CONCEPTS

The technology of the project was approached through a lense of emerging building technology. After conducting research on which EBTs the industry is currently involved with, 3D Concrete Printing was selected as the main technology focus of the project. This was done to promote the inclusion of a currently underdeveloped and high-tech EBT in an environment that would be directly exposed to the spatial designers in the build industry.

Concepts were the initial core of the technology development. Parti diagrams evolved into more complex sketches where the building technology became entangled with other structural systems.

The planning stage becomes more intricate in selecting exactly where the technology focus in the structure would be beyond the EBT. The 3DCP wall and roof connection of the auditorium was selected as the focus point. This would entail the connection between concrete and steel.

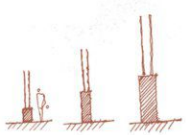
The lack of formwork in the construction process sets this technology apart from normal concrete construction. Less reinforcement is used in the walls as well, resulting in a less intensive use of additional resources to create the 3DCP walls.

Although the technology is not widely used in South Africa at the moment, this project becomes an opportunity to introduce the technology in an appropriate setting.

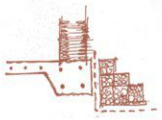
***FOCUS ON** ADDITIVE MANUFACTURING (3D CONCRETE PRINTING)*

PARTI DIAGRAMS

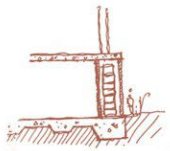
3D Printed Concrete wall parti diagram in plan



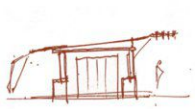
3D Printed Concrete wall in section - levels of hierarchy



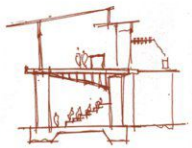
3D Printed Concrete wall detail section with adjacent gabion wal



Explorations of 3DCP wall with infill and foundation structure



3DCP applied to smaller structures with overhangs and pergolas



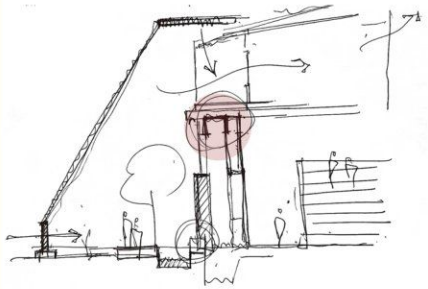
3DCP applied to larger structures - auditorium space used for main detail

PLANNING

SKETCHES

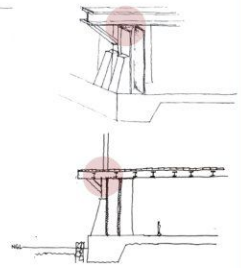
The focus for creating a detail was placed on the connection between the 3DCP wall and the steel roof structure. Following the sketches done during the planning stage, exploded isometric drawing were created in Revit and further developed later in the design. Two iterations were developed, the latter reflecting the internal wall structure.

a rough section through the auditorium wall with focus on the wall to roof connection of the 3DCP wall



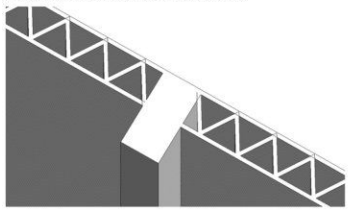
connection detail drawing and wall section below

hand-drawn detail of wall to steel beam connection of roof

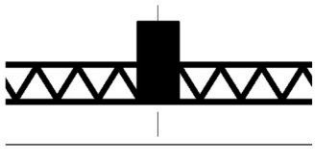


ITERATION 1

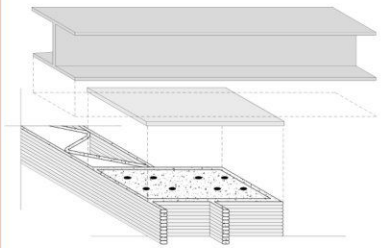
The internal rib structure of the wall did't have an influence on the exterior skin of the building. Columns were too large in size and the placement of steel plates proved to be excessive in this iteration.



3DCP WALL - ITERATION 1



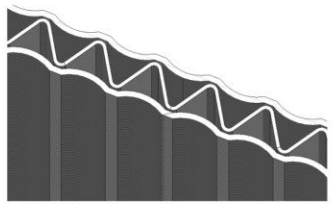
3DCP PLAN DETAIL



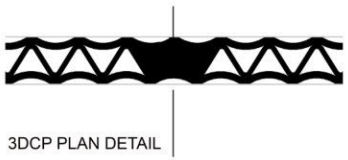
3DCP ASSEMBLY DETAIL
SCALE 1: 10

ITERATION 2

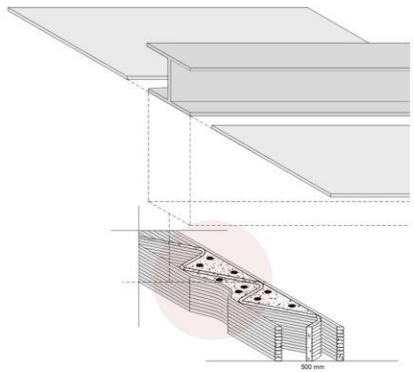
The second iteration was more successful since the envelope started reflecting the inner structure of the 3DCP wall. Additive manufacturing as a construction process was more clearly communicated.



