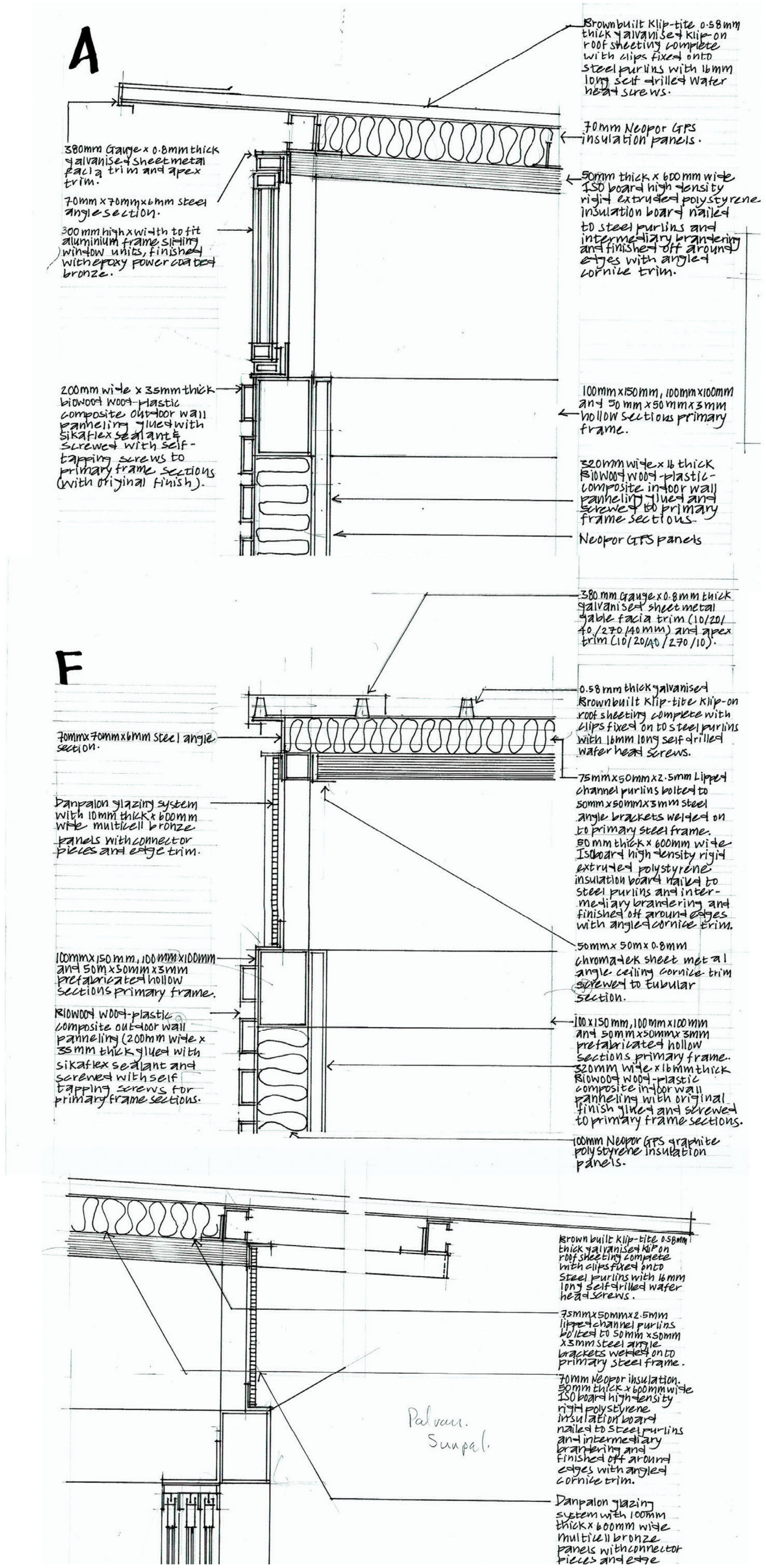
8.2 - Iteration 1, modular system (Author, 2016).



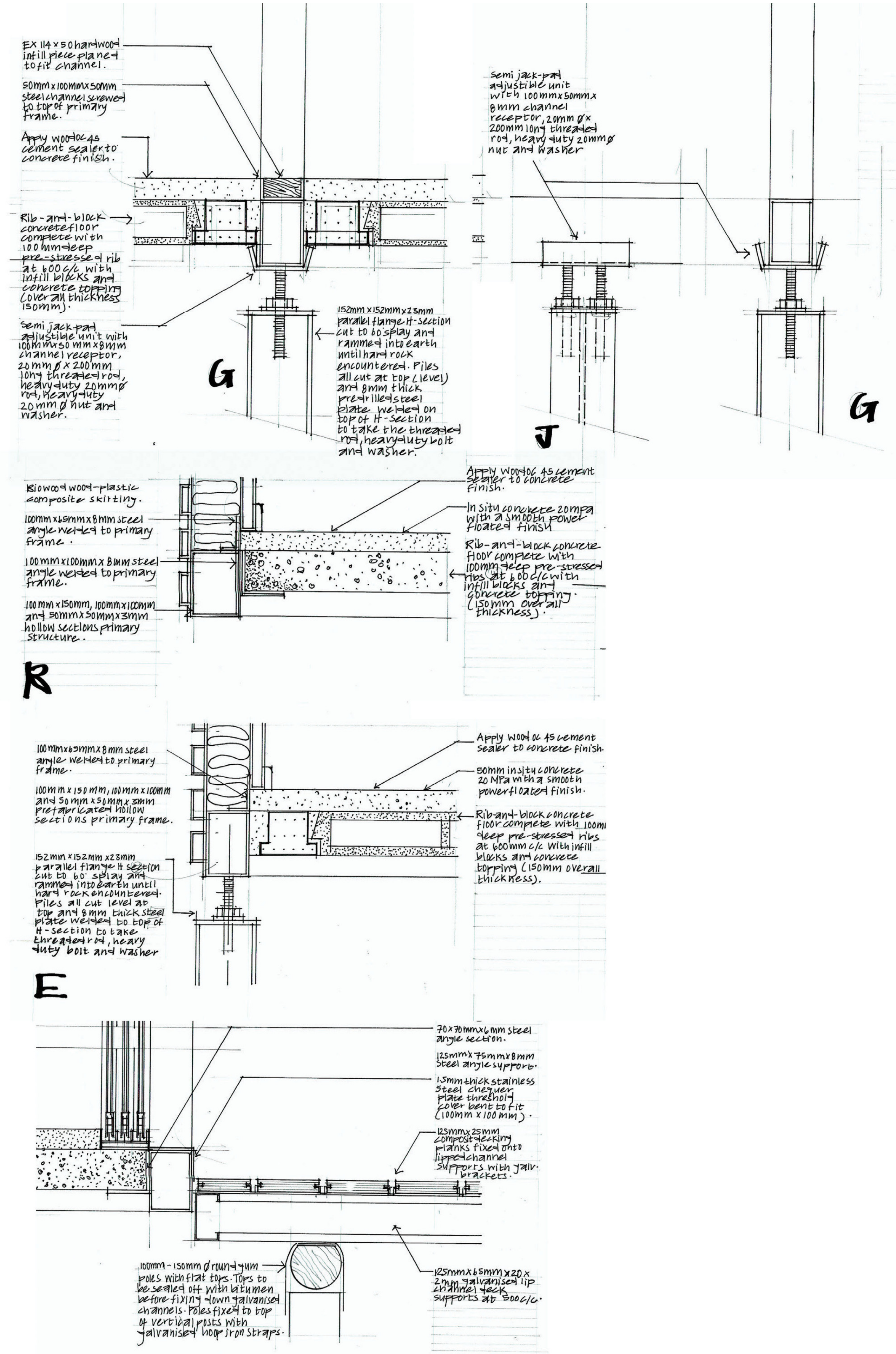
8.3 - Iteration 2, prefabricated system (Author, 2016).



