

Fig 8.1 Technical development section. [Author, 2016]

“And I dream that these garden-closes
With their shade and their sun-flecked sod
And their lilies and bowers of roses,
Were laid by the hand of God.”

Dorothy Frances Gurney
(Willis, 2006: 11)

8.1 Introduction

The making of the building has become an extension of the dissertation intentions, the conceptual approach and design resolutions. This chapter will expand on these informants by discussing the technical concept, material palette, primary and secondary structure, and how the learning gardens come together in the aesthetics of joining focusing primarily on the home-base classrooms. Also discussed here are the solar stack and water system, together with how the building's interior climate is passively controlled.

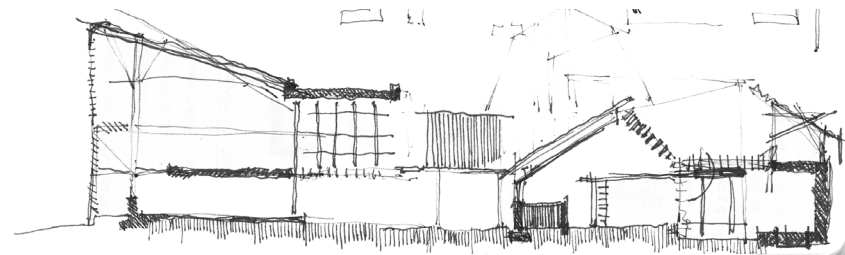


Fig 8.2 Diagram of tectonic resolution of classroom (Author, September 2016)

8.2 Tectonic Concept

The tectonic concept is a refinement of the design concept as an attempt to bring the conceptual intentions to a technical resolution. The stereotomic, the ground and the services (passive climate control and storage facilities), and the tectonic, the columns and vegetation was explored further in plan and section (fig 8.3 and 8.5), and an architectural language was developed that can be applied to every condition in the building. In detailing the section, it becomes important to express the definition of stereotomic and tectonic and qualities dependent on each other and this most apparent where the two meet. The focus, lies in the relationship between the characteristics of the existing garden and the tectonics of the architecture and how this relationship can facilitate learning. The primary tectonic concept is based on the biomimicry of the vertical and horizontal axis of the tree:

Horizontal Axis: The stereotomic, like the trunk of the tree, offers support as well as services to its branches. The plan is based on the relationship between learning spaces and service to learning showing the relationship between these. The placement of the serving and learning spaces are dependent on the nature of the garden. The services offered by these stereotomic trunk-like objects on plan relate to passive climate control and facilitation of storage space for the classroom's needs (Fig 8.3).

Vertical Axis: The vertical axis forms a primary structural system of stereotomic floors and trunks (service spaces); and branches (support columns) all supporting the roof canopies. The secondary structure is dependent on the nature of the garden and how and what type of learning takes place in each (Fig 8.3).

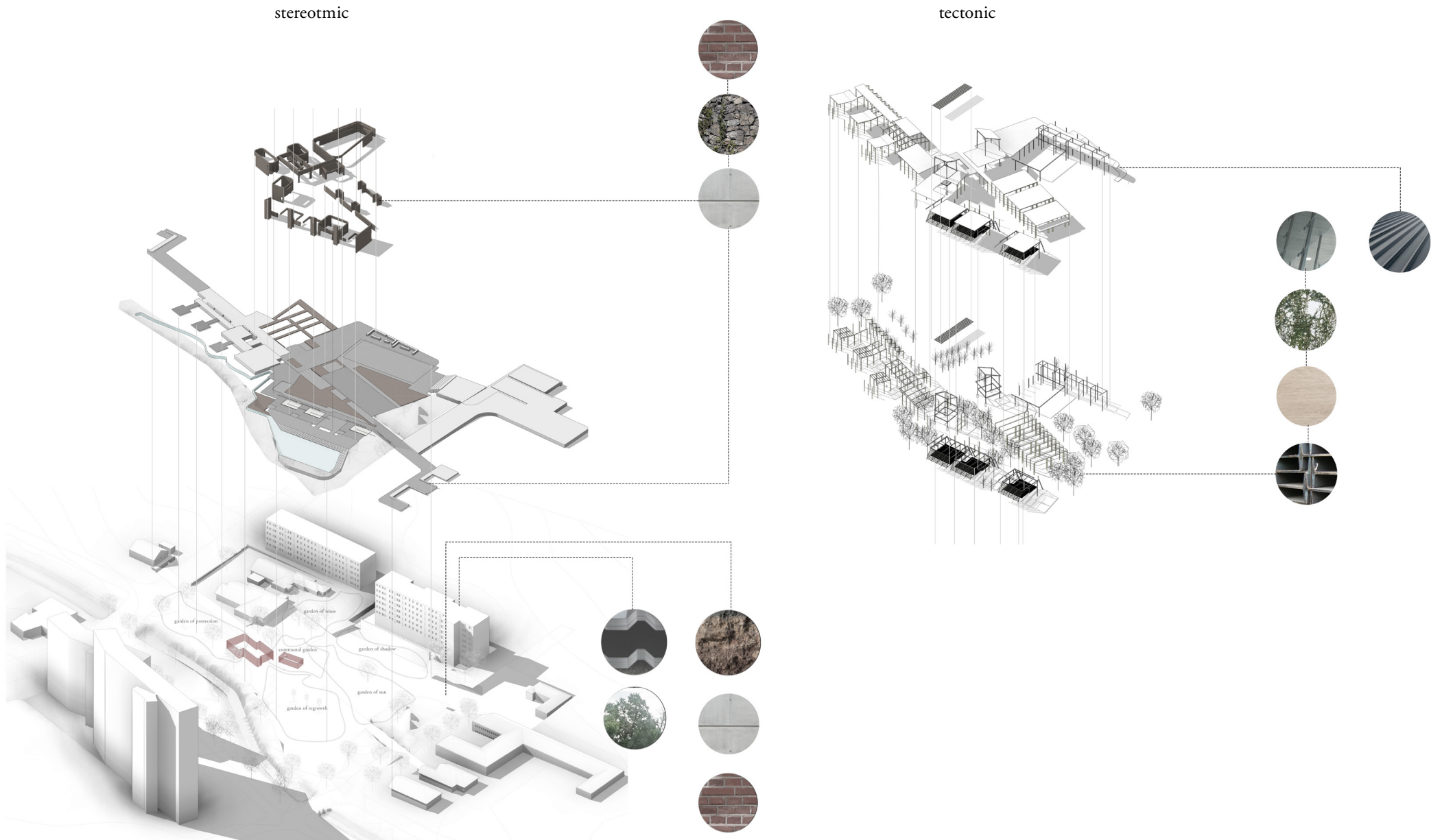


Fig 8.3 Diagrammatic representations of the stereotomic and tectonic concept (Author, November 2016)

8.3 The Material Palette

The definition of the material palette has been determined by the material qualities of the existing site, spatial requirements and conceptual intentions.

In the following pages, the material choices are explained in terms of what exists on site, the spatial requirements of the spaces and the conceptual intentions.

CONCRETE
 Most of the surrounding fabric is of concrete and brick infill



RED FACE BRICK
 Most of the façades of the surrounding flats consist of red face-brick, reflecting Pretoria's brick-making heritage



SOIL
 The soil on site is made up of shale rock closest to the river and avolon and hutton soils that are orange-brown in colour.



STEREOTOMIC QUALITIES ON SITE:

The predominant stereotomic material on site is the ground, which consists of mostly shale rock and avolon and hutton soils of a predominately orange brown colour. The site is relatively flat, however, and using a large amount of rammed earth would be ignoring the surrounding fabric. As mentioned in Chapter 3, the surrounding stereotomic fabric is made up of mostly red face-brick and concrete. Because the dissertation is adopting the principles of the Burra Charter, the design should blend in with its surroundings but also show that it is new in contrast to the existing. The stereotomic materials, as mentioned in 8.2 are related to spaces that become service cores, resembling “trunks” in their function as service cores in nature.



CONCRETE FLOOR SLABS

To create spaces with high thermal mass to prevent fluctuations in temperature throughout the year



RED FACE BRICKS

To blend with the surrounding fabric, red bricks will be used as facade infill in some areas as well where thermal massing in the façades are required



GABION WALLS

Where the earth is retained to create berms, gabion walls filled with rubble from site will be used. The cage will be made from 8x10 double twisted hexagonal woven galvanised steel wire mesh.

Fig 8.6 Material palette, stereotomic (Author, 2016)

STEREOTOMIC SPATIAL REQUIREMENTS

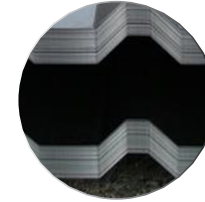
In the classrooms, a comfortable temperature needs to be maintained throughout the year to aid in the children's concentration. A double skin with an air-gap and a single skinned brick walls that provide a large amount of thermal mass will be used in the façades at some points to provide a cooling in the classrooms as well as concrete floor slabs with high thermal mass to provide cooling from the ground. In winter, the concrete floor will act like a thermal battery, building heat in the morning and gradually releasing it late afternoon. Qualitatively, the texture of brick and gabion walls relates to the earth and ground and creates a haptic awareness of the materials of nature. The gabion walls will be used where there are retaining walls as well as for security purposes along the river periphery of the site.

STEREOTOMIC: CONCEPTUAL INTENTIONS

Therefore, the predominant stereotomic material will be concrete, brick, and gabion walls as they relate to how the "tree" is deeply rooted within the ground and rises from it. The different stereotomic materials relate to the proximity of the tree to the ground, where the closest proximity to the ground is concrete and gabion walls (made up of brick and concrete rubble from the site and the demolished Grade R building, as well to support plant growth). The bricks are where the "tree" rises up from the ground and is becoming lighter, as it reaches to the sky.

IBR STEEL ROOFS

The surrounding learning institutions have IBR sheeting as roofing material



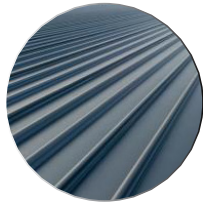
VEGETATION

A variety of tree species exist on site. The supports of trees are more durable where the canopies and leaves of trees change and grow over time.