3DCP WALL - ITERATION 2



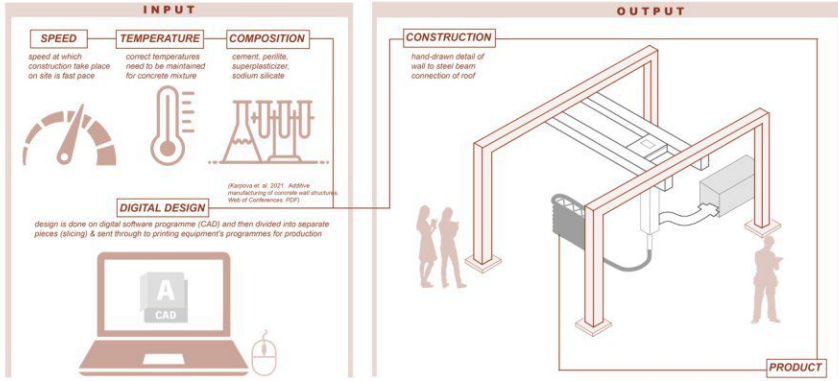
3DCP PLAN DETAIL



3DCP ASSEMBLY DETAIL
SCALE 1: 10

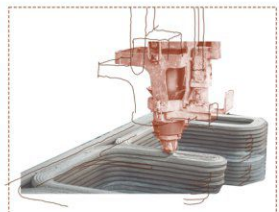
CONSTRUCTION PROCESS

PROCESS DIAGRAM

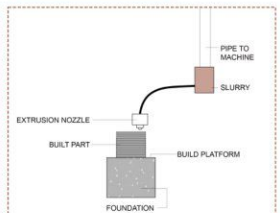


3DCP PROCESS

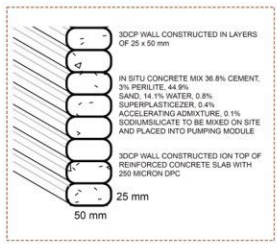
3DCP NOZZLE



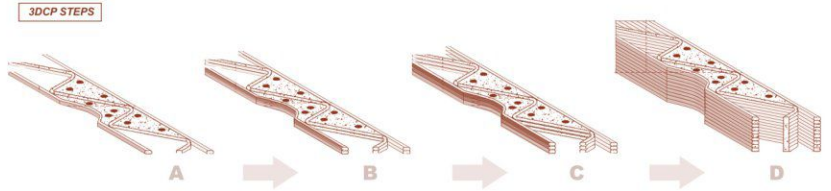
3DCP NOZZLE DIAGRAM



3D CONCRETE LAYER SECTION



3DCP STEPS



SUMMARY

ADVANTAGES

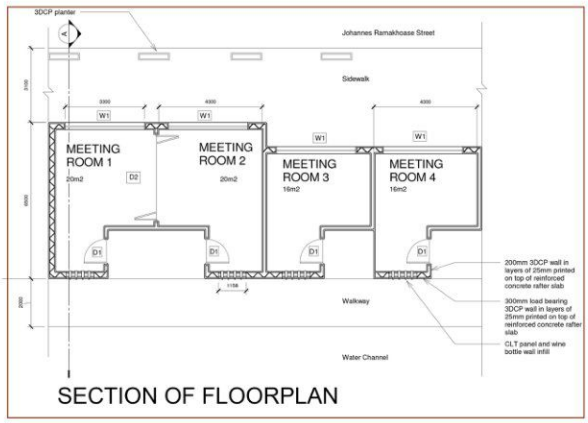
- *DESIGN INNOVATION*
- *ACCURACY OF CONSTRUCTION*
- *CUTS DOWN ON MATERIAL WASTE*
- *REDUCES CONSTRUCTION TIME*

DISADVANTAGES

- *HIGHER COSTS*
- *REGULATION CHALLENGES*
- *SCARCITY OF EXPERTISE AND EQUIPMENT*

TECHNICAL INVESTIGATION

ITERATION 1



SECTION OF FLOORPLAN

Specification

IN-SITU CONCRETE (F)

F1 - MIXES/CASTING/CURING

F10 - Insitu concrete mixes/ Casting/ Curing

F10 100 Insitu concrete mix 36.8% cement, 3% perlite, 44.9% sand, 14.1% water, 0.8% superplasticizer, 0.4% accelerating admixture, 0.1% sodiumsilicate to be mixed on site and placed into pumping module

F10 101 Casting process concrete mix is via pumping module by screw feeder and printed from D25 nozzle in stacking layers

F10 102 Concrete layers printed in 25mm layers with 3 days minimum curing time, covered in polyethylene film

F3 - REINFORCEMENT

F30 - Steel reinforcement

F30 100 T10 steel rebars post-tensioned for insitu rafter slabs

F4 - FINISHES/JOINTS/SUNDRIES

F40 - Design joints in insitu concrete

F40 100 200mm fibre board expansion joint fillers to be inserted at joints between interior concrete surfaces and 3DPC walls

F5 - IN-SITU CONCRETE ELEMENTS

F50 - In-situ concrete foundations

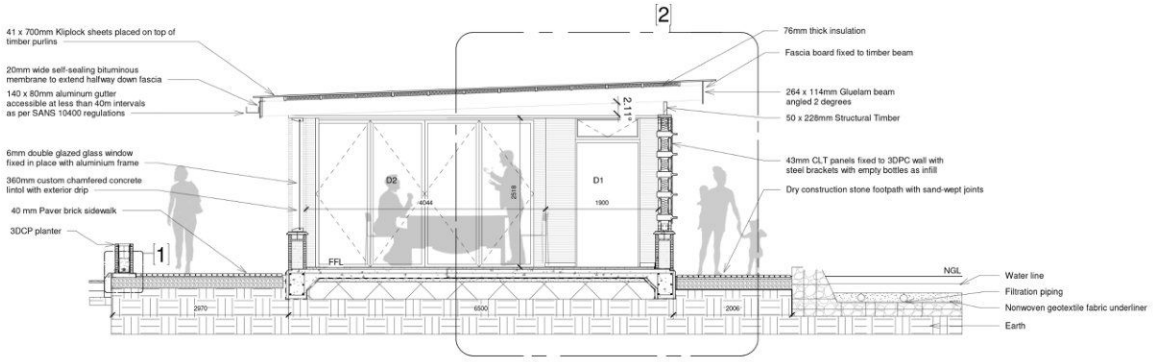
F50 100 In-situ reinforced concrete rafter slab foundations created with in-situ 3DCP