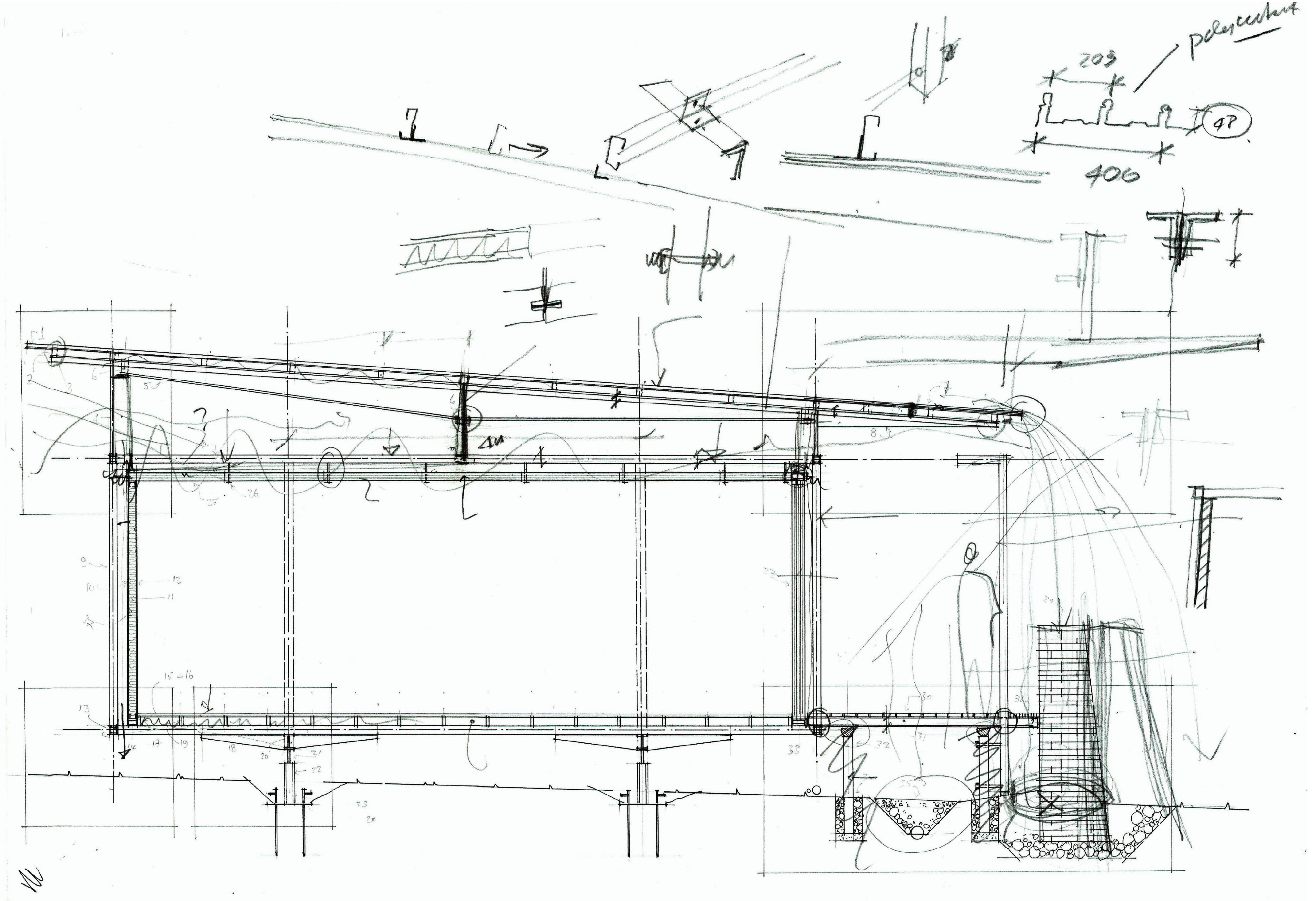
8.4 - Iteration 3, kit assembly system (Author, 2016).



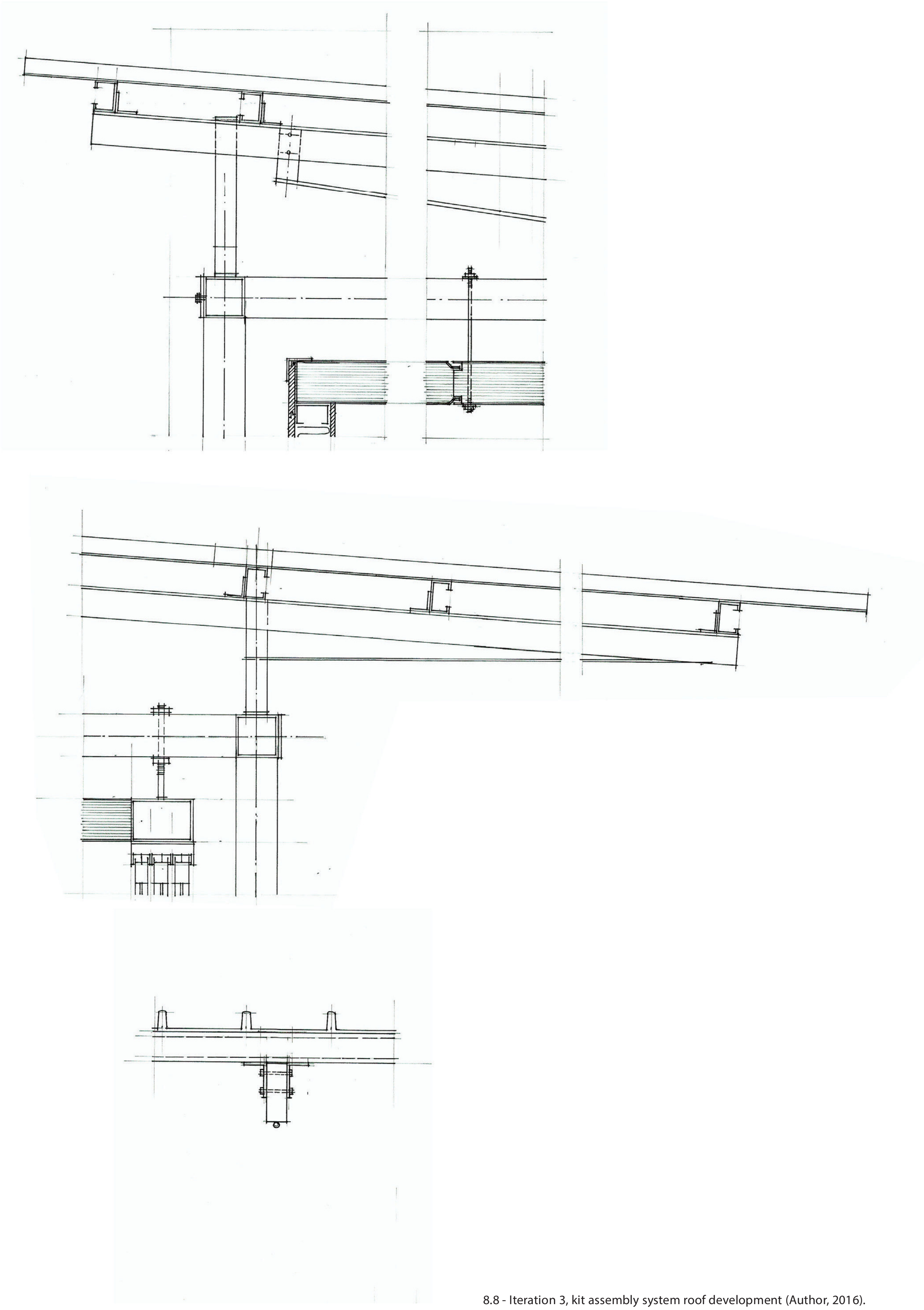
8.5 - Iteration 3, kit assembly system roof details (Author, 2016).