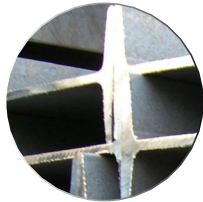
TECTONIC MATERIALS ON SITE

A range of different species of trees grow on site (refer to tree analysis in Chapter 3) but the majority of trees are Acacia and Canary Island Pine. The Pine trees are alien species and the well known Acacia tree is indigenous to South Africa and should be protected. Vegetation and tree canopies are light elements which change over time. Another tectonic aspect of the site is the steel IBR roof sheeting that covers most of the existing schools' roofs. Because of the trees on site, timber was seen as another appropriate tectonic material to be used as supports for outdoor pergola and shading systems.



TIMBER

Timber columns will be used as support systems in outdoor learning spaces as well as interior finishes to resemble the trees and vegetation on site.



KLIP-LOK

Klip-Lok 700 roof sheeting will be used to relate to the steel roof sheeting of the existing fabric but it also creates a texture that relieves potential glare to the flats that look down on the building.



STRUCTURAL STEEL

a steel structure relates to the concept of lightness fixed to heaviness as well as serves as the new material introduced on site which is dependent on the natural, stereotomic materials

Fig 8.7 Material palette, tectonic (Lysacht, 2016)

TECTONIC SPATIAL REQUIREMENTS

Internal spaces need to be well lit, especially in classrooms where a steady and well diffused 400 lux is required. The steel structures need to have adequate openings to allow the natural light into the spaces, however, attention needs to be given in allowing the inlet of natural light to be diffused. Shading systems and screens will be introduced to allow this to take place, as well as to create an awareness of the changing seasons with the use of planted shading systems with indigenous plants such as wild jasmine and geranium.

TECTONIC: CONCEPTUAL INTENTIONS

An appropriate response to material is using steel which is faster to construct and longer lasting, together with Saligna timber columns and pergolas as a support system in outdoor spaces. These allow for the mimicry of the lightness of tree branches, coupled together with the use of dark grey painted Klip-Lok 700 roof sheeting adding texture to the roof plane and creating a lightness in the roof system, resembling the concept of the roof being a canopy over the spaces and functions below. The roof sheeting also relates to the metal sheeting used in the area. Saligna columns will be used in outdoor spaces for the support of treated Saligna pergolas. This is because the buildings become lighter (or more tectonic) around their peripheries relating to the concept of the tree. The first floor of the classrooms will be of Saligna timber members to support the intentions.

8.4 Primary and secondary structure

The technical concept, together with the material palette gave rise to how the structure will be put together. The primary structure will therefore be made up of concrete floors, brick and steel columns. The secondary structure becoming tectonic steel framing to support the primary.

PRIMARY:

The primary structure consists of a thick concrete base with cast in-situ reinforced concrete foundations, coupled with a large 2x2m brick column reinforced with concrete set into the wall. The brick column is made up of one double skin layer of brick, a 50mm air-gap filled with concrete at the base and insulation at the top, creating a large amount of thermal mass necessary to form a solar stack to cool the space. Wherever retaining walls are required, brick walls and gabion walls are proposed reiterating the building's or "tree's" relationship to the ground. The gabion walls also support plant growth, which becomes a didactic element.

SECONDARY:

A steel profile is fixed within the brick column and branches outwards, freeing itself from the brick column and grounding itself on the other end of the building with a concrete base. The profile is made up of hot rolled galvanised steel 203 x 102 x 25 taper flange I-section rafters at 10m spacing that meet the same size columns welded together and meeting the ground at a concrete base foundation. In the home-base classrooms, the portals are spaced every ten metres which relates to the classroom sizes of 10m x 12m. The portals are laterally supported by hot rolled galvanised steel 152x89x17 taper flange I-section rafters and cross braced with steel rods. Fixed to the top of the portal frame are 50x100x20x2 cold formed lipped channel steel purlins to which the Klip-lok 700 roof sheeting will be fixed. Saligna timber acoustic ceiling panels are fixed to the underside of the profile and suspended to a greater depth in the service cores to provide a plenum for electrical services

TERTIARY:

In the garden of regrowth, the primary and secondary structure will foster the new life or regrowth through the incorporation of a planted shading system or skin, with the plants supported by a steel planted mesh fixed onto a lightweight steel beam system. The skin will puncture the interior as well as form shading on the outside. The aim is that the skin will be maintained by the children. This will form as a continuation of the roof canopy but with smaller sized steel members, where onto a planting mesh will be fixed to facilitate the growth of plants. Water pipes with perforations to allow for the outlet of water will be fixed to the steel members to water the plants as well to provide a level of evaporative cooling on the northern boundary of the classrooms.

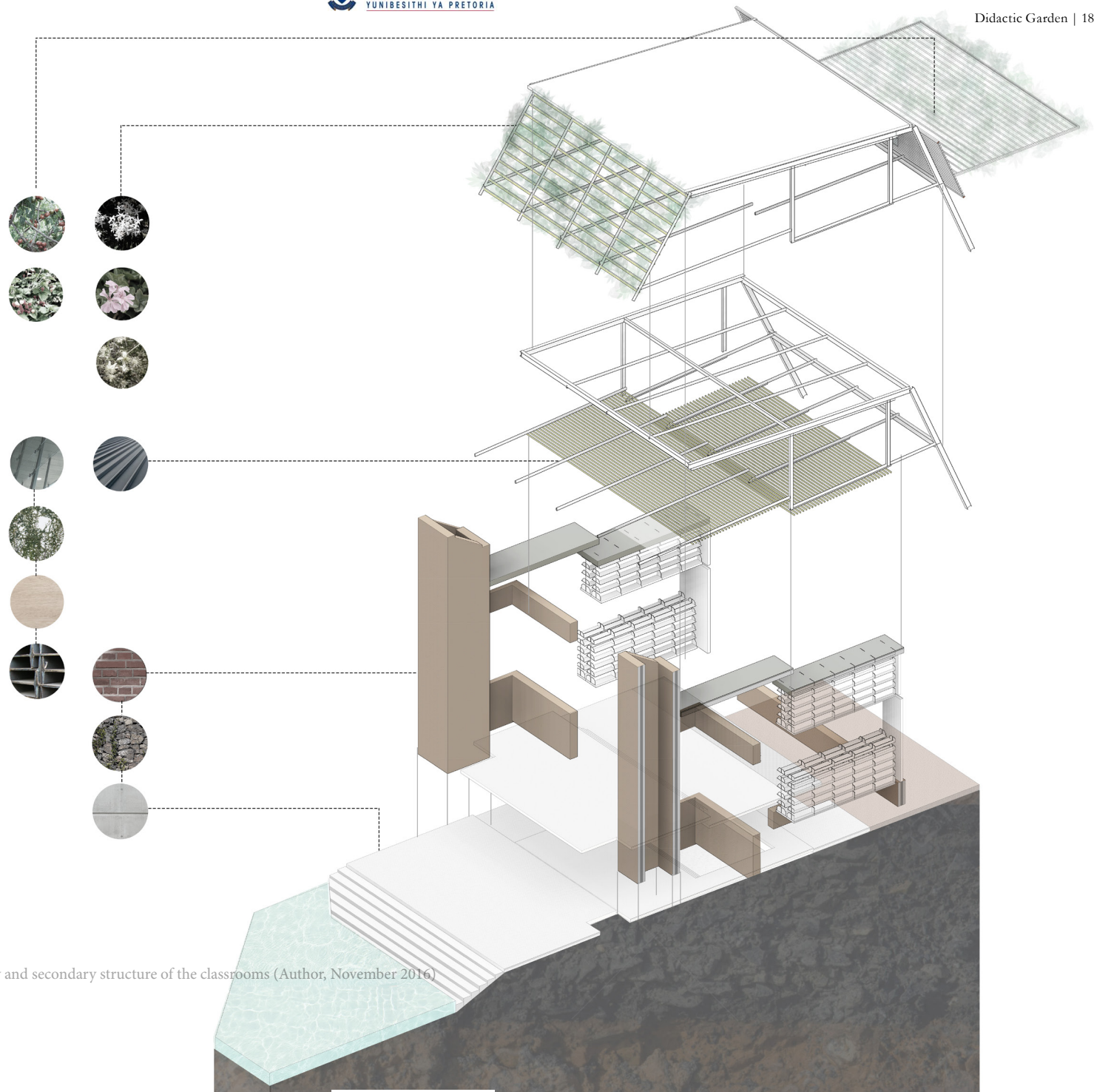


Fig 8.8 technical explosion showing primary and secondary structure of the classrooms (Author, November 2016)

8.5 The Joining of the Tree

Considering the material choices and conceptual intentions, the detailing of how these materials relate should be shown as separate entities that depend on the other for structural support and therefore although separate, form a sense of continuity. Just as the parts of the tree fulfil different functions and different aesthetic relationships, it remains one entity. The detailing of these should reflect that concept.

THE BRANCHES

The intention of the tectonic is to have a light character but also a continuity in the way materials are joined. For the steel portal frame, the adequate depth for its span had to be identified in order to be self supporting the portal-like structure. Welded junctions gave a sense of continuity in the portal but also shows that they are different entities in material and function. The timber acoustic ceiling sits in line with the bottom flange of the I-section members but steps back at the prominent joining of the portal to show how the members are joined.

THE TRUNKS AND ROOTS + THE BRANCHES

The heavy brick walls join to the tectonic steel elements through a concept of structural dependence and continuity, together with the juxtaposition of complete integration of the materials and partial separation. As the building leaves the ground, it is heavy, containing stereotomic elements and lighter elements integrated within the stereotomic. As the building or structure reaches the canopy, the portal frame separates itself from the heavy brick column and becomes the roof canopy. The roof structure supports the tertiary structure of the planted skin through a system of continuous beams that run in line with the suspended timber floor. Where the portal frame becomes the roof canopy, a small shaft of glass is placed between the brick column/stack and the roof sheeting together with a the slatted timber ceiling to emphasise where the two elements join as well as to highlight the dappled inlet of light that the roof canopy offers to the learning spaces

THE TRUNKS

Where the brick wall meets the concrete floor, because of their different expansion and contraction rates therefore a shadow line is proposed along the skirting line to express the different materials but the skirting itself will be chamfered to express the continuity between them.