F52 - Insitu concrete floors/ roof decks

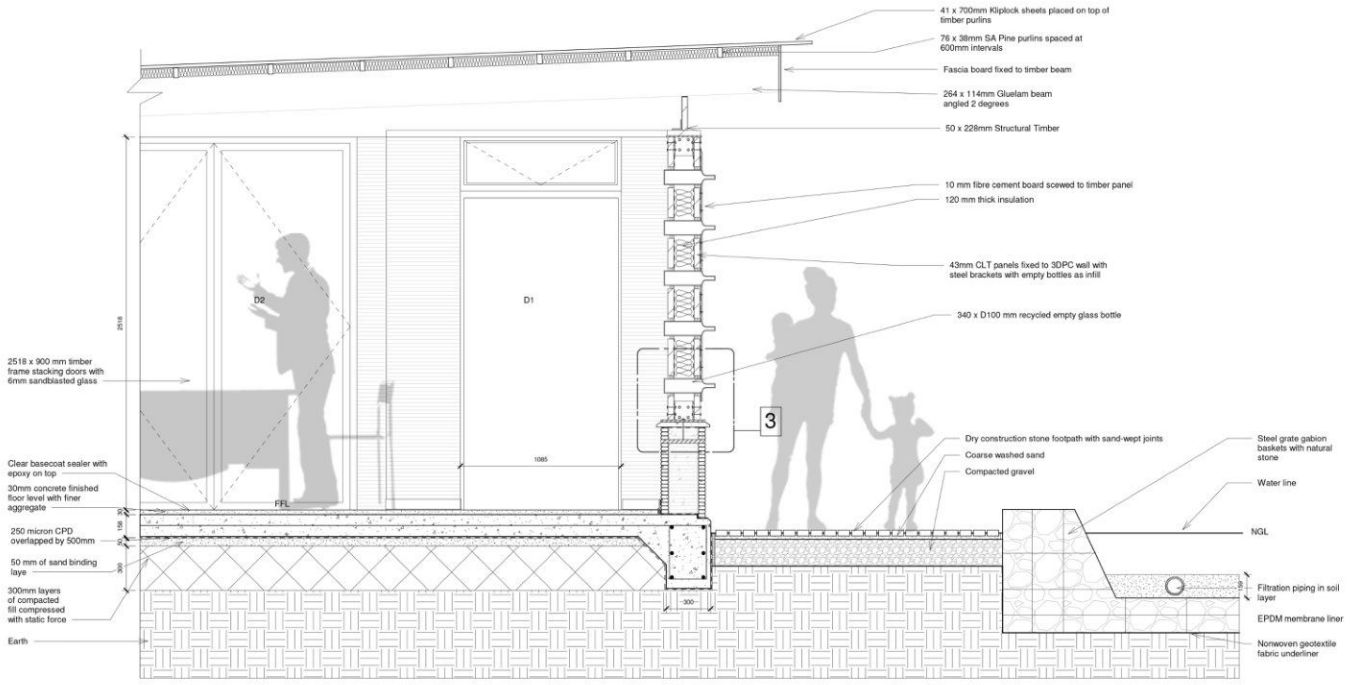
F52 100 100 mm thick concrete floor created in-situ with 3DCP

F54 - Insitu concrete frames/ wall panels/ stairs

F54 100 25 x 50 mm layers of concrete mix with perlite filler printed with 3D concrete manufacturing gantry machine, with printed walls covered with polyethylene film after printing during curing process