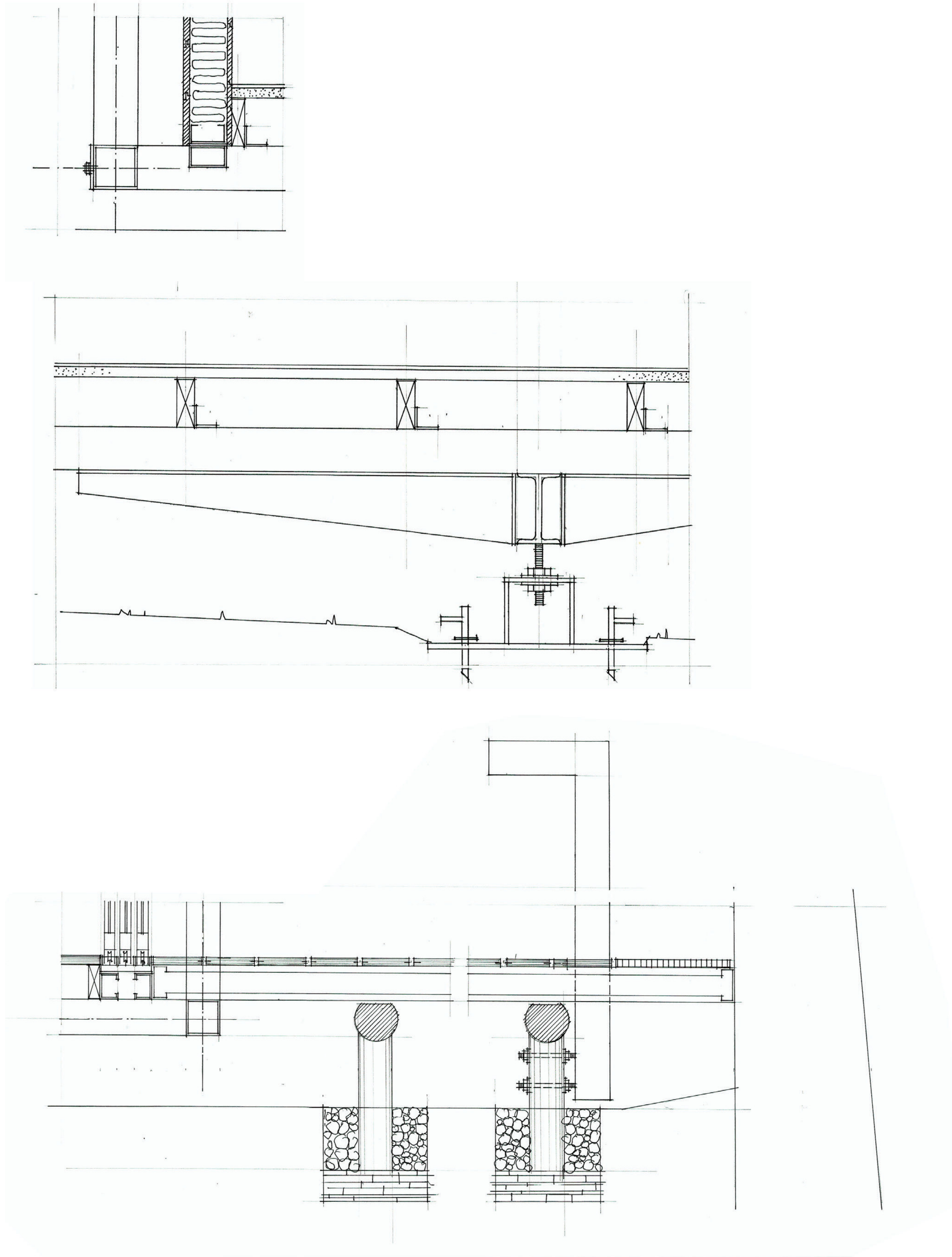
8.6 - Iteration 3, kit assembly system floor details (Author, 2016).



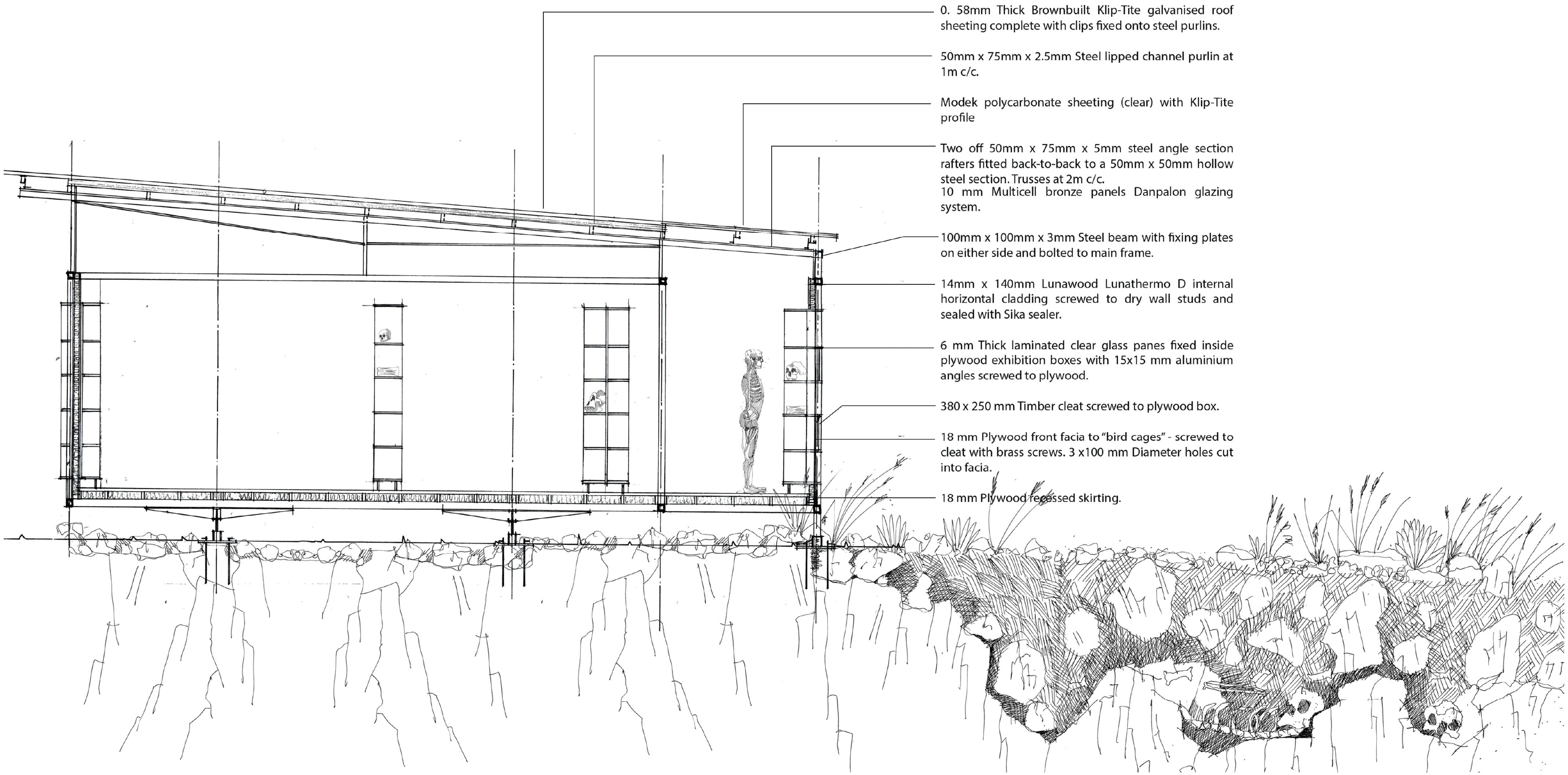
8.7 - Iteration 3, kit assembly system development (Author, 2016).