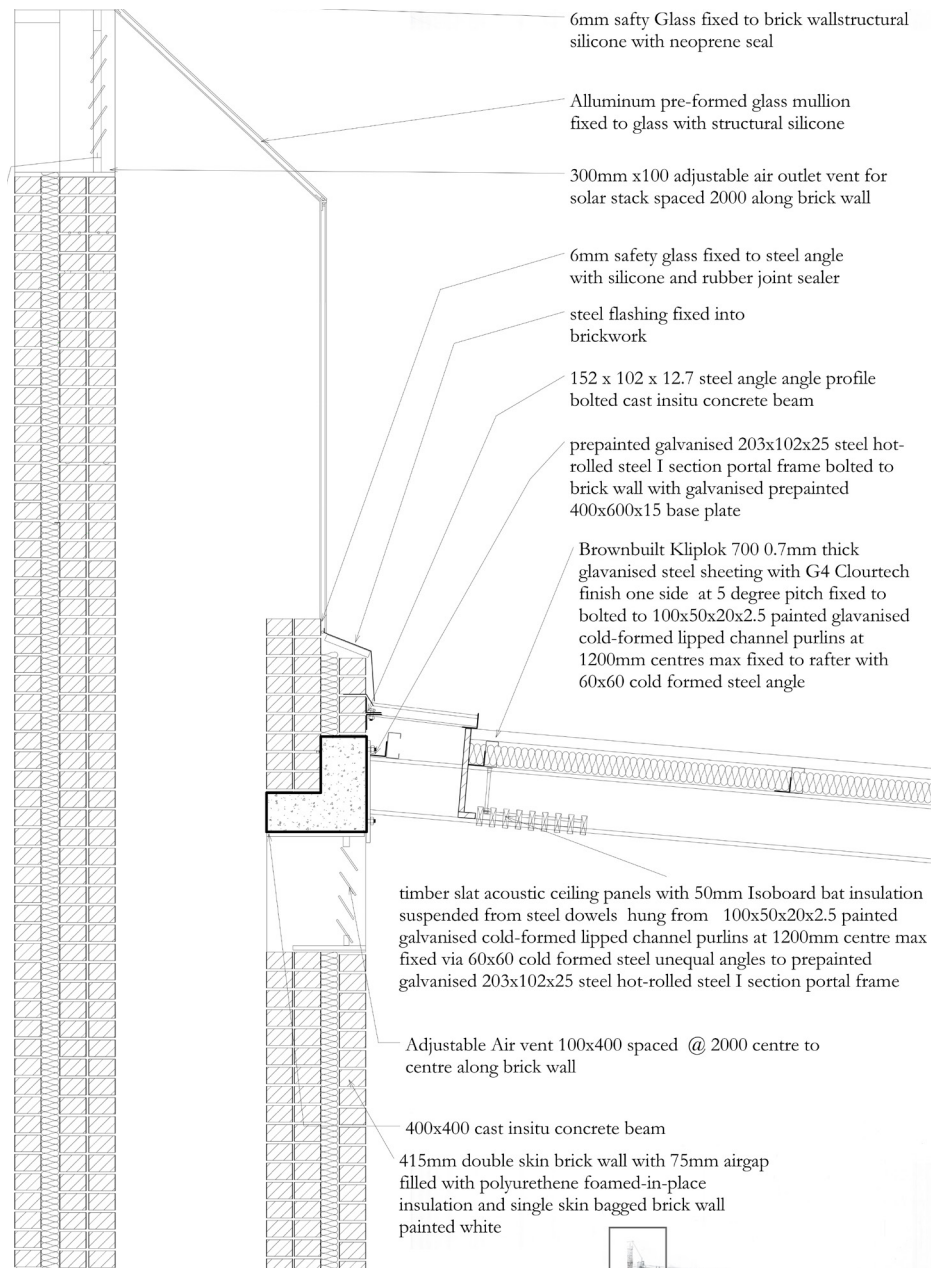


Fig 8.9 Detail showing how the concept influences the aesthetics of joining (Author, September 2016)

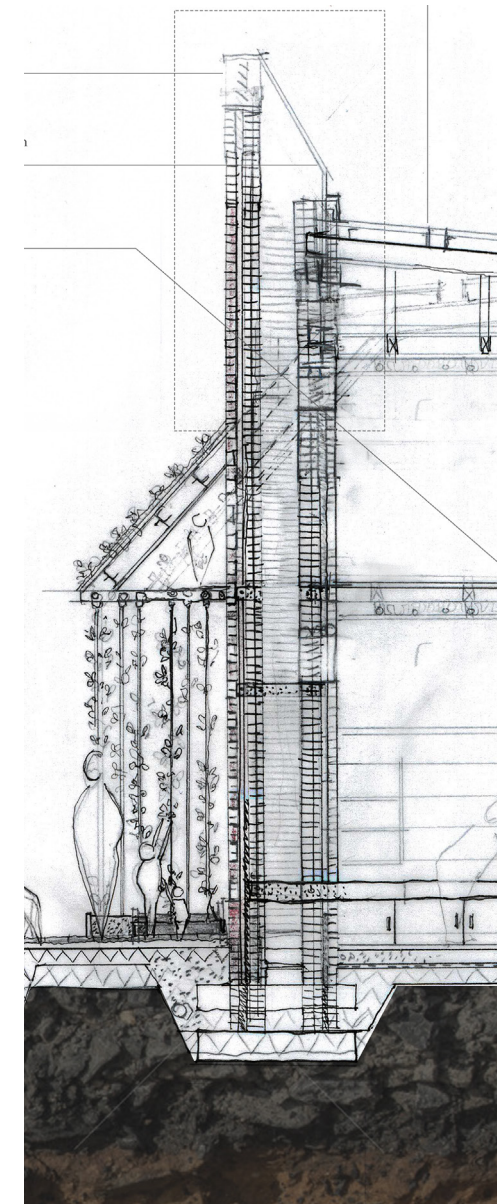
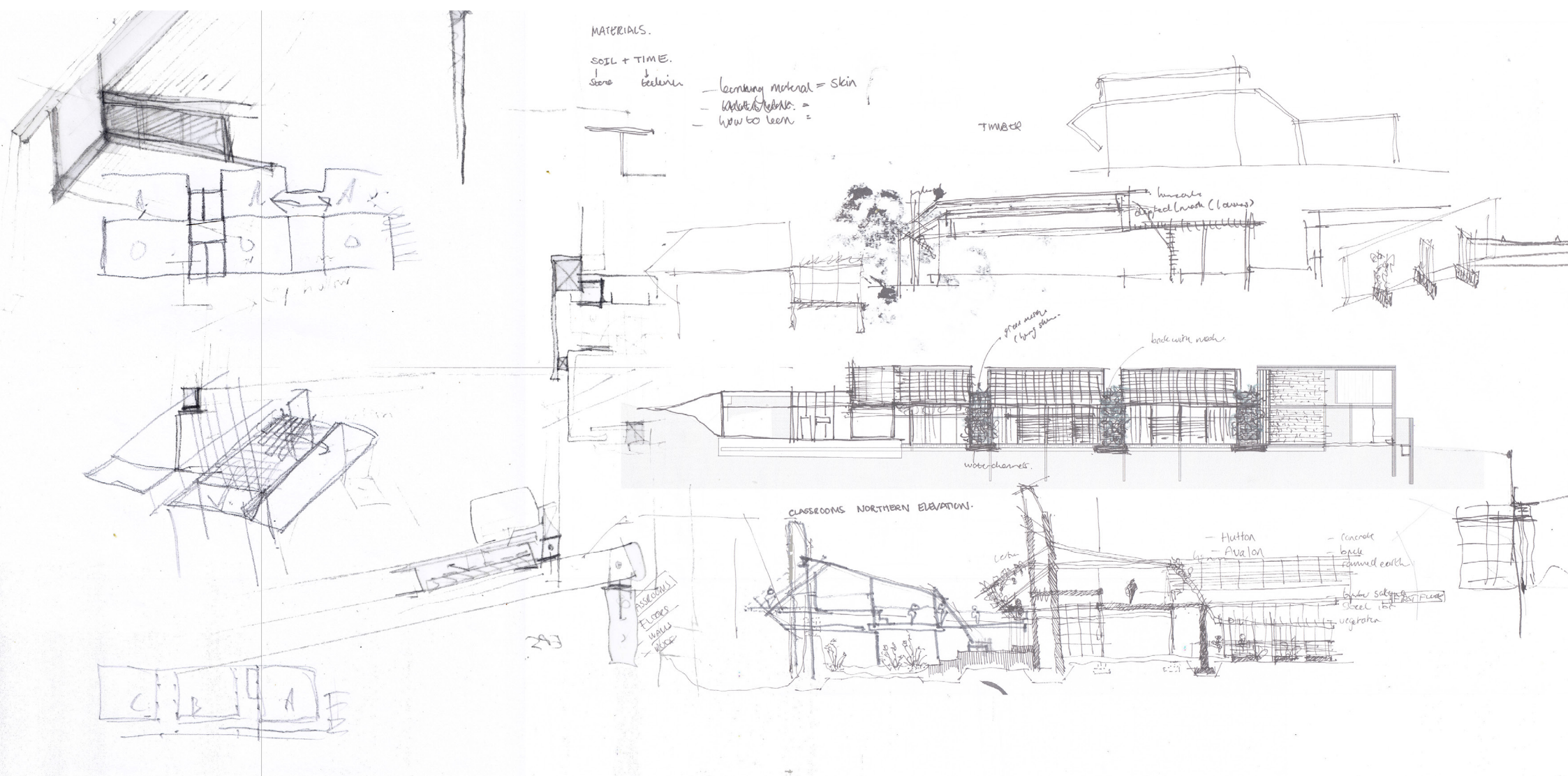


Fig 8.10 Section through solar stack and joining of portal frame (Author, 2016)