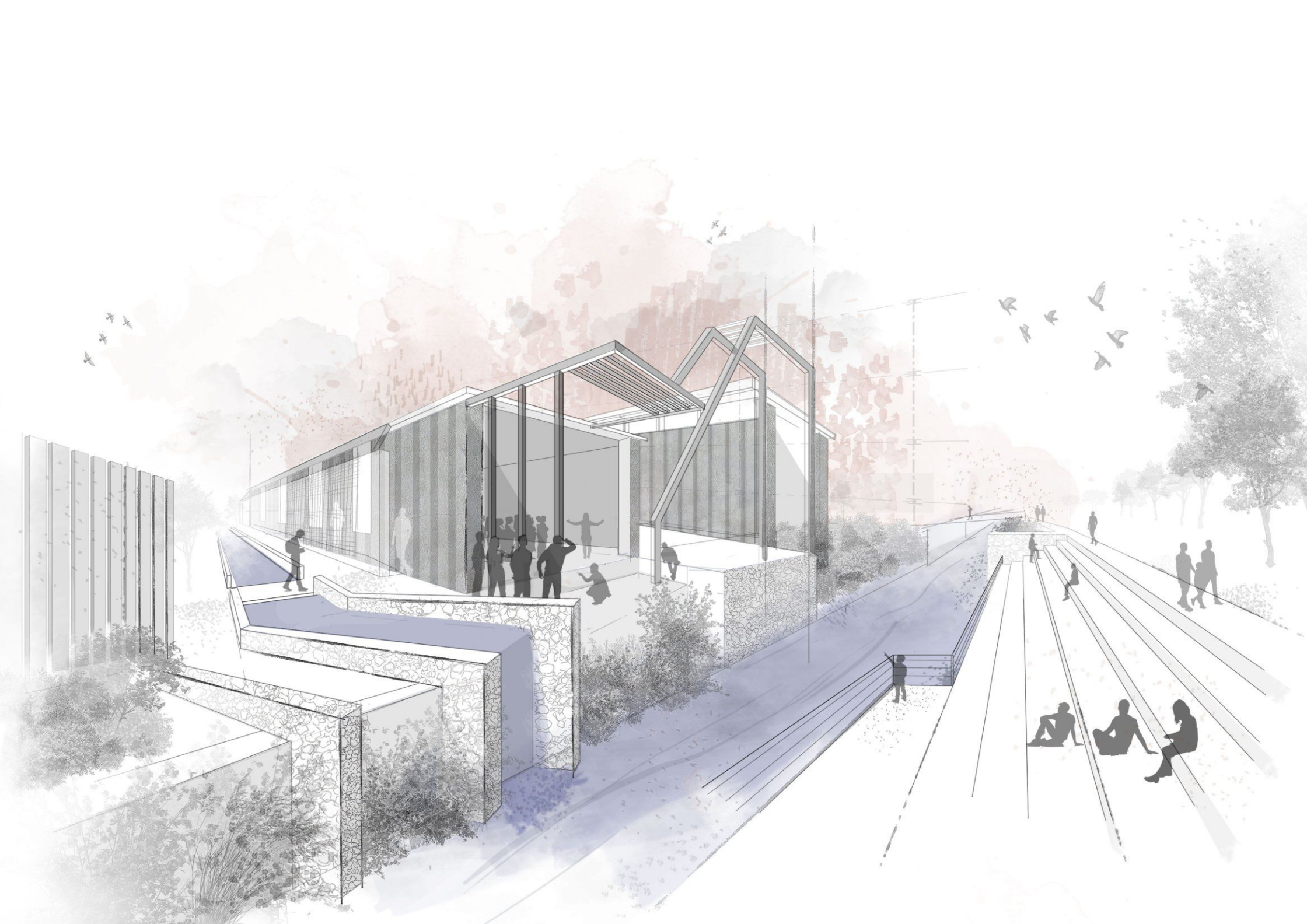


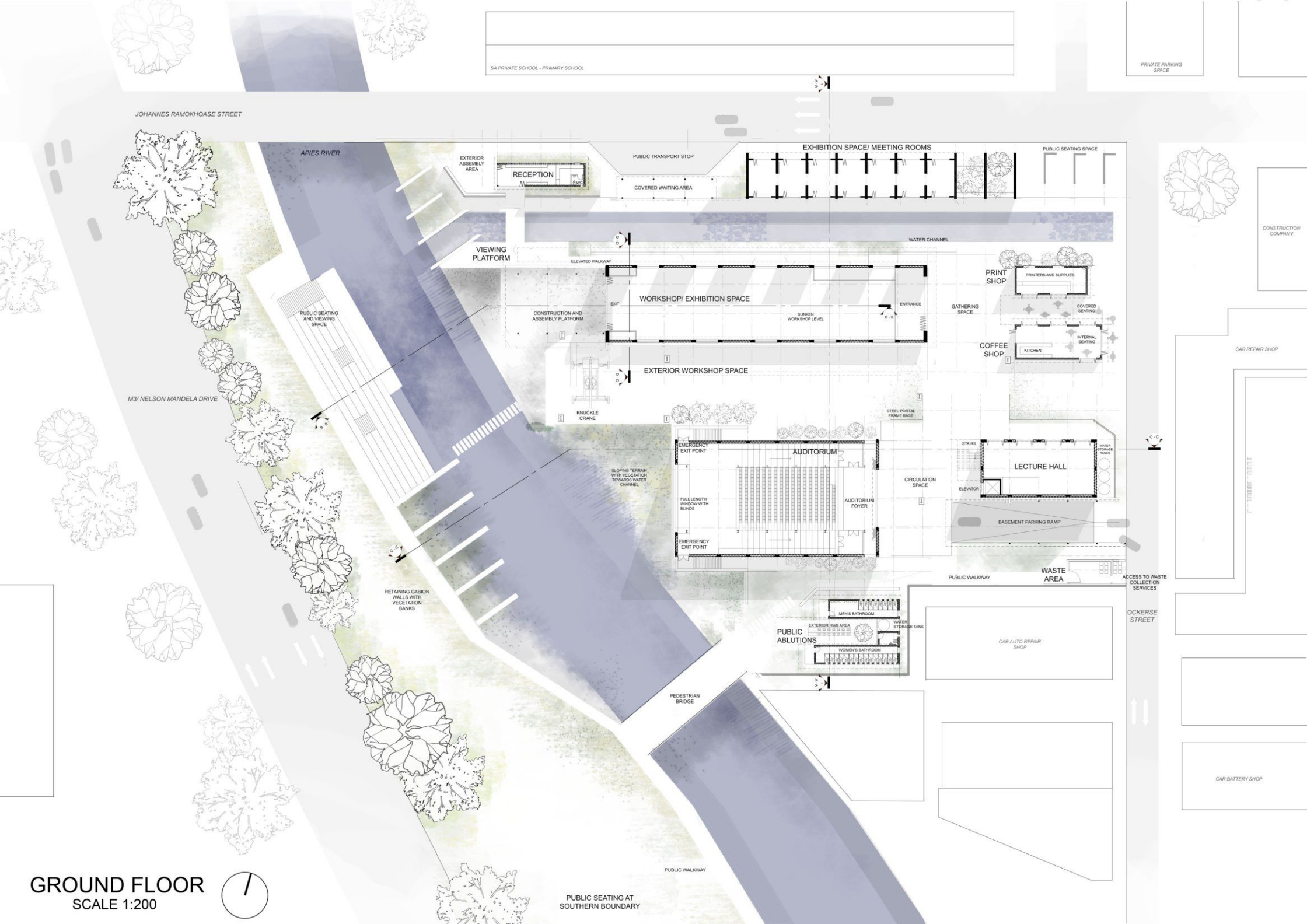
SECTION A-A
SCALE 1:50



DETAIL 2
SCALE 1:20

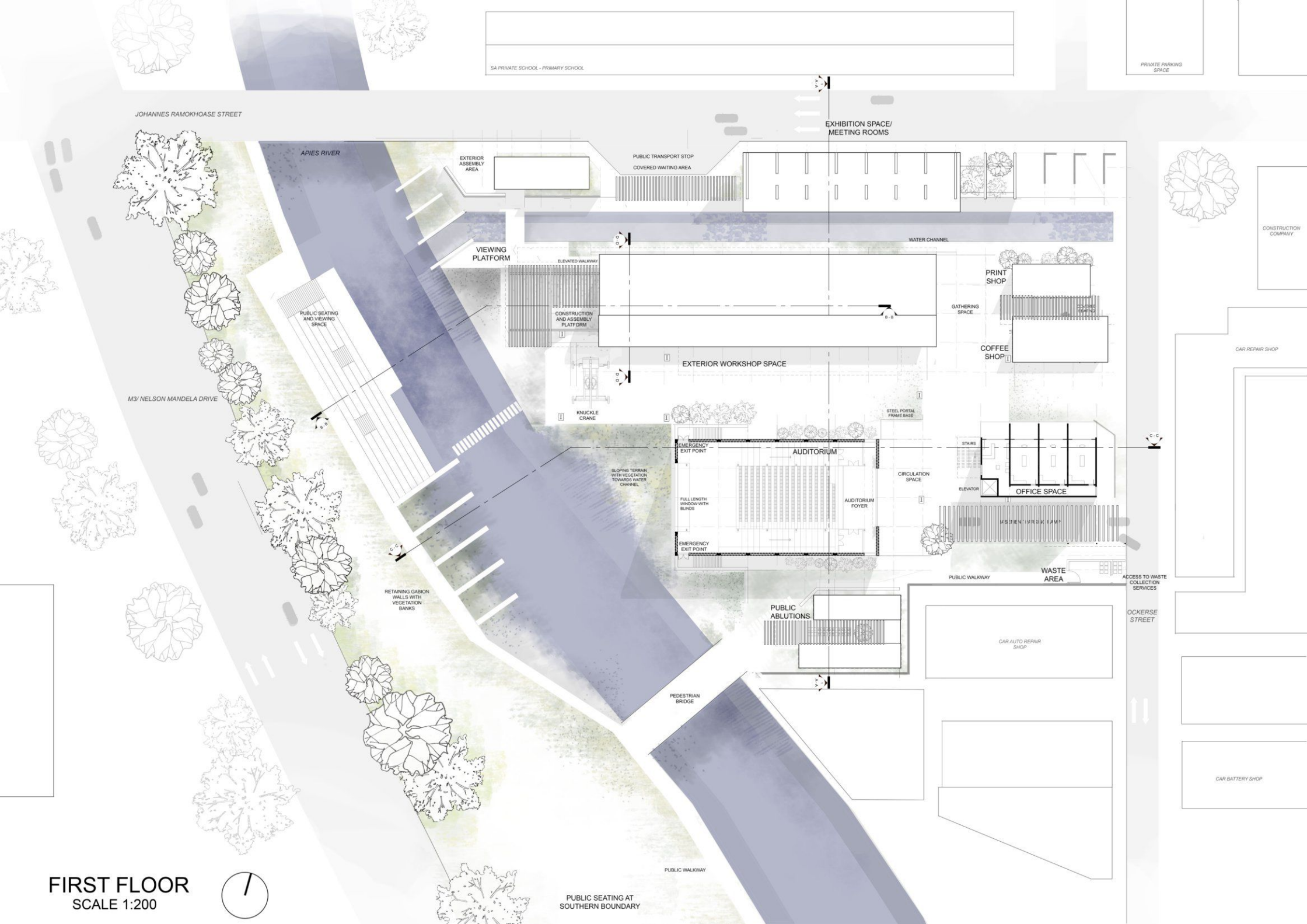
DETAILS