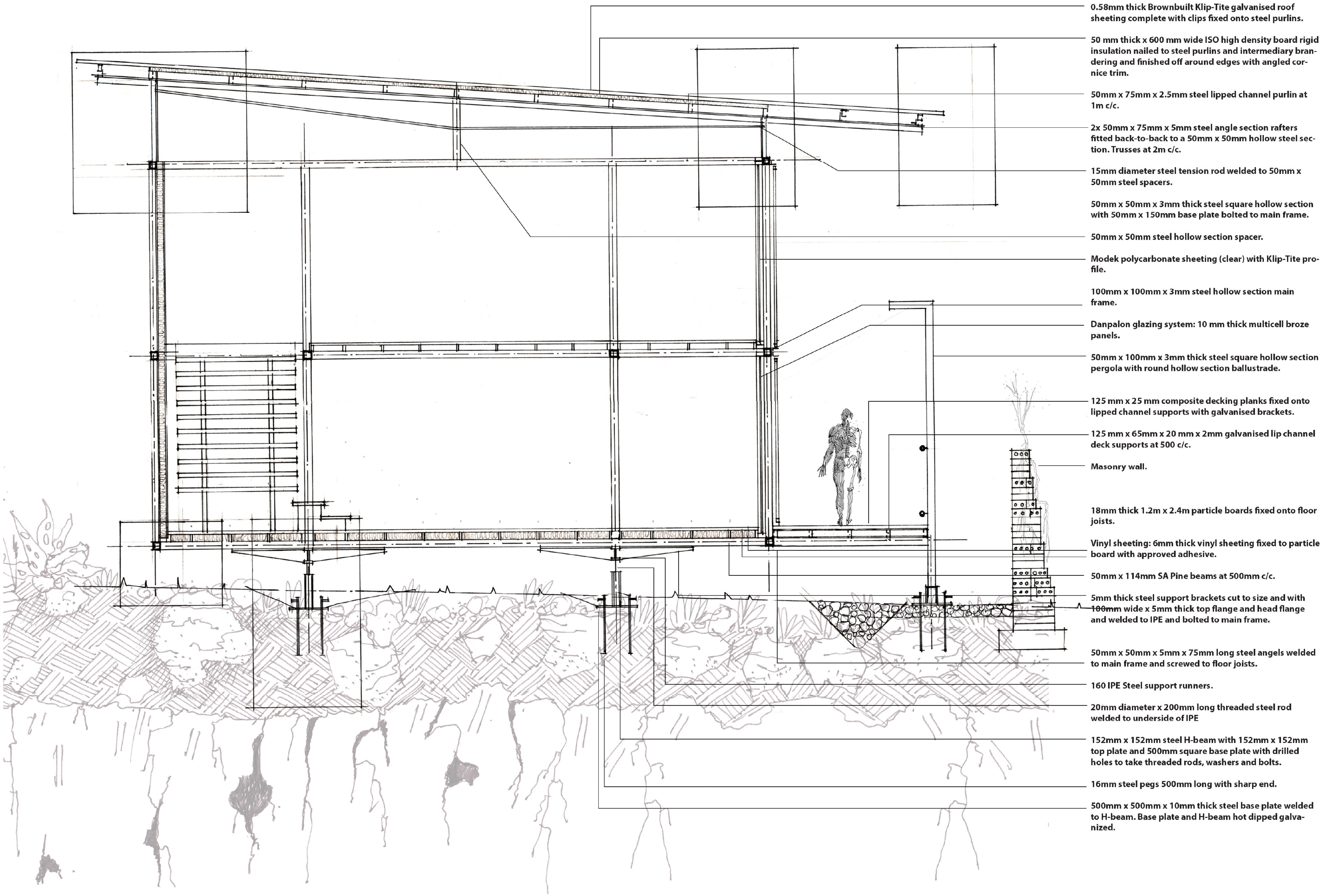
8.8 - Iteration 3, kit assembly system roof development (Author, 2016).



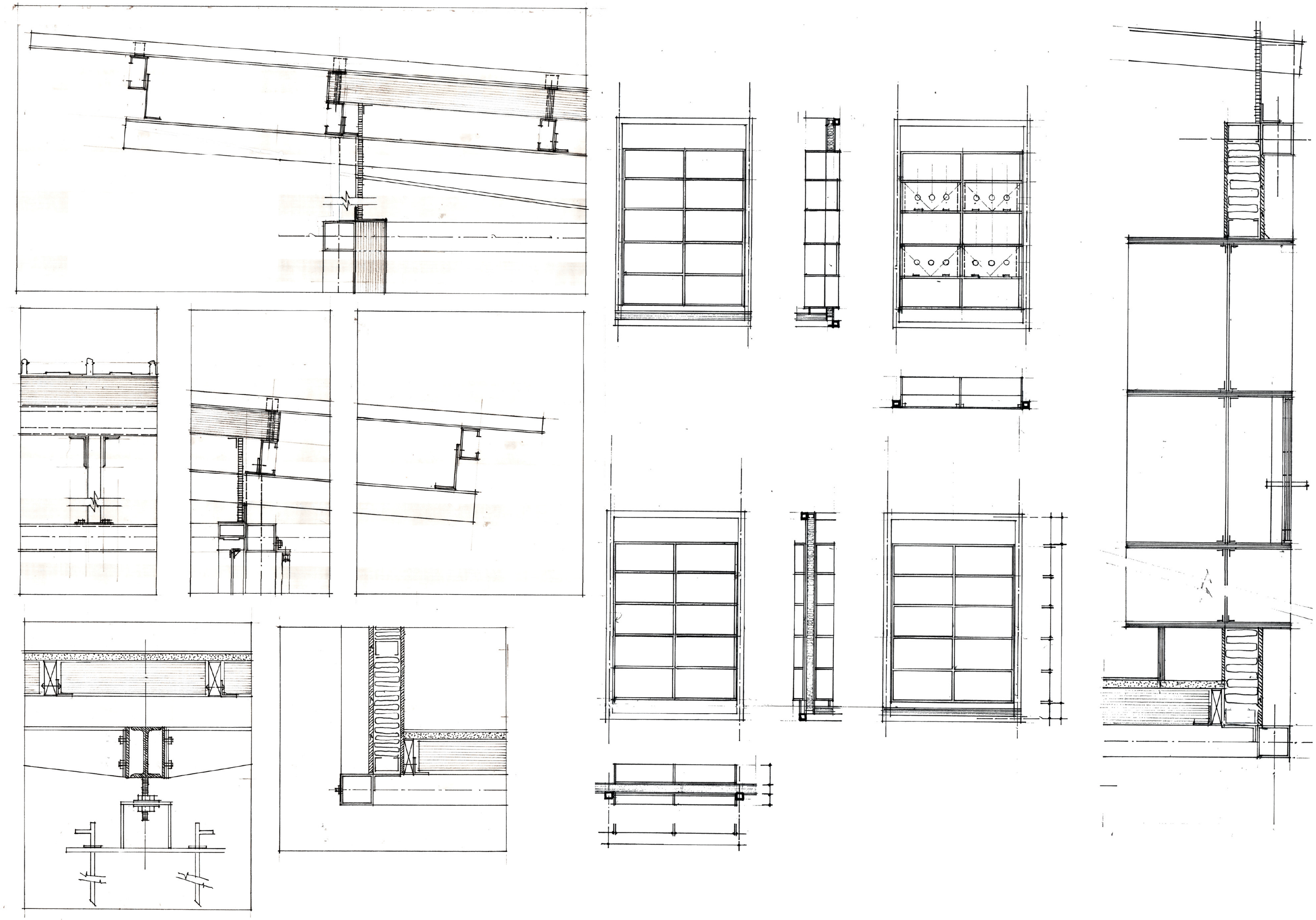
8.9 - Iteration 3, kit assembly system floor development (Author, 2016).



8.10 - Iteration 3, kit assembly system finalised section through library (Author, 2016).



8.11 - Iteration 3, kit assembly system finalised section through reception (Author, 2016).



8.12 - Iteration 3, kit assembly system finalised details (Author, 2016).

8.4 Technical precedent study

"The love of the site environment will prohibit one from leaving the building as a mark." – Krynauw Nel

Malapa refers to a fossil hominid site in the Cradle of Humankind. The site became known for the discovery in 2010 of a new species of hominid, the two-million-year-old Australopithecus sediba (Vuso, 2014). Krynauw Nel Architects and engineer Peter Fellows were commissioned to design a structure for this site, with the brief requiring a structure which would protect the fossil site from the elements – specifically violent rainstorms, acid rain and falling debris.

The structure won the 2014 Steel Awards, with the Southern African Institute of Steel Construction's Spencer Erling stating that: "The judges noted that the determination of the construction team, the quality of its work and the fact that it left the site almost as it found it, were among the factors that made it obvious that this project represents excellence in the use of steel for every possible reason" (van Wyngaardt, 2014).