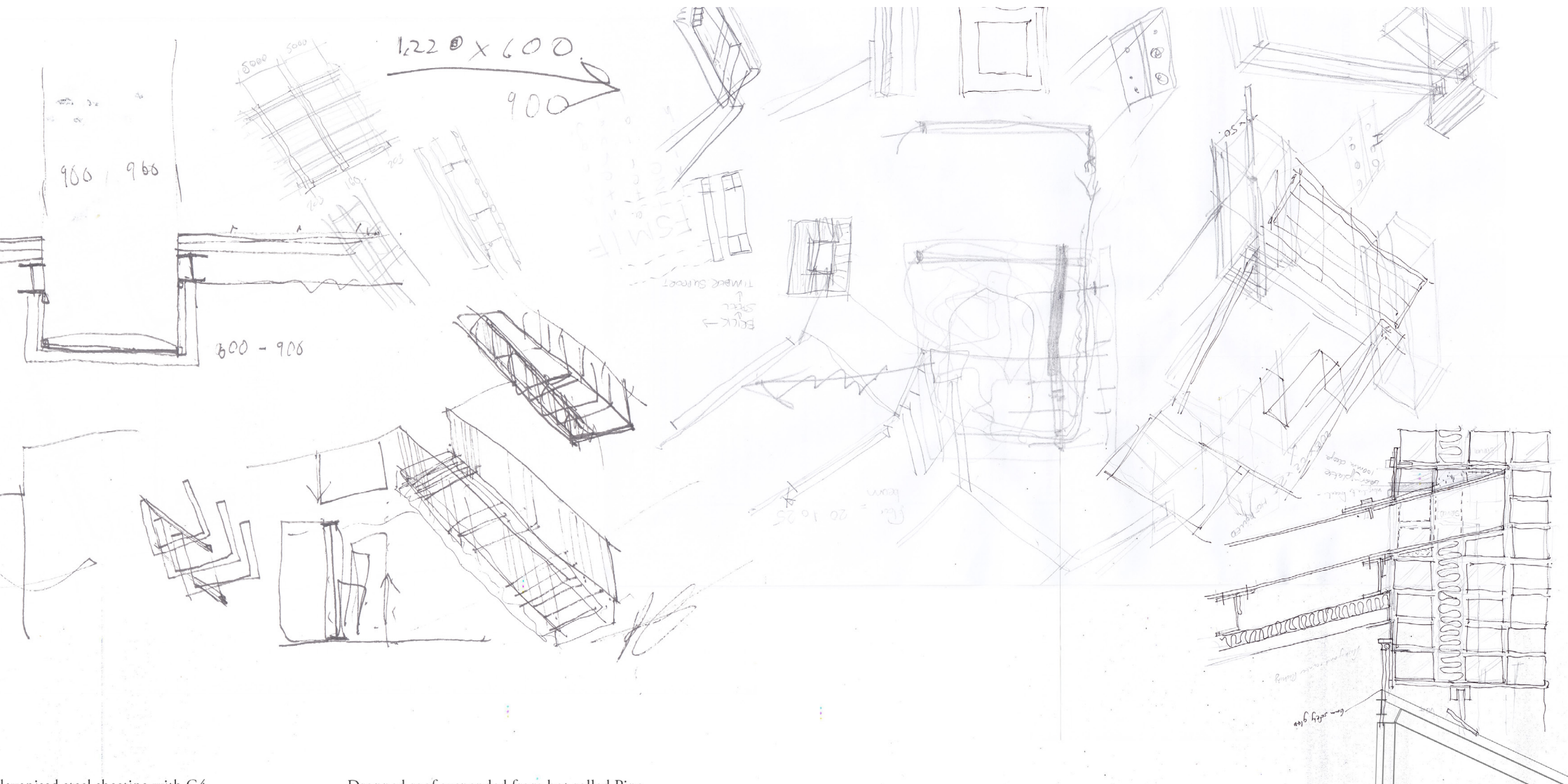
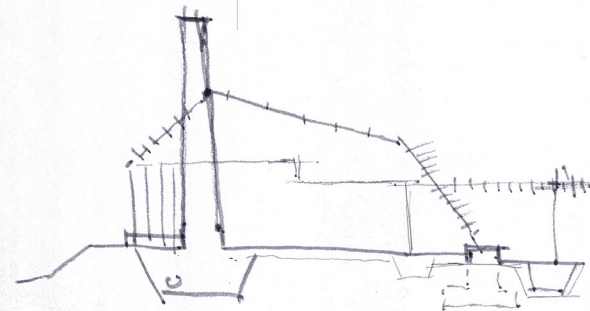


Fig 8.11 Technical Explorations (Author, 2016)

8.6 The Section : Technical Exploration

The Section under investigation is cut through the Reggio Emilia home-base classrooms and more specifically, the service core of the classroom which holds storage space for cupboards, display boards and locker shelves. The section displays the quiet and loud spaces by the differentiation between levels where the quiet space drops lower than ground level to create a sense of privacy for activities such as reading and napping. The more public spaces are on ground level with a higher ceiling level to facilitate group activities such as painting and writing. The second level of classrooms are also shown. The service core on the second level facilitates the dropped roof between classrooms to provide separation between classrooms, to hold the cupboards and shelves and also to allow for a modular design that can be adapted easily as well as providing children who live in the flats that overlook the area to identify their classroom from their flat, creating an identity of each classroom space. This modular spacing also incorporates the biophilic principle of integrated parts to whole where each classroom is a separate entity but forms part of the classroom structure.



Gabion walls to hold up artificial wetland made of brick and rubble from demolished Grade R building

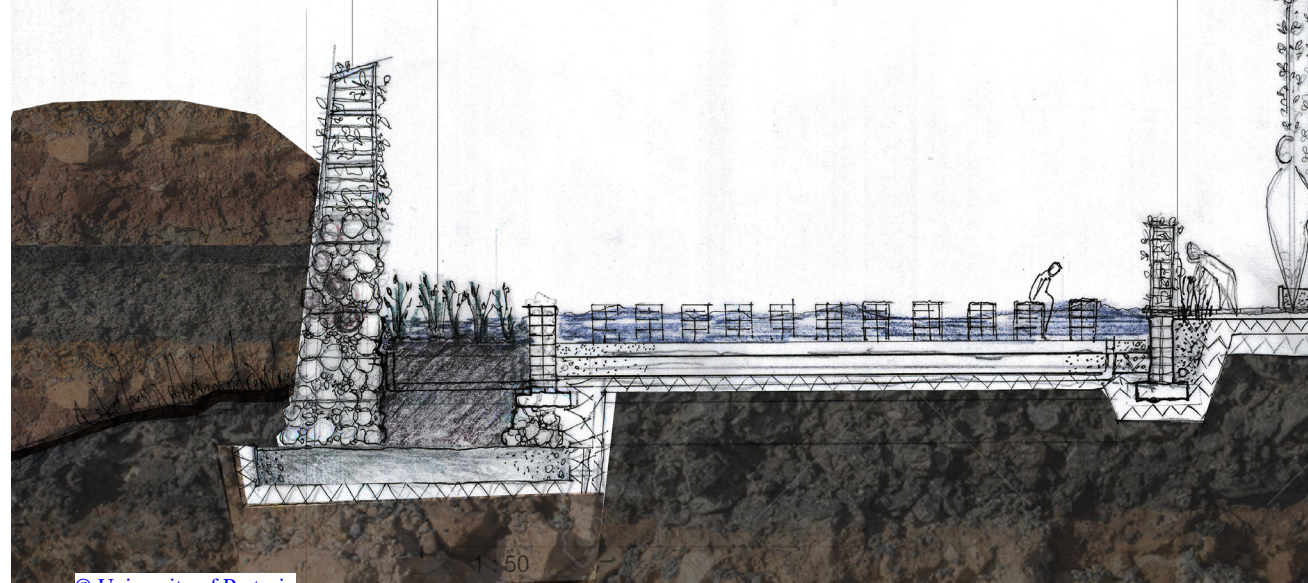
Artificial wetland captures rainwater to send to underground water storage tanks to later be used within building.

Storm water channel directing excess flow away from building

Aluminum framed 300x100 adjustable air outlet vent for solar stack

Aluminum pre-formed glass mullion fixed to glass with structural silicone

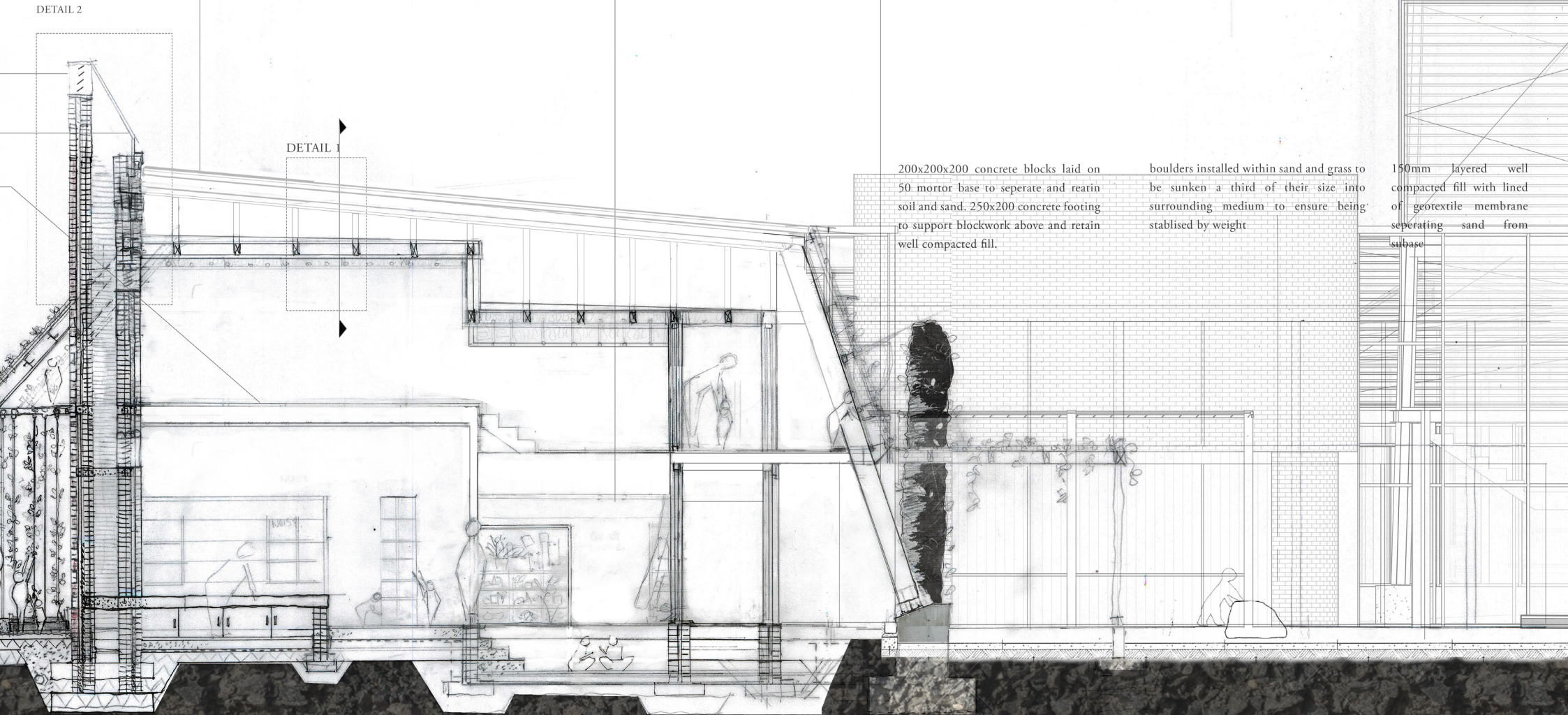
22 x 175 timber ceiling board supported on 38 x 114 joist