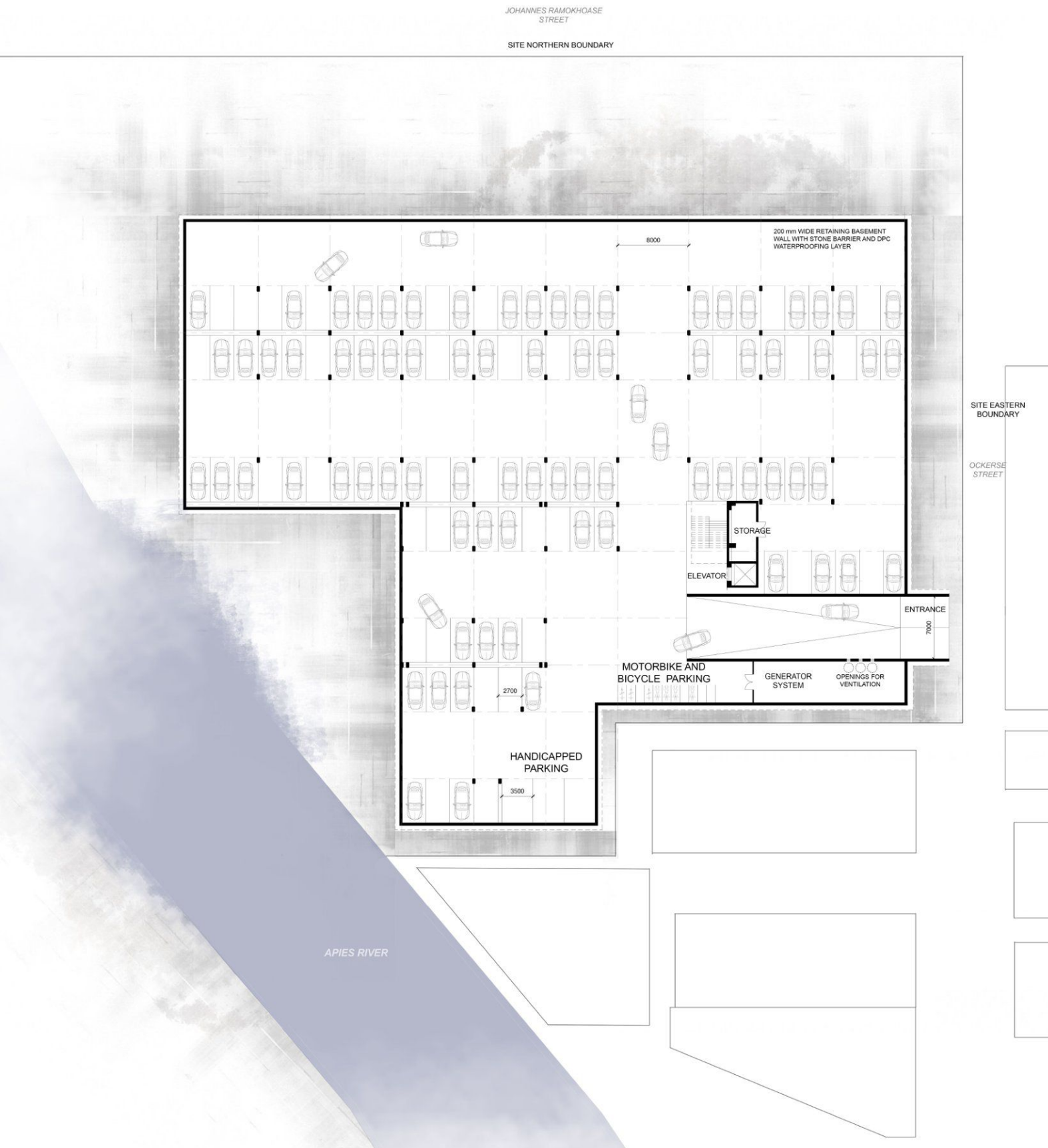
GROUND FLOOR

SCALE 1:200



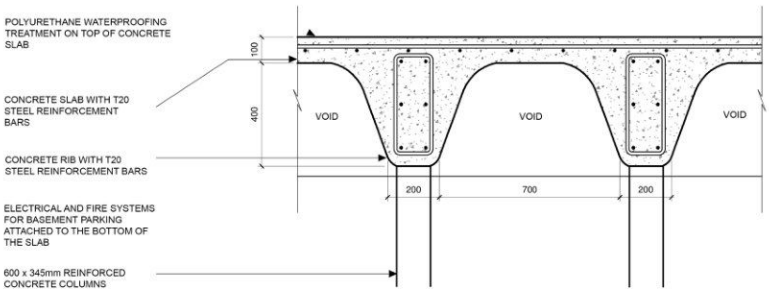
FIRST FLOOR

SCALE 1:200

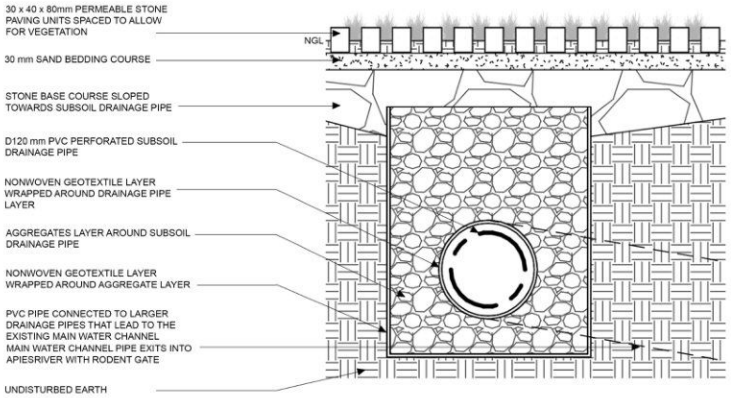