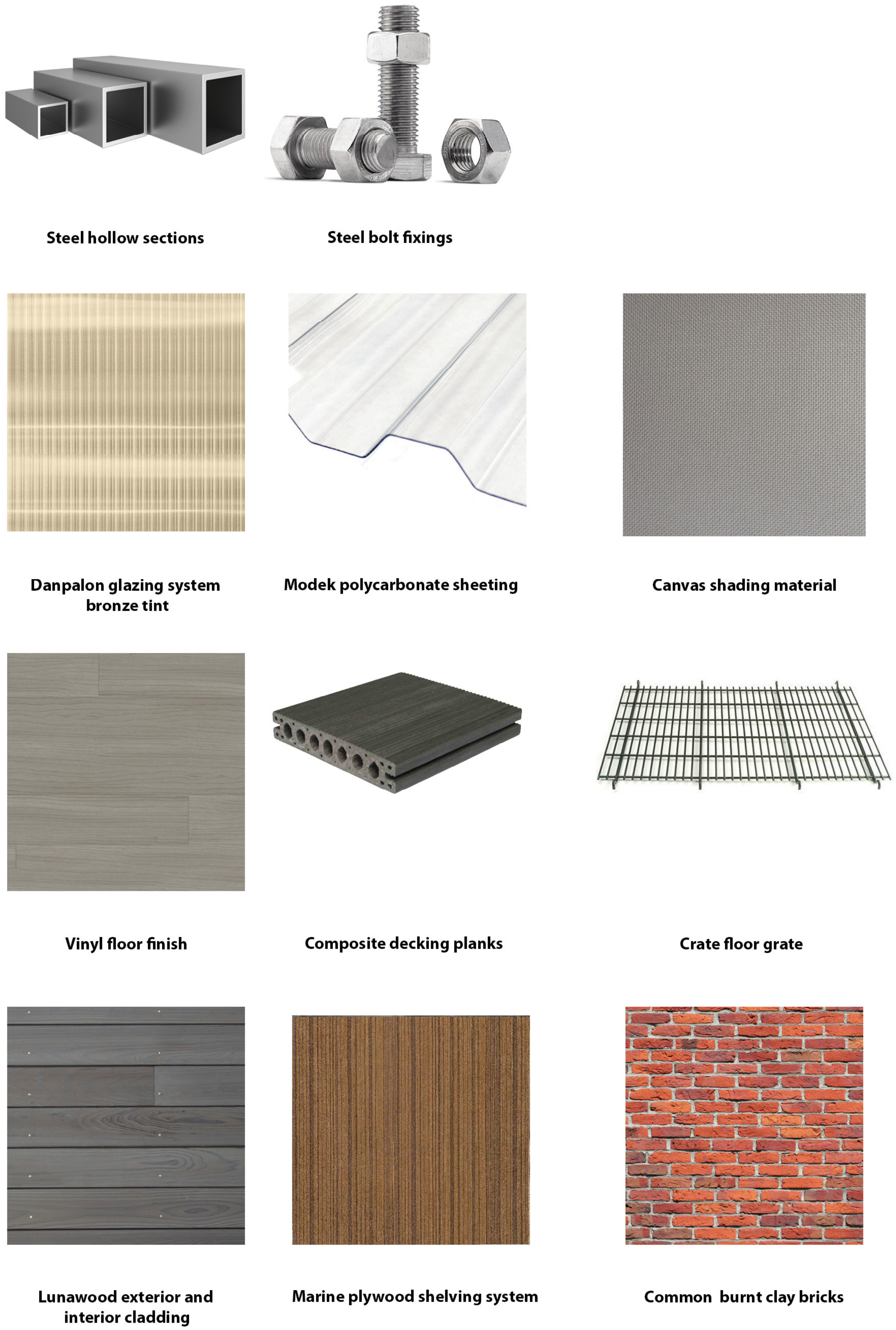
The structure facilitates research as well as small groups of tourists separated from the research activities. Rocks can be lifted from the site by the structure to a vehicle point from where they can be transported for further analysis. The structure had to be low maintenance, and due to the possibility of veld fires had to be fire resistant for 20 minutes. Water was to be harvested and held by the structure. Although the brief required materials to be manufactured in South Africa, the need for environmentally-friendly materials eventually outweighed this prerequisite. Finishes include a white stinkwood ceiling, sheltered by an aluminium and wood-fibre cement roof. A hoist is able to carry weights of one ton and deposit them on a truck (Blaine, 2014).

The foundation is not significant, allowing the structure to be relatively free-standing, and the structure itself does not make contact with the ground earmarked for future excavation. Instead, the eight spindly steel "legs" of the structure are bolted into rock, so its largest impact on the site is the size of a piece of A5 paper. In addition, the structure was designed to be largely assembled off-site and craned in for final assembly. The architects wanted minimal damage by contractors to the area (Blaine, 2014).

Due to the nature of the environment the construction is temporary, resulting in it being bolted together, but also permanent as it will be used for an extended period, thus necessitating durable materials. Each leg is fairly easily moved so that if the excavations move in a different direction, this can be accommodated. As a collarbone was the first fossil found here, the structure's "legs" are clavicle-shaped at the top — and then split on the downward swing to disappear into the trees. These legs were inspired by nature, as insects such as mosquitoes use their many legs to distribute their weight. The inspiration also included the oval formation of the surrounding trees, the slope of the surrounding hills, the concept of an anatomy theatre-in-the-round, and poetry such as making the visitor crouch to enter the structure – mimicking entering a cave and being relieved on emerging.

The architects designed the structure to be higher than the thick clump of trees in order to allow tourists to view what is going on without disrupting the work of the scientists. The elevated structure contains a free-floating walkway, constructed of recycled plastic, which allows wildlife such as snakes to move under it, and leopard and buck to not be disturbed (Blaine, 2014).

8.13 - Malapa (GIfA Awards 2015, www.youtube.com).



8.14 - Material palette (Author, 2016).

8.5 Materials

8.4.1 Demountable structural materials

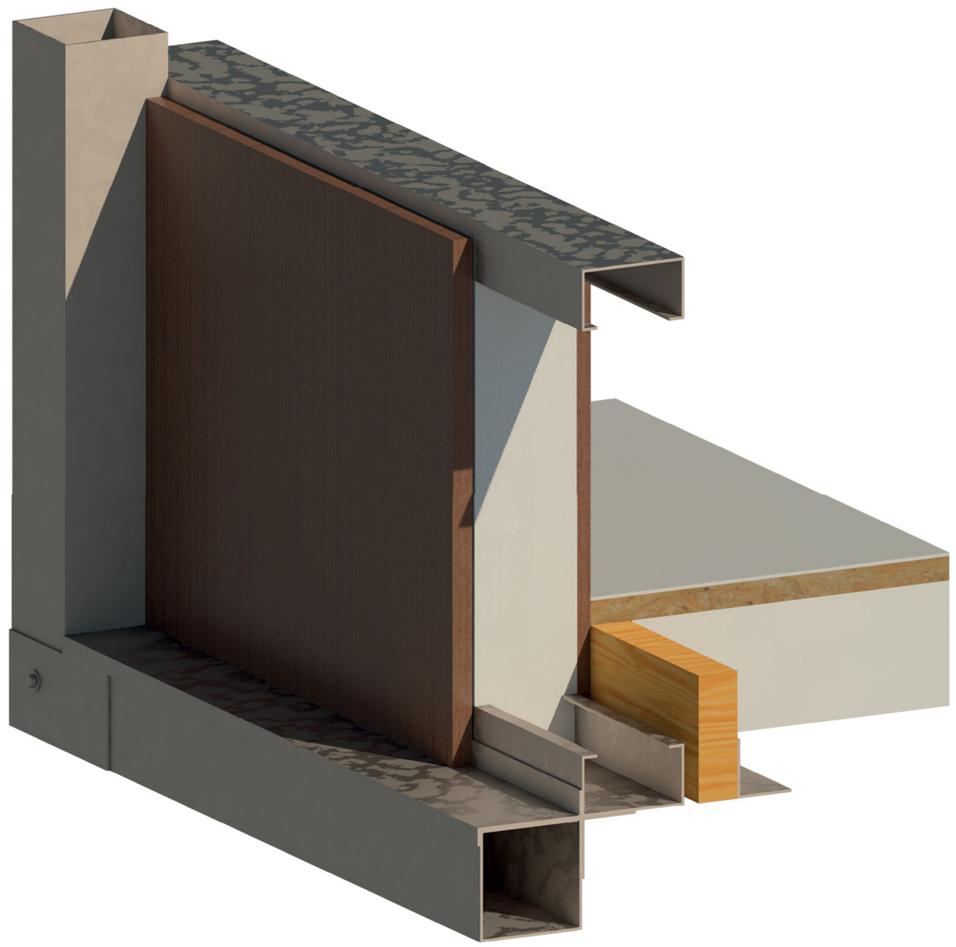
Steel was chosen for the primary structure, as the use of metal refers to the archaeological grid (consisting of steel cables) and allows for the structure to contrast with and emphasise the natural landscape. No wet construction is required and the material is easily sourced from close by.

8.4.2 Demountable infill materials

The choice of infill materials was primarily based on the weight and functioning of the material within the landscape. Although the design does not aim towards mimicking the landscape but rather to contrast with it, it remained important to recognise the qualities of the landscape which draw people out of the city towards it.