Brownbuilt Kliplok 700 0.7mm thick galvanised steel sheeting with G4 Clourtech finish one side at 5 degree pitch bolted to 100x50x20x2.5 painted galvanised cold-formed lipped channel purlins at 1200mm centres max fixed to rafter with 60x60 cold formed steel angle and fixed to 30mm Isoboard bat insulation according to engineers details

Dropped roof suspended from hot rolled Pine slatted ceiling boards suspended from 203x102x25 hot-rolled steel I-section rafters bolted to 100x100x3 cold formed square hollow section frame

galvanised steel planter mesh fixed to pre-painted galvanised 100x50x20 cold formed steel lipped c channels, bolted to pre-painted galvanised 203x102x25 hot-rolled steel I section portal



200x200x200 concrete blocks laid on 50 mortar base to separate and retain soil and sand. 250x200 concrete footing to support blockwork above and retain well compacted fill.

boulders installed within sand and grass to be sunken a third of their size into surrounding medium to ensure being stabilised by weight

150mm layered well compacted fill with lined of geotextile membrane separating sand from subbase

Fig 8.12 Section exploring technical concept and material joining (Author, 2016)

8.7 The Water System: First resolution

The programmatic functions as well as the presence of the Walkerspruit called for the integration of a water process into the children's education as well as in the design of landscape and the building. It was considered that the base flow from the Walkerspruit be diverted into a side-channel that meanders through the site, purified using the five-step filter system and led into a small wetland that will be maintained by the children, however, taking away from the walkerspruit proved inappropriate as the little ecological value it holds would run dry as its base flow was diverted.

In figure 8.10, a diagrammatic representation of this system is shown. Together with the side channel diversion, a rain water harvesting system was proposed where runoff from the roofs where diverted into small rainwater gardens at the base of the building and then pumped into a surge tank which is located in the central garden and thereafter pumped to water towers that hold the water needed to serve the building.

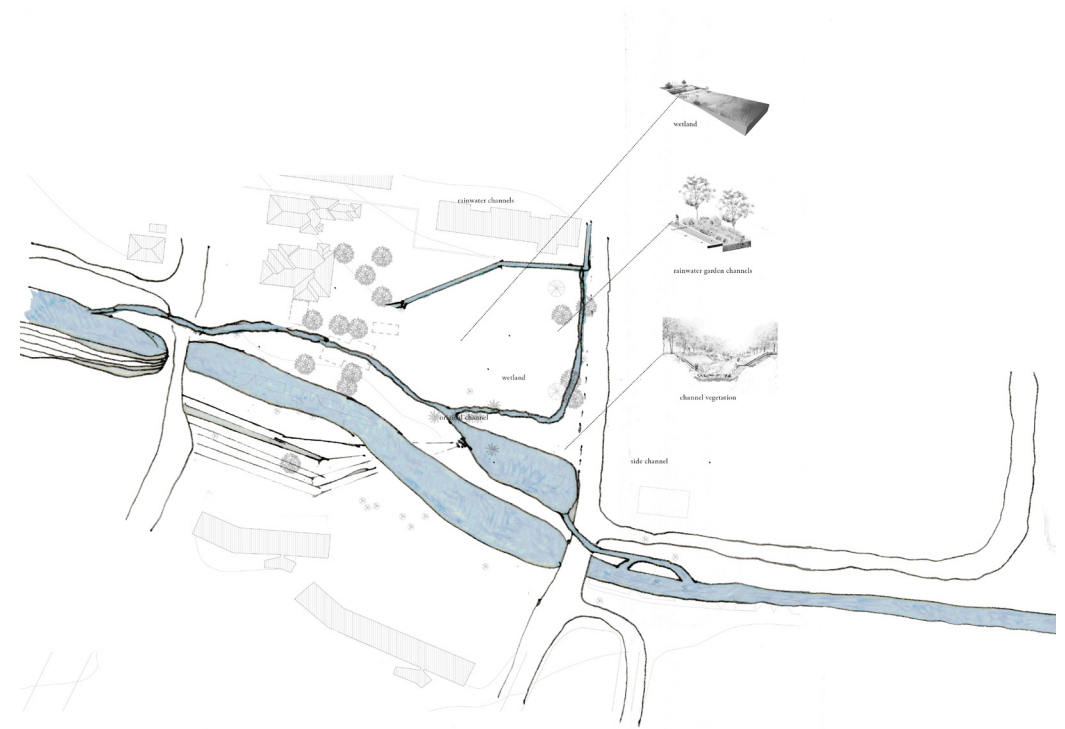


Fig 8.13 Diagram of proposed water system and its processes (Author, 2016)

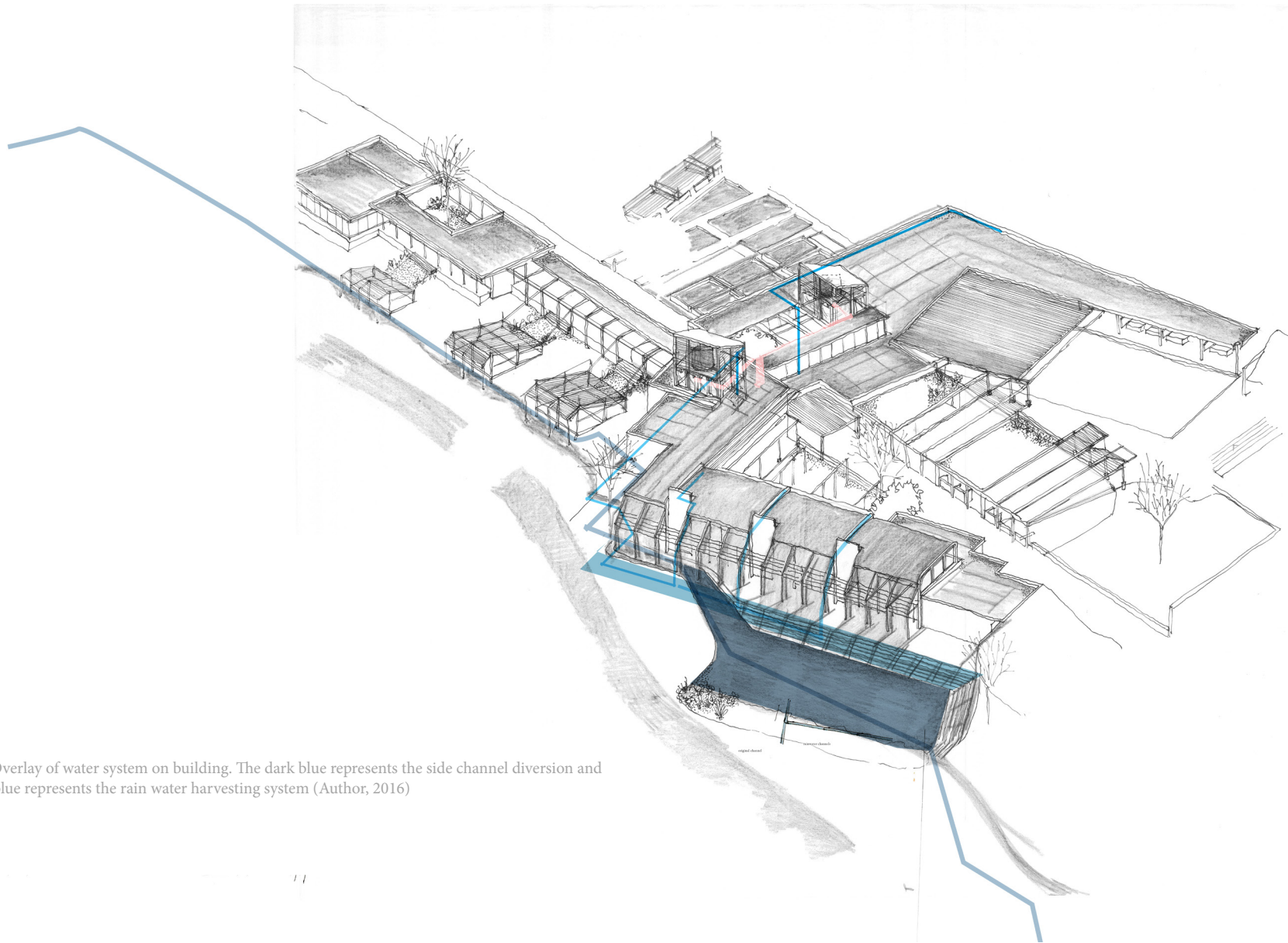


Fig 8.14 Overlay of water system on building. The dark blue represents the side channel diversion and the light blue represents the rain water harvesting system (Author, 2016)

8.8 The Water System: Water Budget

It was then proposed to integrate the rainwater system with the wetland and create a new ecosystem through the purification of the runoff of water from the roofs.

WATER BUDGET

A water budget was calculated (refer to Appendix, Table 1) to establish the amount of water that can be collected from the rooftops and the thereafter the size of tank needed in order to support the water demand of the building and its users. It was originally proposed that composting toilets be used throughout the building to not only save water but also provide compost for the vegetable gardens and planted areas. However, they were identified as unhygienic in a school environment especially when dealing with young children. One set of composting toilets were proposed while the rest of the toilets were fed with grey-water by the other functions on site. Where there is not enough grey water, a municipal connection will have to be used.

8.9 The Water System: Final Resolution

Since the amount of water that can be stored in tanks far exceeds that which can be collected from the roof, it will be better to only collect a certain amount and let the rest either flow into a French drain or into the soil. The maximum amount of water that can be housed is 370m³ or 370000 litres. Two 90m³ tanks will be housed in the towers and 204m³ will be housed in the form of three 68m³ tanks, underground.