BASEMENT FLOOR

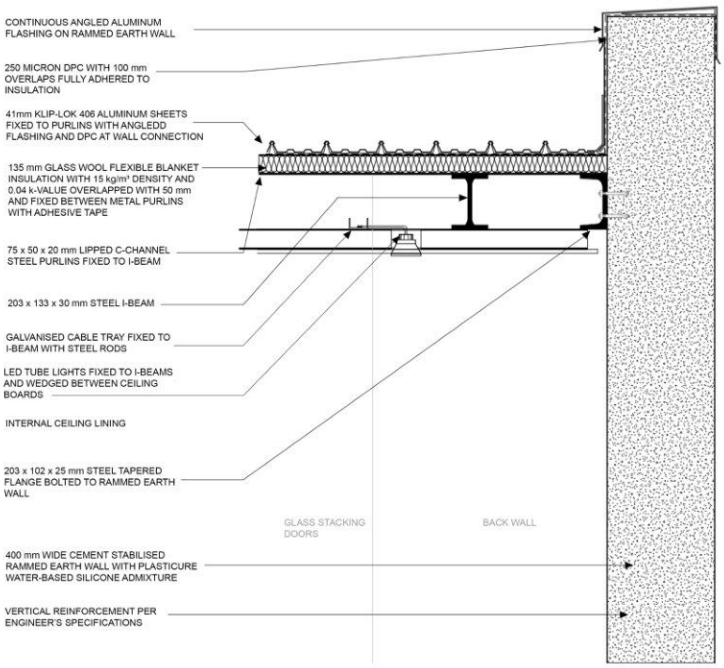
SCALE 1:200



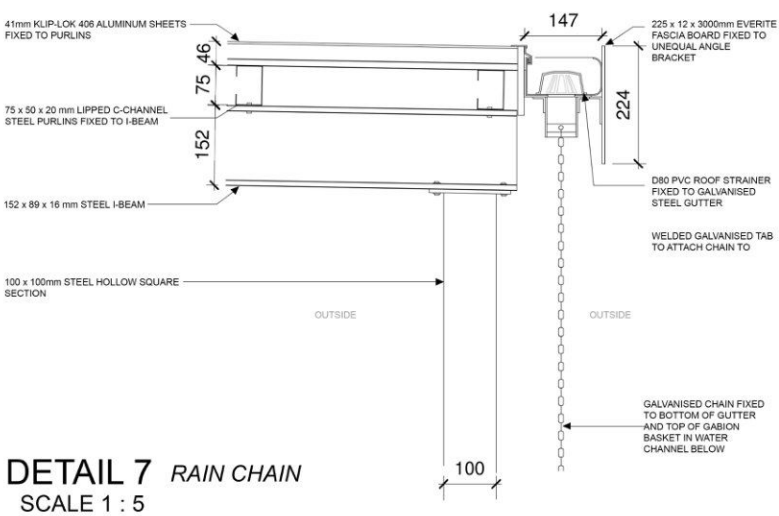
DETAIL 4 *REINFORCED CONCRETE SLAB SECTION*
SCALE 1 : 10