IInitially Biowood wood-and-plastic composite interior and exterior wall panelling was explored in order to clad dry wall partitioning, as the material is light, waterproof and fire resistant, and incorporates a tongue and groove connection system. But it was found to be less suitable for the environment than Luna wood. The tongue and grove exterior cladding is screwed to the structure and sealed with Sika-flex glue.

The elevated walkways consist of composite decking planks supported by the primary structure. Loose-packed bricks and cobblestones address any topographical edges and allow for vegetative growth.

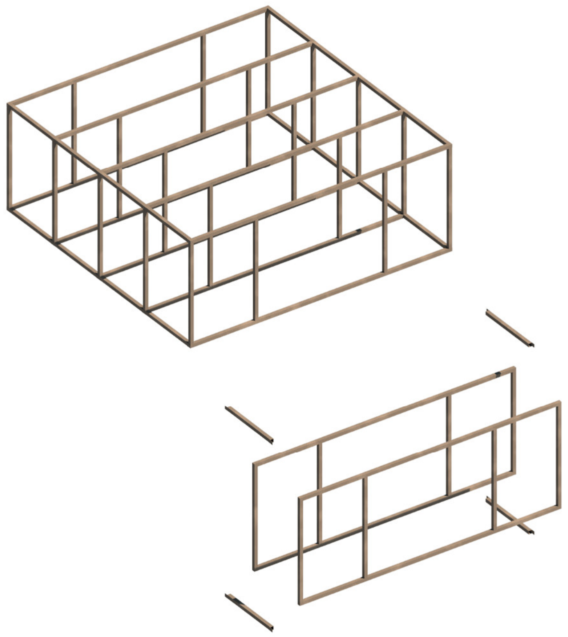


8.15 - Detail section perspective of infill materials (Author, 2016).

8.6 The structure

8.6.1 Demountable primary structure

The primary structure consists of 100mm x 100mm square hollow sections, welded together under factory conditions to form a rectangular 3m x 8m panel. Additional structural supports are welded to the panels 2m from either side. The panels are placed vertically on site and then connected horizontally by 100mm x 100mm square hollow sections with connector plates on either side and bolted to the main panels.



8.16 - Detail perspective of primary structure and exploded view (Author, 2016).

8.6.2 Demountable foundations

The dolomitic nature of the site requires the structure to respond to geological movement. Because of the sensitivity of the site, and the solution is dictated by the concept of demountability. Pile foundations and permanent concrete solutions are to be avoided. The Jacpad foundation system was considered. Jackpad foundations can reach a maximum height of 450mm. The system will therefore not work where the slope of the site calls for a higher solution. In order to address this, as well as actually fixing the structure to the site as required in certain instances it was initially decided to replacing the support block and incremental packers with a 152mm x 152mm x 30mm H-section which is rammed into the earth and cut to be level. This solution was found to be insensitive to the landscape and consisting of too many supports (for each 2m x 3m unit). The system was iterated by the addition of a load bearing I beam running horizontally underneath the structure, with would reduce the need for support to 4m x 4m. The system now consists of three components:

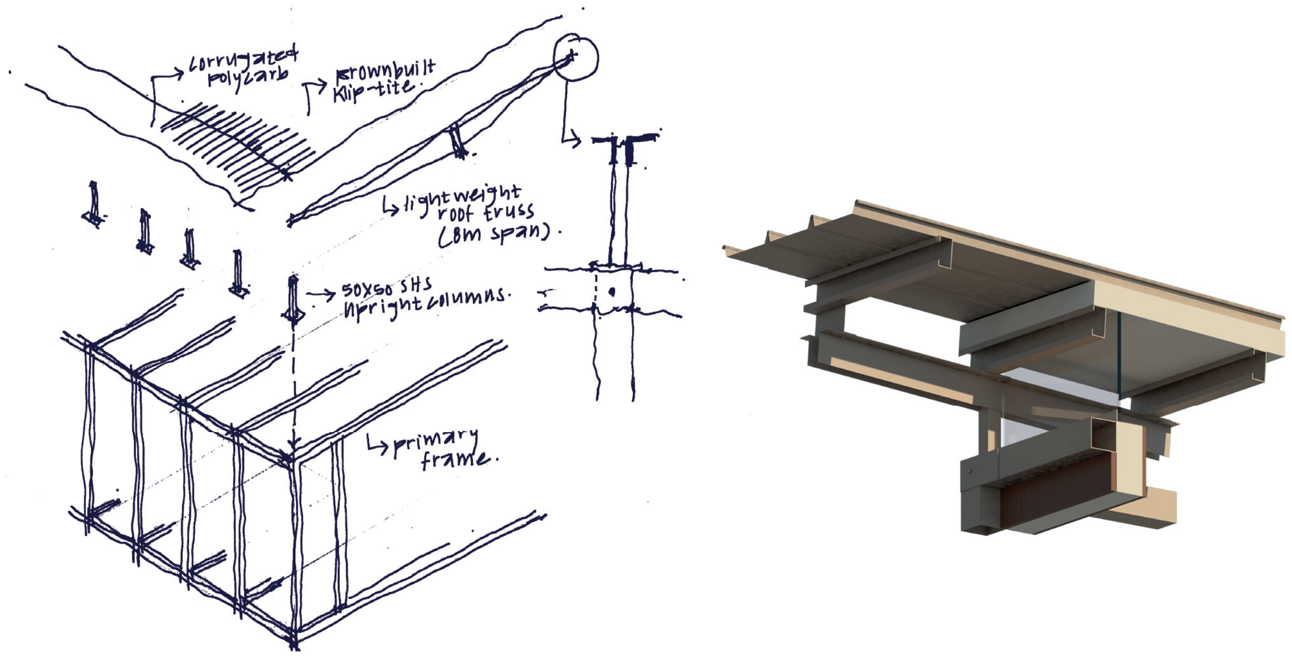
- Double threaded rods welded to the bottom of the 160 IPE.
- The rods are bolted to the head of a 152mm x 152mm H-section mounted vertically with a double system of nuts and washers
- The H-section is supported from a 500mm x 500mm x 10mm steel base plate which is placed level on a compacted section of earth. Four 16mm pegs rammed through holes in the base plate into the earth secure the bases in the landscape.

The advantages of the system are that it is small, relatively light and portable, the height can be adjusted to support the structure in the case of moving dolomite and the installation is quick with little ground or remedial works necessary.

8.17 - Detail section perspective of demountable foundations (Author, 2016).

8.6.3 Demountable roof

In order to unify the primary frame, as well as reduce joints and complicated connections, light weight roof trusses at 2m centres span separately over the primary frames. The roof consist of 0.58mm thick Brownbuilt Klip-Tite galvanised roof sheeting fixed onto 50mm x 75mm light steel lipped channel purlins that are supported on two back-to-back 50mm x 75mm steel angles separated by and supported on 50mm x 50mm upright columns. These columns are in turn bolted to the primary frame structure. The two steel angle rafters are strengthened by a 12mm tensile rod. The roof acts as the proverbial broad rim hat and overhang the primary structure on all sides.



8.18 - Detail section perspective of demountable roof (Author, 2016).