The rainwater runoff collection will be firstly, fed into a trash trap filter which deals with floating debris, thereafter a oil and sediment filter and then will be fed into a UV filter because the water cleaned by the wetland will be fed into a bio-pool which needs to be free of pathogens for the children to swim in. The water will be stored in underground tanks after going through this process. Thereafter, the water will be fed into a wetland and bio-pool to clear the water of nitrates and to provide nutrients to the plants of the wetland. Any pathogens that occur in the swimming area will be dealt with another UV filter to make the water potable. After this, the water will be pumped to a surge tank with pump to pump 180m³ of water to the water towers and fed into the building where needed.

And of course, all will be made as visible as possible in order to create a didactic connection between the child and the water they use in order to create an awareness of the importance of water.



Fig 8.15 The water system (Author, 2016)

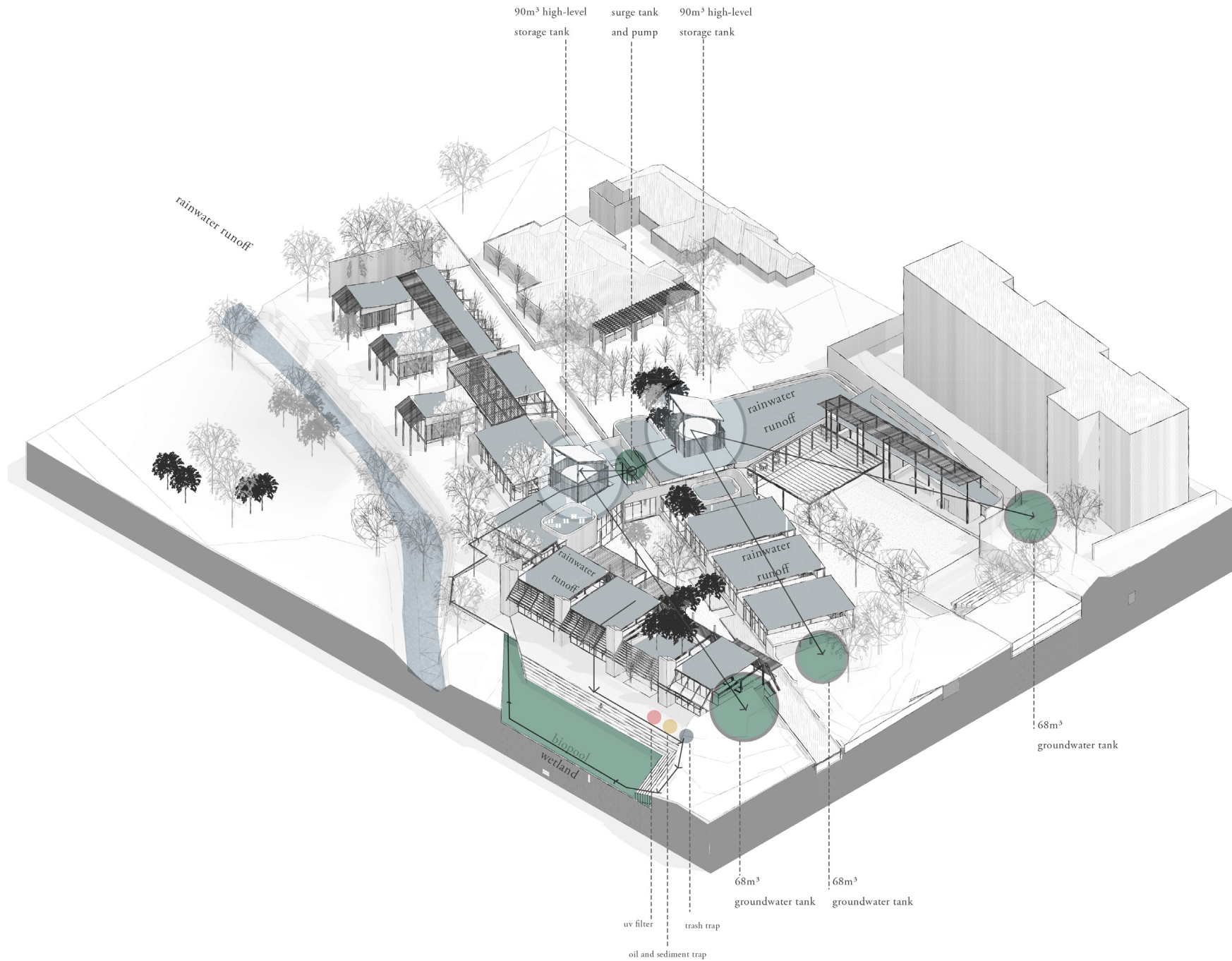


Fig 8.16 New water system showing process of rainwater collection, purification and reuse (Author, 2016)

8.10 Passive Climate control and services

8. There are three methods of passive climate control that will be incorporated within the home-base classrooms specifically.

This includes a solar stack which is shown (refer to Fig 8.9) in section, serving as the service core in the classrooms. The services it provides is cooling in summer and heating in winter of the classroom spaces as well as becoming a heavy backing for storage shelving and cupboards in the classrooms.

The second passive climate control is through the planted shading system or living skin which provides shading to the northern façades as well as deep set balconies which also allow access to the skin to be maintained by the children. The skin is designed to be essential to the climate control of the building, enabling a direct physical and sensory connection between natural systems and plants and the children that help them to survive. The use of the skin relates to the sun's angles throughout the seasons enabling sunlight to penetrate the building in summer to remain outdoors in summer and prohibited by the deciduous plants on the skin.

The third is the use of evaporative cooling which will be integrated onto the skin through water pipes that are fixed to its frame and will water the plants and at the time cool the building in summer.

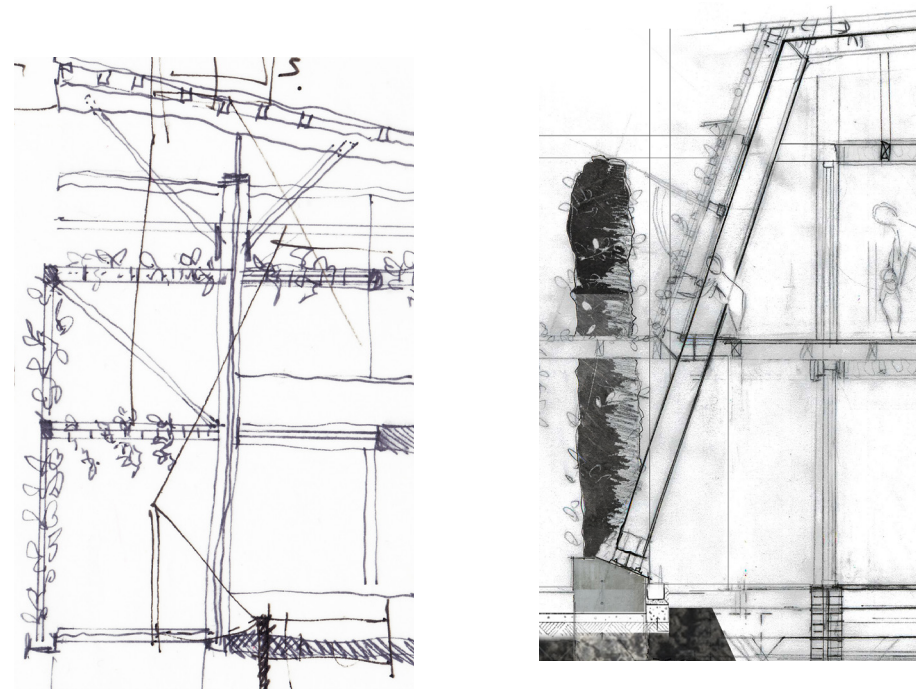


Fig 8.17 Development of living skin and how it punctures the building's facade (Author, 2016)



1. Strawberries (EzGro Garden, 2013)



3. Ivy-leaf geranium (Net Plant Finder, 2016)

8.10.1 The Living Skin

The living skin will be made up of a steel beam system with a galvanised steel planting mesh fixed thereupon using cold formed lipped channels. The aim of the skin is to fulfil a multitude of functions including connection to identity of place as well as providing shading for the northern and southern façades as well as forming environmental teachers to the children, helping them learn about the upkeep and care of plants through spaces that are directly connected to their everyday classroom. The watering of the plants on the skin will also provide evaporative cooling to the building in summer months. In winter, to save water, plants will be watered less using hose-pipes.

The types of plants that will be grown on the skin include tomatoes and strawberries on the lower levels that will be directly accessed by the children. These are suitable as they are ground covers and provide fruit that can be picked and cared for by the children. In the higher levels that are less accessible, *Pelargonium peltatum* will be planted. It is commonly known as ivy-leaf geranium. It is indigenous to South Africa and is known for its pink flowers. It has also been categorized as one of least flammable plants and can be grown within a building protection zone. Other creepers that can be grown on the skin include wild jasmine which attracts a variety of birds and *Clematis brachiata*, commonly known as Traveller's Joy which is mostly found in Gauteng with attractive fragrant flowers that appear in summer months.



2. Vine Tomatoes (Grow It Organically, 2016)



4. Wild Jasmine (Florida friendly plants, 2010)



5. Clematis brachiata (wikipedia, 2014)

Fig 8.18 ground level plants (Author, 2016)

Fig 8.19 Higher level creepers (Author, 2016)

Ventilation

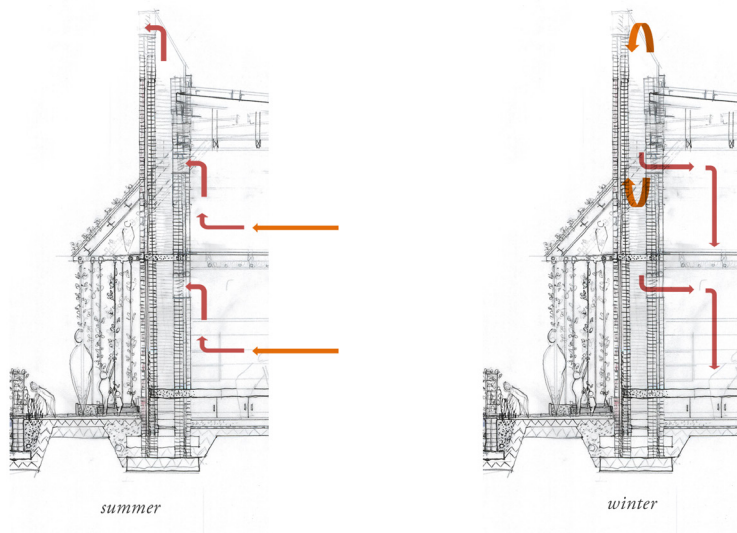


Fig 8.20 During summer months, the stack aims to cool the space through an updraught created by the form of the stack, the glass on top and the thermal mass and paint colour (Author, 2016).