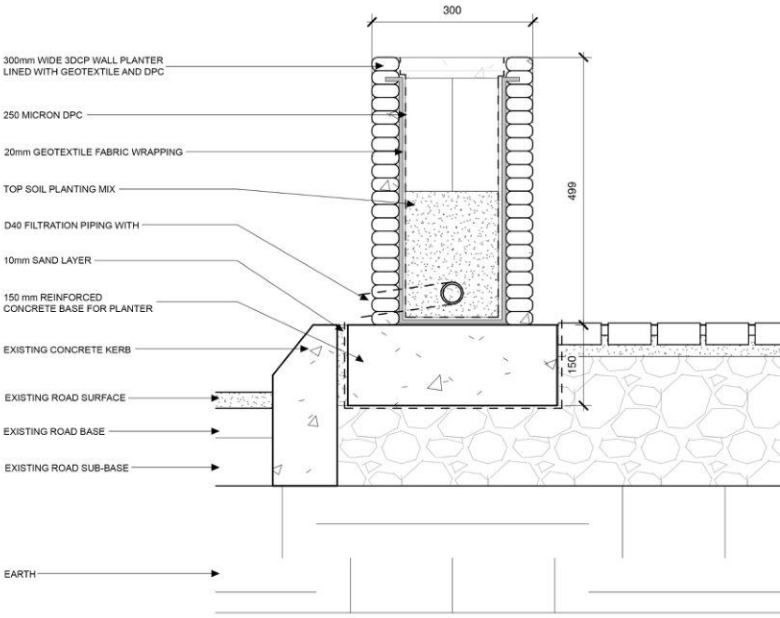
DETAIL 5 *SUBSOIL DRAINAGE PIPE*
SCALE 1 : 5



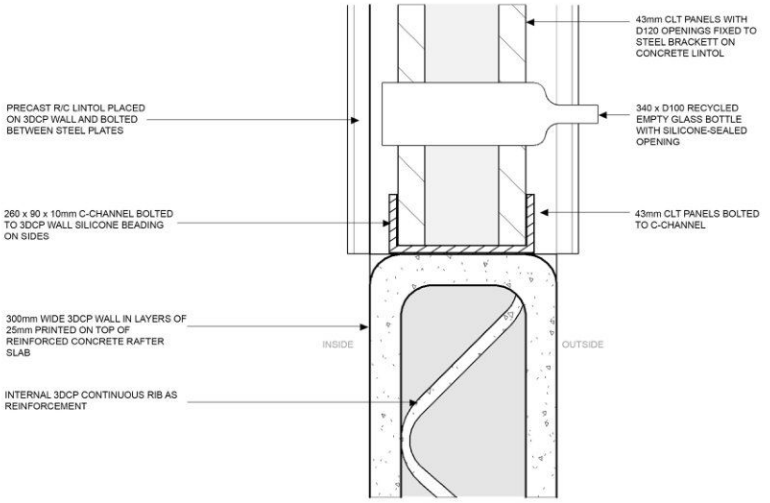
DETAIL 6 *ROOF CONNECTION DETAIL*
SCALE 1 : 5