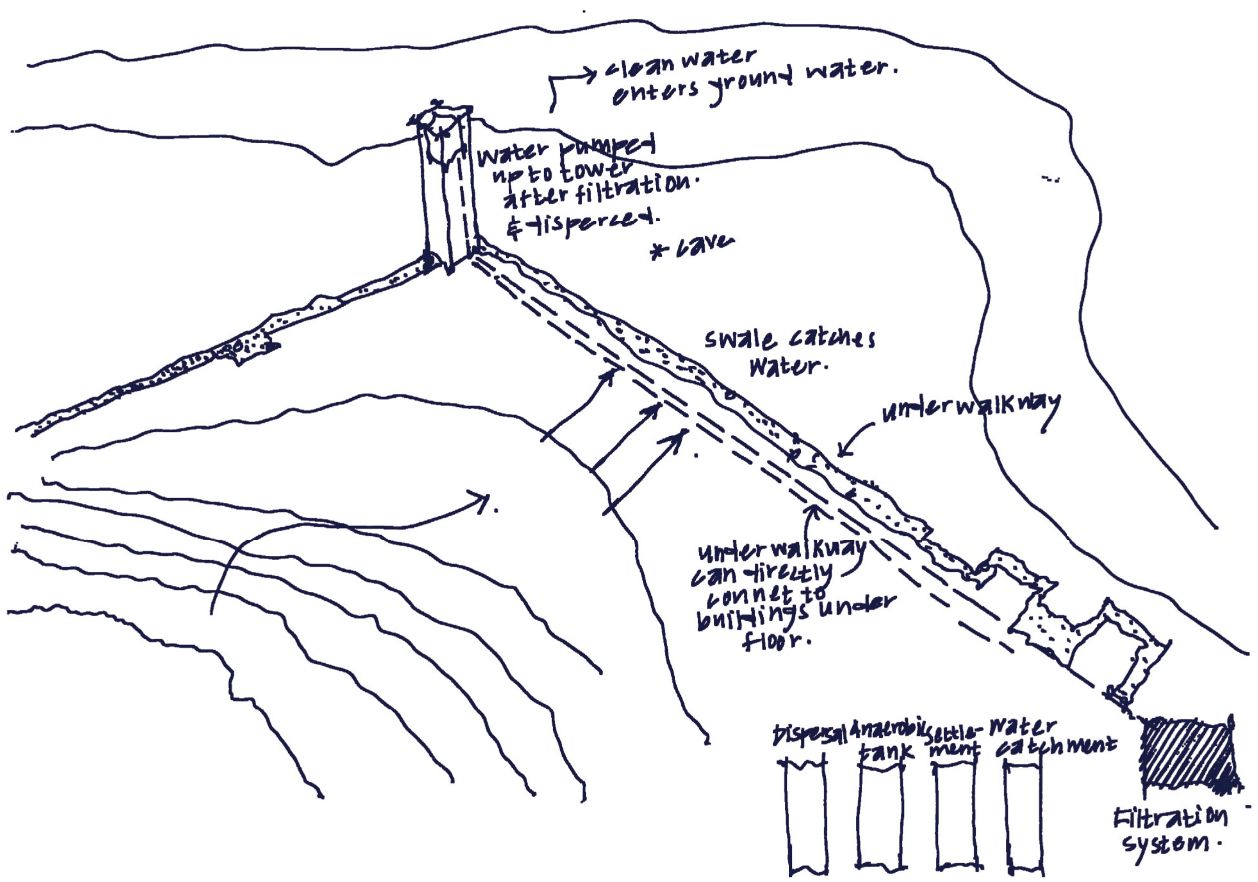
8.7 Demountable services

8.7.1 Demountable water supply

The limited availability of water at the Cradle of Humankind is not only the result of environmental and climatic factors, but is owed to historic and current mining activities. The Cradle of Humankind forms part of the Malmani Subgroup, which houses within the dolomitic geology an extensive karstic aquifer. This aquifer supplies most of the groundwater in the area while overlying the gold-bearing quartzite rocks of the Witwatersrand Supergroup. Although groundwater is abundant in the area, the dolomitic rocks along the southern part of Gauteng and the North West Province were dewatered for deep mining. This dewatering dislocated the usual recharge and discharge rates for the groundwater and interfered with the natural flow of the ground- and surface water in these areas. In addition to the disrupted discharge and recharge rates of the groundwater, the water system is threatened by mining pollution in the form of acid mine drainage (Durand, Meeuvis & Fourie, 2010:74&79); therefore, although groundwater is present in the area, it cannot be used.

In order to maintain the lowest possible impact to the landscape and geology, as well as keep to the concept of demountability, water harvesting is implemented. Through calculations it became evident that not enough water could be harvested from roofs, so swales which follow the natural topographical flow of the site were implemented to harvest water from a greater area. The swale runs underneath the proposed walkway where water from the landscape and roof can be harvested. The water is then filtered and processed, after which it is pumped to a water tower located on the archaeological datum point of the site. The pipes of this system are not buried in the ground, but lie underneath the elevated walkway provided adjacent to the buildings. Water then runs below the elevated structures to where it is needed.
Greywater, such as water from dishwashing, is filtered through an immediate grease trap before connecting to the water harvesting system. Brown water is addressed through the implementation of self-contained toilets.

The water system filters all water to be potable, which then allows for clean water to infiltrate the groundwater if there is spillage during processes such as wet sieving in the course of excavation. The water source can be extended to serve the informal farming community, adding additional value to the intervention.



8.19 - Demountable water supply (Author, 2016).

8.7.2 Demountable energy supply

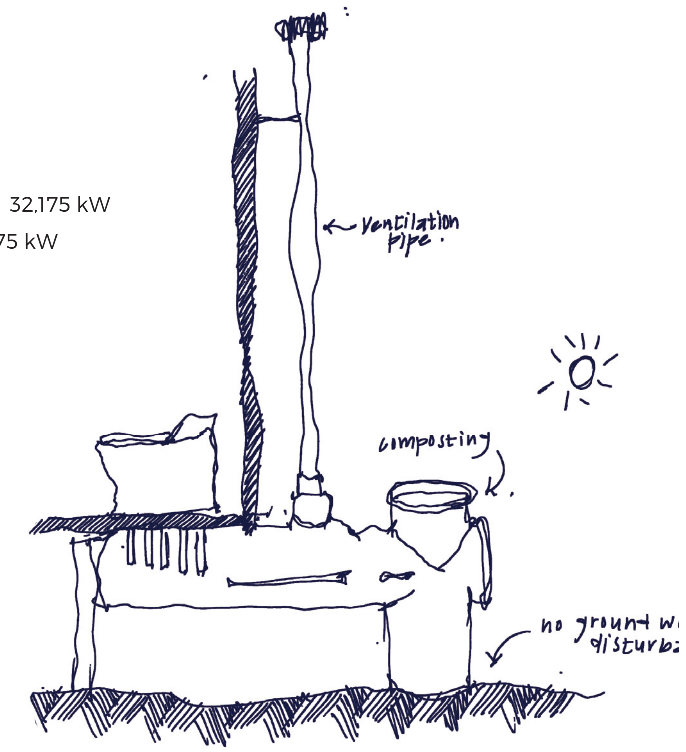
Solar energy is harvested from solar panels on the roofs. Calculations suggest the amount of energy generated in this way is insufficient to satisfy demand. Gas will augment the supply. Each building block is equipped with a distribution board with circuits connecting power to each unit. When a unit is removed, the circuit is disconnected. In so doing, power to other units is not interrupted.

Solar panel calculations:

Restaurant and administration: 224 m2/1.9m2 = 117 panels = 32,175 kW
Workshop and laboratories: 155 m2/1.9m2 = 81 panels = 22,275 kW
Archives and library: 244 m2/1.9m2 = 128 panels = 35,2 kW

8.7.3 Demountable ablutions

Self-contained composting toilets and urinals are implemented on site in order to reduce water consumption and site works. The toilets stand above ground, with the composting facility underneath the structure. The placement of the toilets allows for sunlight to reach the composting facility . Each composting toilet facilitates 3 to 4 people and is cleaned every nine months. For this reason, the toilets have been located and the vehicular access determined by the need for easy access. The dominant wind direction is NNW which means that odours will be blown away from the buildings.



8.20 - Demountable ablutions (Author, 2016).

8.8 Systems and climatic strategies

8.8.1 Introduction to the climate

The climate of the Cradle of Humankind corresponds to that of the typical Highveld climate and falls within the Cold interior climatic zone. The Cradle is a summer rainfall zone with temperate summers and moderately cold winters (Eloff, 2010:25-26). Eloff (2010:25-28) shows rainfall to be 781.7mm on average, with the highest amounts of rain falling in late February and early March. The highest levels of humidity are experienced in the month of February at 80.06%, with the lowest occurring in September and reaching 46.77% (Eloff, 2010:29). The highest wind speeds are reached in the month of August, mostly found to be northerly, and with north-easterly winds also prominent. Wind is the most dynamic variable influencing fire behaviour (Eloff, 2010:30-32). Wind conditions have an ecological function, as they have a particular impact on the fire system, pollination and seed dispersal in the area.

8.8.2 Passive strategies

The following passive strategies, suggested by Peter Muller (2013:105), are implemented in the design:

- Insulation is provided in the form of Neopor GPS, which achieves the same quality of insulation as polystyrene but with 30% less material usage. During the iteration process it was found that additional insulation was required in the roof.
- North- and south-facing walls are maximised.
- Northern and southern glazing is dominant.
- Cross ventilation and night-time cooling is implemented,.

8.8.3 Active strategies

The implementation of underfloor water heating was investigated but deemed unnecessary. Mechanical ventilation is required in the laboratory facility which is powered solar power.