Daylighting

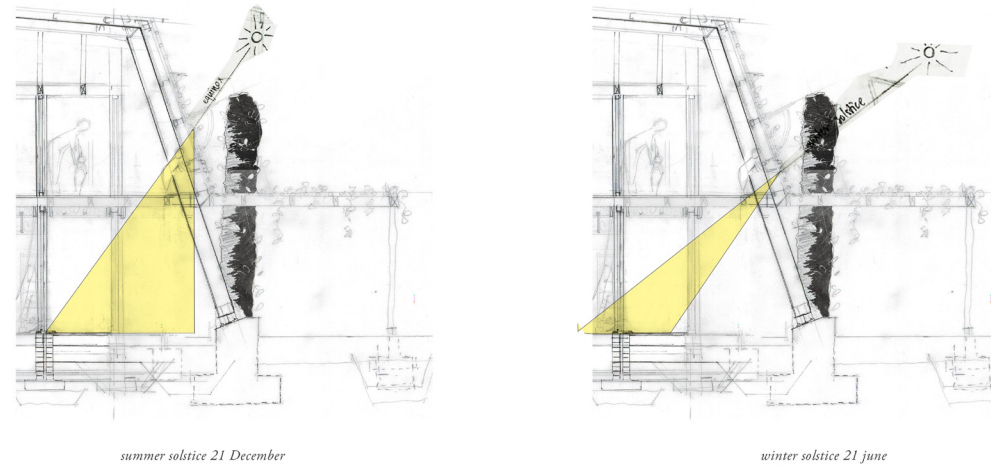


Fig 8.21 The pergola and deep set circulation corridor and balcony lets sun into the classrooms in winter and shades it in summer (Author, 2016).

8.11 Waste Management

With regards to the management of waste on site, the recycled and reused vegetable garden will be used for the creation of compost and the use of it for the vegetables to be used for cooking in the cafeteria. The compost created by the composting toilets on site will distributed to the planted areas on site to provide them with valuable nutrients where the organic waste of the kitchen will be distributed back into the vegetable garden. Paper, glass, cardboard and plastic will be sorted through in the recycle garden attached to the existing Ring Ting Pre-primary.

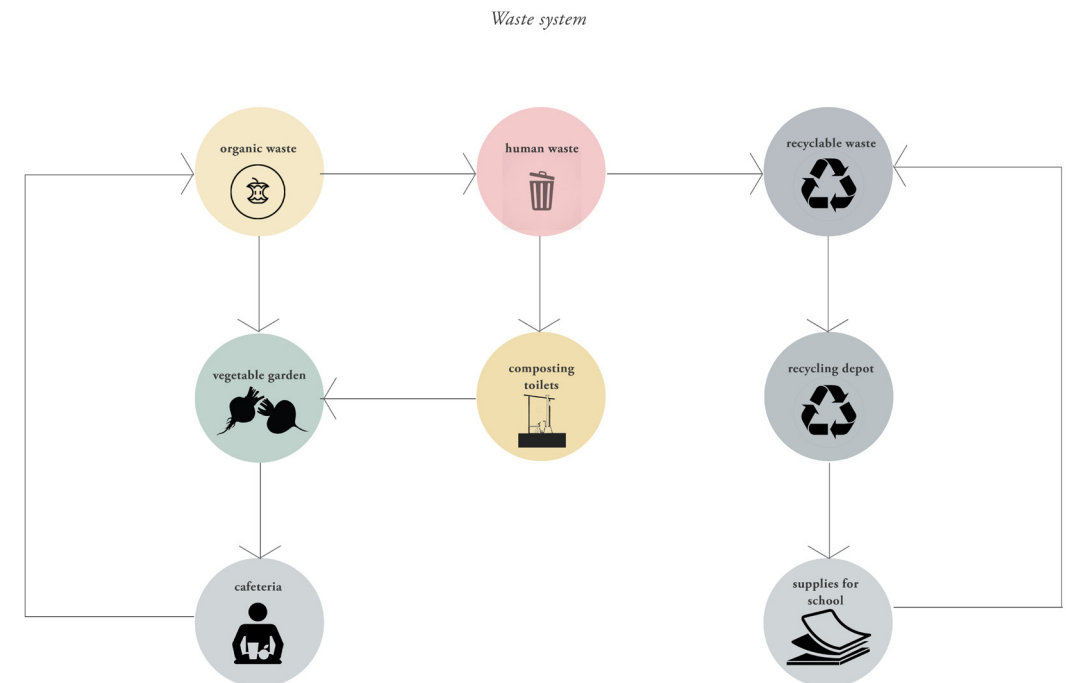


Fig 8.22 Waste management system. (Author, 2016)

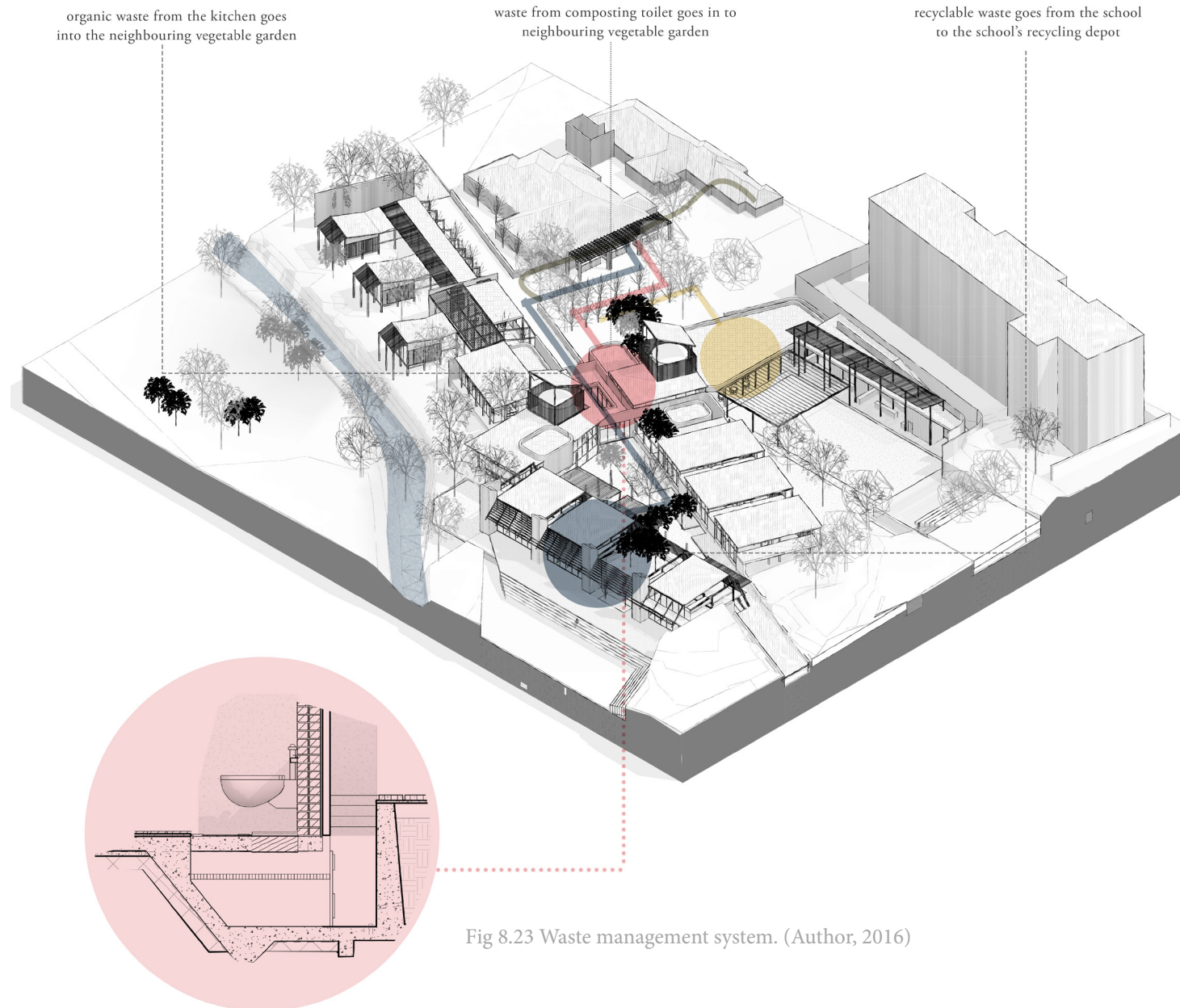


Fig 8.23 Waste management system. (Author, 2016)