SANS 204 FENESTRATION

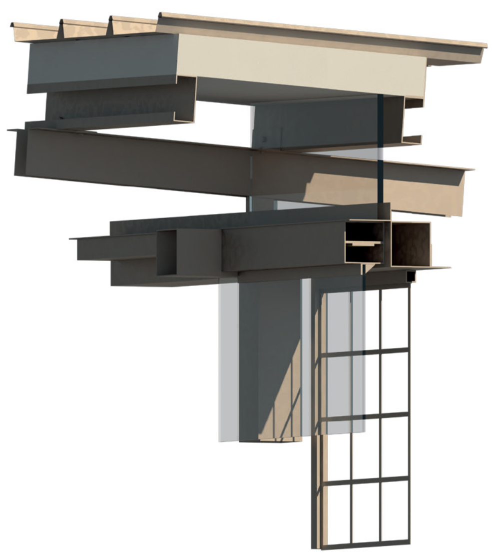
	ORIENTATION	PROJECTION		HEIGHT	P/H	E	SHGC	AREA
Window N	n	2	3	0.67	0.33	0.37	2.28	0.278
Window S	s	0.5	0.1	5	0.16	0.81	4.56	0.59
Window E	e	0	0	0	1.19	0.37	2.655	1.17
Window W	w	0	0	0	1.3	0.37	2.655	1.28
							3.318	

Danpalon 10 mm Bronze SHGC 0.37
U- value 2.11
R- Value 0.4739
SHGC Constant = 0.15 for Climate zone 1 x 46.61 = 6.99

U constant = 1.2 x 46.61 = 55.93

Conductance

	AREA	U VALUE	Total	
N	2.28	Danpalon	2.11	4.88
S	4.56	Clear single	7.9	36.02
E	2.655	Danpalon	2.11	5.6
W	2.655	Danpalon	2.11	5.6
			52.1 = smaller than 55.93	



8.21 - Detail section perspective through fenestration (Author, 2016).

8.9 Landscape interventions

8.9.1 Access

The site is currently fenced off with wire mesh and gum poles to prevent public access and cattle theft. The researchers access the site through an overgrown farm gate from Sterkfontein Road, while three other points of illegal entry have been identified. After entering the site, the researchers travel up an eroded gravel road using off-road vehicles.

A new access road from Sterkfontein Road is proposed, connecting to the group framework tourism corridor, which would allow research staff as well as a tourist shuttles to enter the site. The road moves past the informal farming community, connecting the cave site and the community as well as the proposed researcher accommodation located within the area. The route follows a slope no greater than 1:10 to reduce the risk of erosion.

8.9.2 Parking

Currently erosion on site is most evident at the access road to the fossil site. Where the new access road is proposed, care is taken to not create any hard surfaces that could become eroded and would lead to an increase in runoff. An EnviroGrid Geocell system is implemented, which consists of a three-dimensional cellular confinement system made from plastic with individual cells resembling a honeycomb. The grid is filled with rocks or soil and can be vegetated, allowing for deep root growth. The system slows the flow of water down the slope, thereby reducing erosion. The intervention is extensive, yet will have a positive long-term impact on the landscape.

8.9.3 Storm water

Rain occurs mainly during the summer at the Cradle, often in the form of thunderstorms. Averaging between 650 and 750mm per year, it recharges the natural groundwater through sinkholes (Maropeng, 2016). As karst areas often lack well-defined natural surface drainage systems, surface water dissipates through infiltration or by dropping into sinkholes. Sinkholes are typical formations of karst terrains and are in essence surface expressions of the internal drainage and erosion process. Acting as funnels, rapid surface storm water runoff is directed from the ground surface into karst aquifers. Additionally, storm water runoff can modify local groundwater conditions, increasing the possibility of sinkhole collapse.

Kromdraai Cave lies on a topographically high position in the Cradle. Management measures are implemented in order to address the accumulation of storm water at the northern edge of the site, which is contaminated by cattle farming activities and road water before meeting the Blaauwbankspruit. These management measures consist of vegetative controls and wetlands.

Vegetated surfaces can decrease runoff velocity, filter solids, enhance sedimentation, and increase infiltration (Zhou & Beck, 2008). Pollution removal is therefore assisted naturally while soil erosion is decreased. Near the ditch of the Sterkfontein Road, runoff accumulates and continuously filtrates into the underlying karstic aquifer. A swale on either side of the road is proposed to aid soil filtration, maximising contact with the soil and reducing the threat of sinkhole collapse due to ponding surfaces. Moving further down the slope, a wetland area is proposed adjacent to the Blaauwbankspruit, where the water table is near the ground surface and the land is swamped by relatively shallow water. The wetland treatment system, a variation on detention pond methodology, removes runoff pollutants primarily through sediment retention and vegetative uptake. The wetland provides highly effective highway runoff management, because it absorbs large quantities of suspended and dissolved materials (Zhou & Beck, 2008).

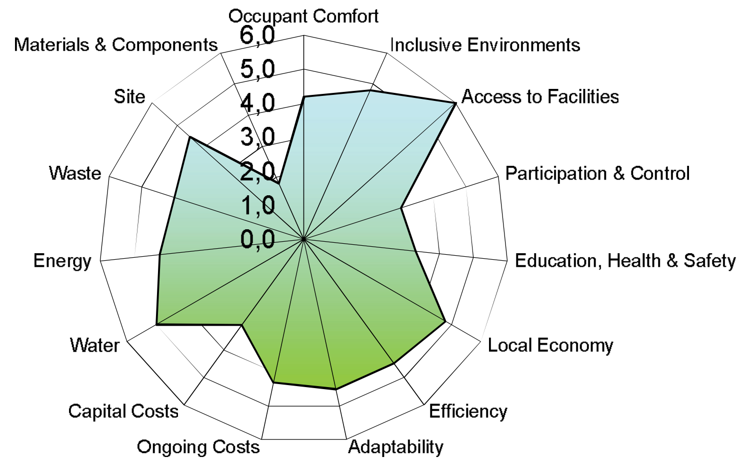
8.9.4 Fire

Wild and uncontrolled fires are a general problem within the Cradle of Humankind, and currently no guidelines exist to deal with the issue. Many families reside nearby and fire is a constant safety threat in dry seasons. Fire-prone structures are at risk and the site is ultimately vulnerable. The owner of the site uses controlled fires to aid the growth of vegetation and as a means of controlling invasive species.
Firebreaks on the boundaries of the farm are implemented as a means of preventing wildfires from spreading across to neighbouring farms. In the case of controlled fires, structures should not be impacted as the process is managed to not reach the areas around the proposed intervention. Nonetheless, the following measures are additionally implemented to increase the safety of the structure (Michler, 2013):

- Eaves and vent openings are secured to prevent embers from starting a fire in the interior.
- The roof is protected by choosing an appropriate material such as steel.
- Window openings are kept small as smaller sizes are more stable than larger windows.
- Complex shapes and protuberances are avoided to reduce the threat of embers lodging in the structure. A standing water source is available for firefighters, fire hose reels are provided at strategic points and each space is provided with fire extinguishers.

SUSTAINABLE BUILDING ASSESSMENT TOOL (SBAT- P) V1

PROJECT
Project title: The Scientist, the collector and the treasurehunter
Location: Kromdraai cave
Building type (specify): Commercial
Internal area (m2): 600
Number of users: 100
Building life cycle stage (specify): Design



8.22 - Sustainable building assessment (Author, 2016).

8.9.5 Red data species, rare plants and wildlife

Although it is known that species on the Red List of South African Plants as well as other important plants occur at Kromdraai, no known records or botanical and faunal lists exist. The lack of information makes the protection and proper management of these species impossible. The programme of the research facility allows for an archive to be established of not only the fossil finds, but for the documentation of the landscape surrounding the fossil finds. The intervention limits access to the site during night-time, aiming to not disturb wildlife such as owls and bats.

Aloe greatheadii var. davyana, commonly known as the spotted aloe or Transvaalaalwyn, is proposed as a means of rehabilitating the excavated site. The plant is indigenous to the Cradle of Humankind, with a specimen already located on the site. The plant has been used as a soil binder in disturbed areas such as mine dumps and is pollinated by birds, bees and butterflies (Hardy & Hardy, 2007). The Aloe greatheadii is the most important indigenous South African bee plant(Human, 2006:13). The plant furthermore possesses medicinal properties and can be used commercially. Because of the succulent nature of the plant, very little water is needed.