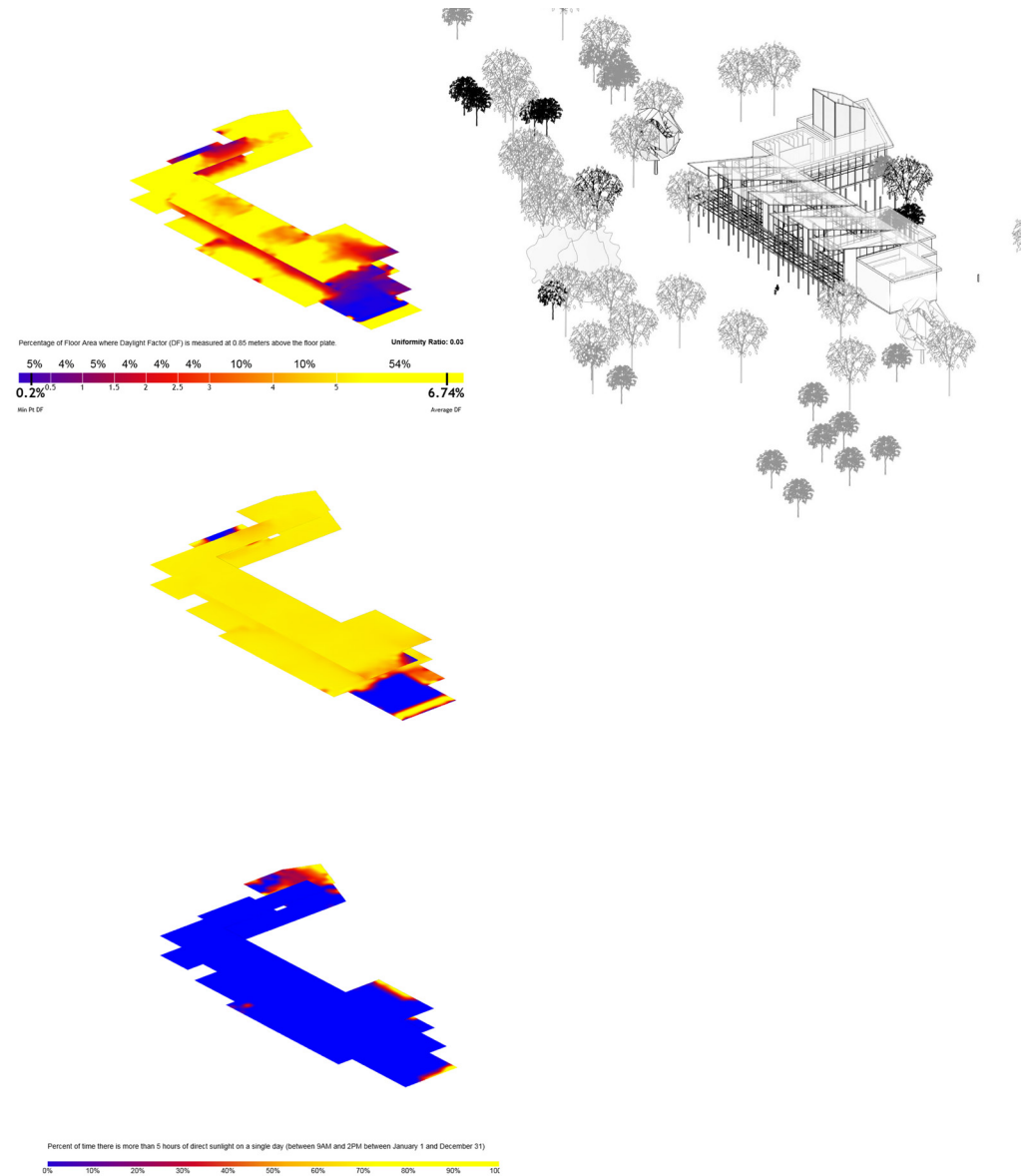


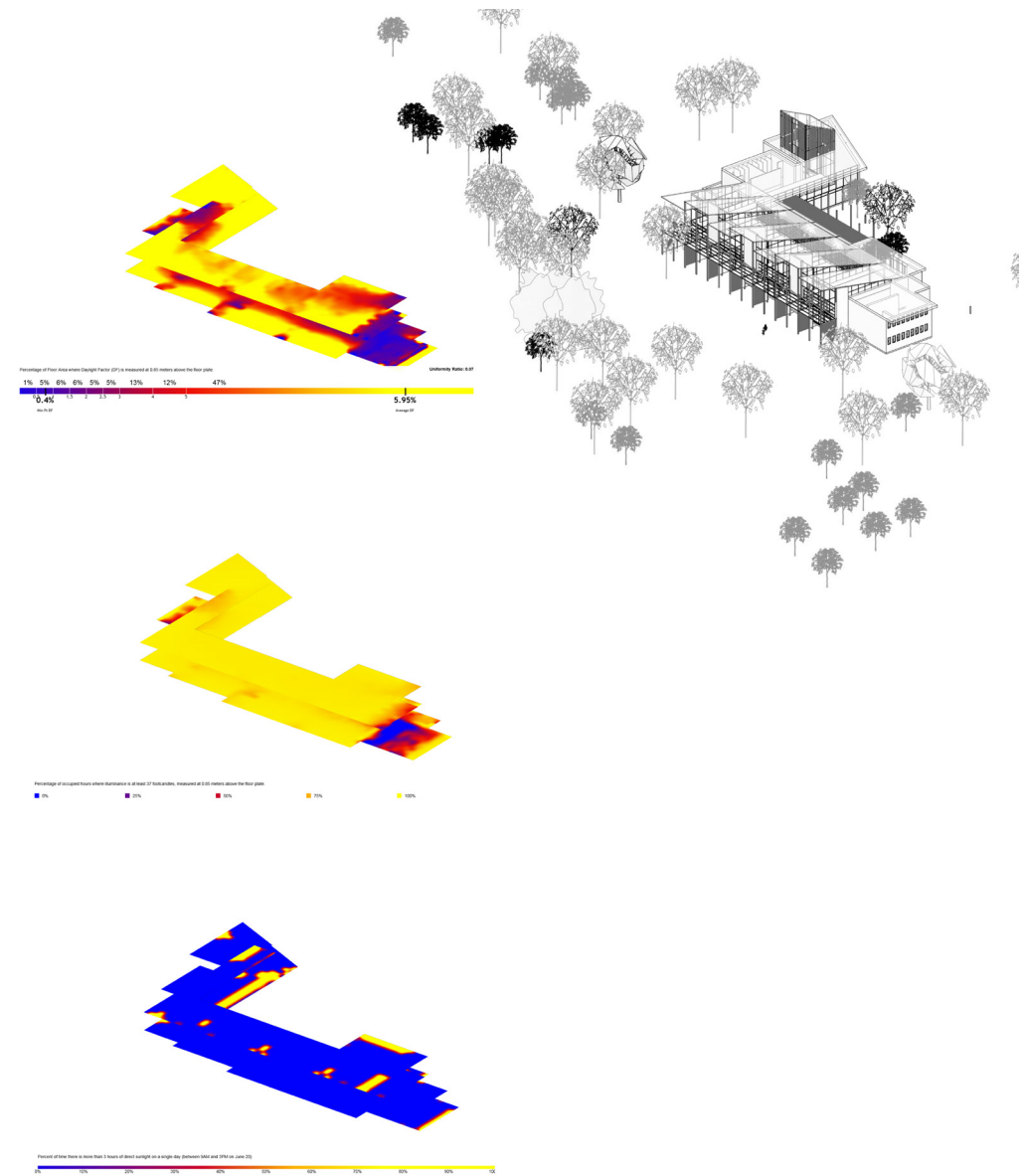
Fig 8.24 Base design daylighting analysis (Author, 2016)

8.12 Daylighting Iterations

Daylighting iterations were conducted on the home-base classrooms in order to establish a design resolution that enabled the classroom spaces to match up to the deemed to satisfy lux levels in school classrooms. According to the Department of Education in South Africa, the recommended artificial lux levels in classrooms, offices and libraries should be 200 lux and for art rooms such as Reggio Emilia home-based classrooms, the lux levels should be 300 lux (South Africa, Department of Education, 2012: 13). However, biophilically, the ideal would be to reach those levels using natural daylighting as far as possible and only artificial lighting where daylighting is not possible.

8.12.1 Base Design

The base design analysis was conducted at the stage where the classrooms had tilted roofs which allowed too much harsh sunlight into the classroom spaces and therefore proved that additional shading was necessary. The bathroom spaces also proved to be too dark and additional windows needed to be added. The results concluded that the majority of the spaces were over-lit with only the bathrooms being too dark.



8.12.2 Iteration 1

The results from the base design analysis resulted in shading being added to the south facade as well as a pergola to the north of the building in the courtyard space. Small windows were added to the bathrooms. Shading was added to the circulation well. The changes seemed to have little effect on the overall result, however, and the tilted roofs were redesigned to reduce the direct sunlight inlet into the classroom spaces.

Fig 8.25 Iteration 1 daylighting analysis (Author, 2016)

8.13 SBAT

A Sustainable Building Assessment Tool (SBAT) study was completed in order to assess whether the design was sustainable in terms of Social, Economic and Environmental Factors. The Overall Score resulted in a good score with factors such as access to facilities rating the highest. Because of the fact that the classroom sizes are much larger than the deemed to satisfy guidelines, factors such as site and cost of building rated lower.

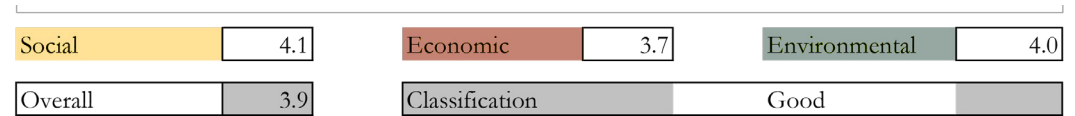
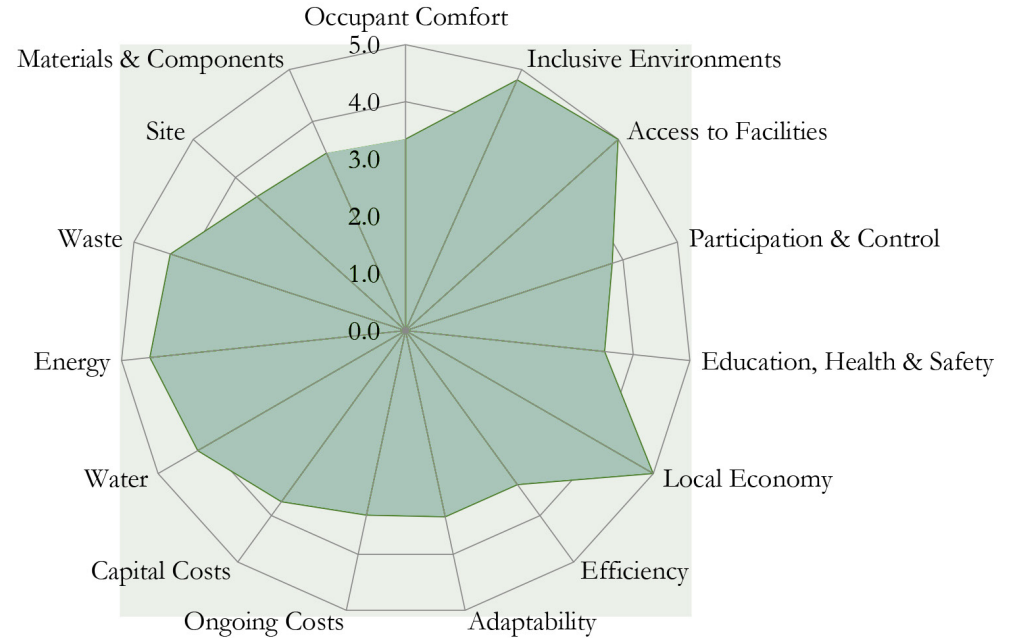


Fig 8.26 SBAT Graph and resultant score (Author, 2016)