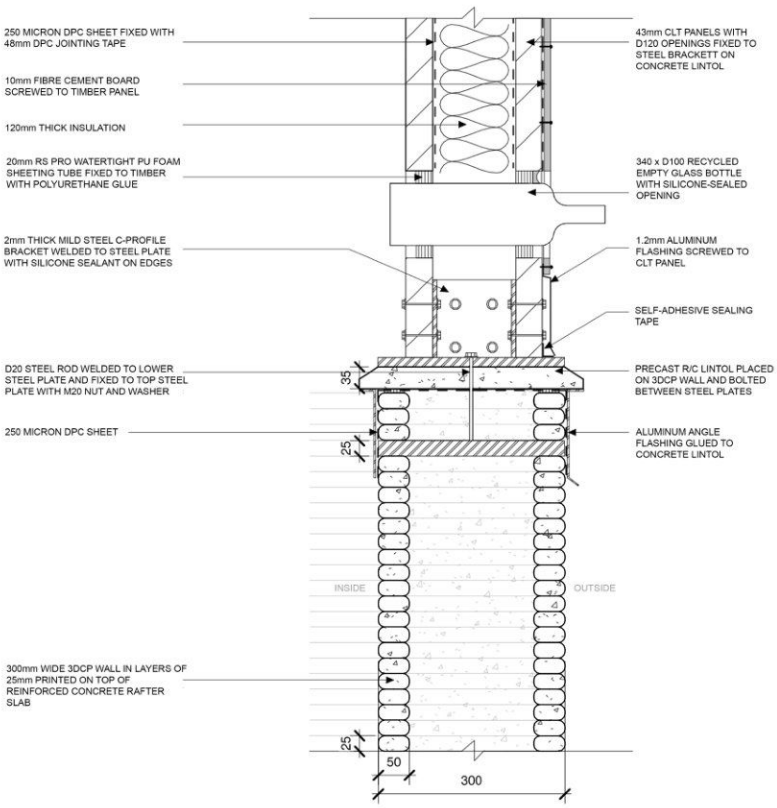
DETAIL 7 *RAIN CHAIN*
SCALE 1 : 5



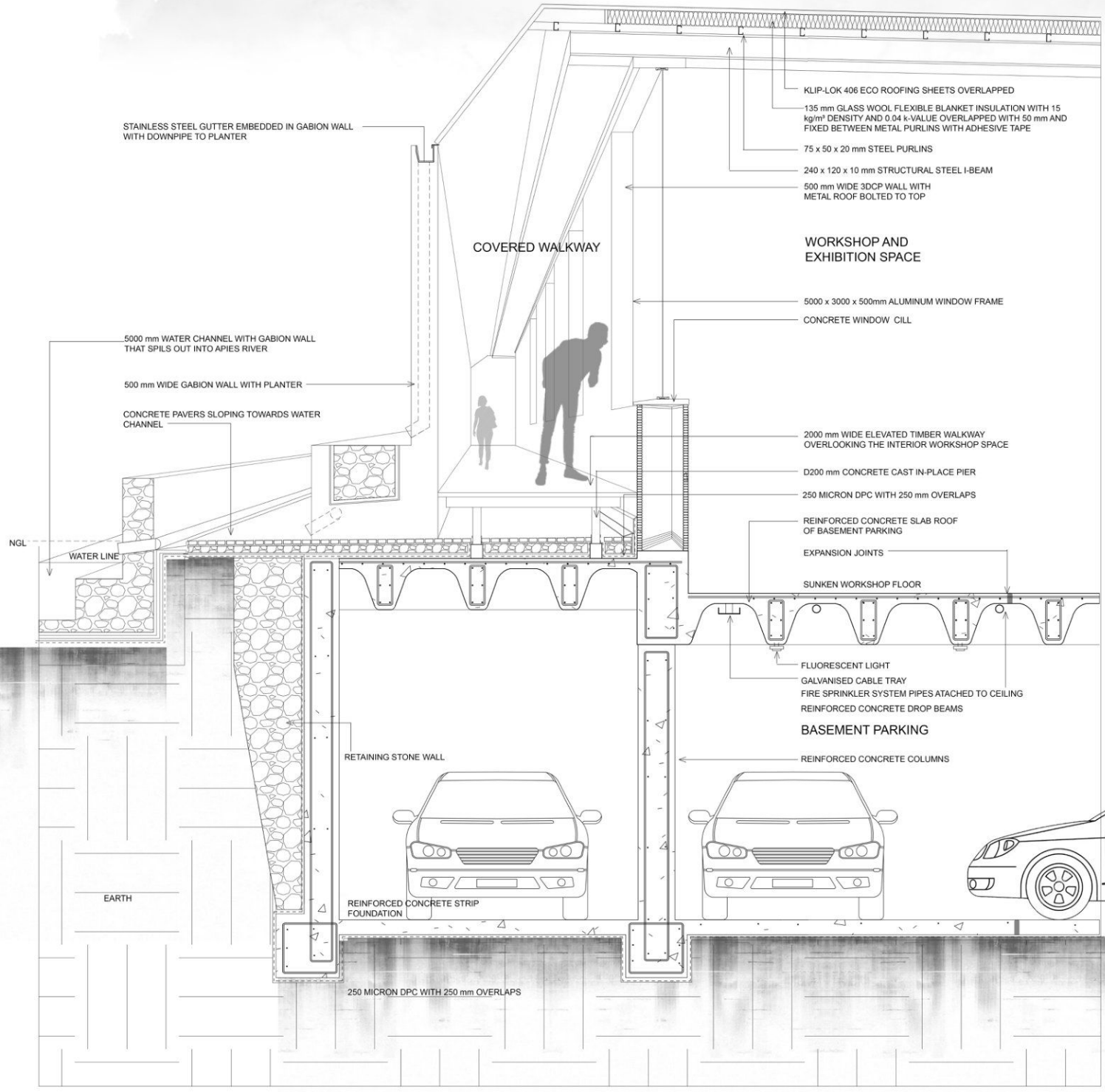
DETAIL 1 *PAVEMENT PLANTER*
SCALE 1 : 5



DETAIL 2 *3DCP WALL PLAN DETAIL*
SCALE 1 : 5



DETAIL 3 *3DCP WALL SECTION*
SCALE 1 : 5



SECTION D-D

SCALE 1:20

71 mm KLIP-LOK 406 ALUMINUM SHEETS FIXED TO PURLINS WITH OVERLAPPING SECTIONS. STRUCTURAL UNDERLAY PLACED UNDER ALUMINUM SHEETS

250 MICRON DPC WITH 100 mm OVERLAPS FULLY ADHERED TO INSULATION

356 X 171 X45 mm STEEL I-BEAM JOINT WITH BOLTED WEB PLATES IN 5000 mm INTERVALS ON TOP OF REINFORCED CONCRETE COLUMNS IN 3DCP WALLS
75 x 50 x 20 mm LIPPED C-CHANNEL STEEL PURLINS FIXED ON TOP OF I-BEAM WITH THERMAL SPACERS BETWEEN ROOF SHEETING

203 x 90 x 30 PARALLEL FLANGE CHANNEL BOLTED TO I-BEAM WITH ANGLE CLEAT WITH 200 mm GLASS WOOL FLEXIBLE BLANKET INSULATION WITH 15 kg/m³ DENSITY AND 0.04 k-VALUE OVERLAPPED WITH 50 mm AND FIXED BETWEEN METAL PURLINS WITH ADHESIVE TAPE

356 X 171 X45 mm STEEL I-BEAM FIXED TO STEEL PLATE WITH WELDED ANGLE CLEAT

6 mm FIXED GLASS PANE FIXED TO WINDOW FRAME WITH ANGLED WINDOW CILL AND WATER DRIP WITH 250 MICRON DPC LINING SEALED WITH CONTINUOUS SILICONE BEAD WATERPROOFING

CONTINUOUS STEEL PLATE CHEMICALLY FIXED TO REINFORCED 3DCP COLUMNS AT 5000 mm INTERVALS AT 3 DEGREE ANGLE EPOXY ADHESIVES USED TO CHEMICALY BOND STEEL PLATES TO REINFORCED CONCRETE COLUMNS

250 MICRON DPC IN CONTINUOUS LAYER WITH 500 mm OVERLAPS, FOLDED INTO INTERIOR AND EXTERIOR ENVELOPE SHAPE AND FINISHED WITH RUBBER FLASHING GLUED TO 3DCP WALL WITH POLYURETHANE GLUE

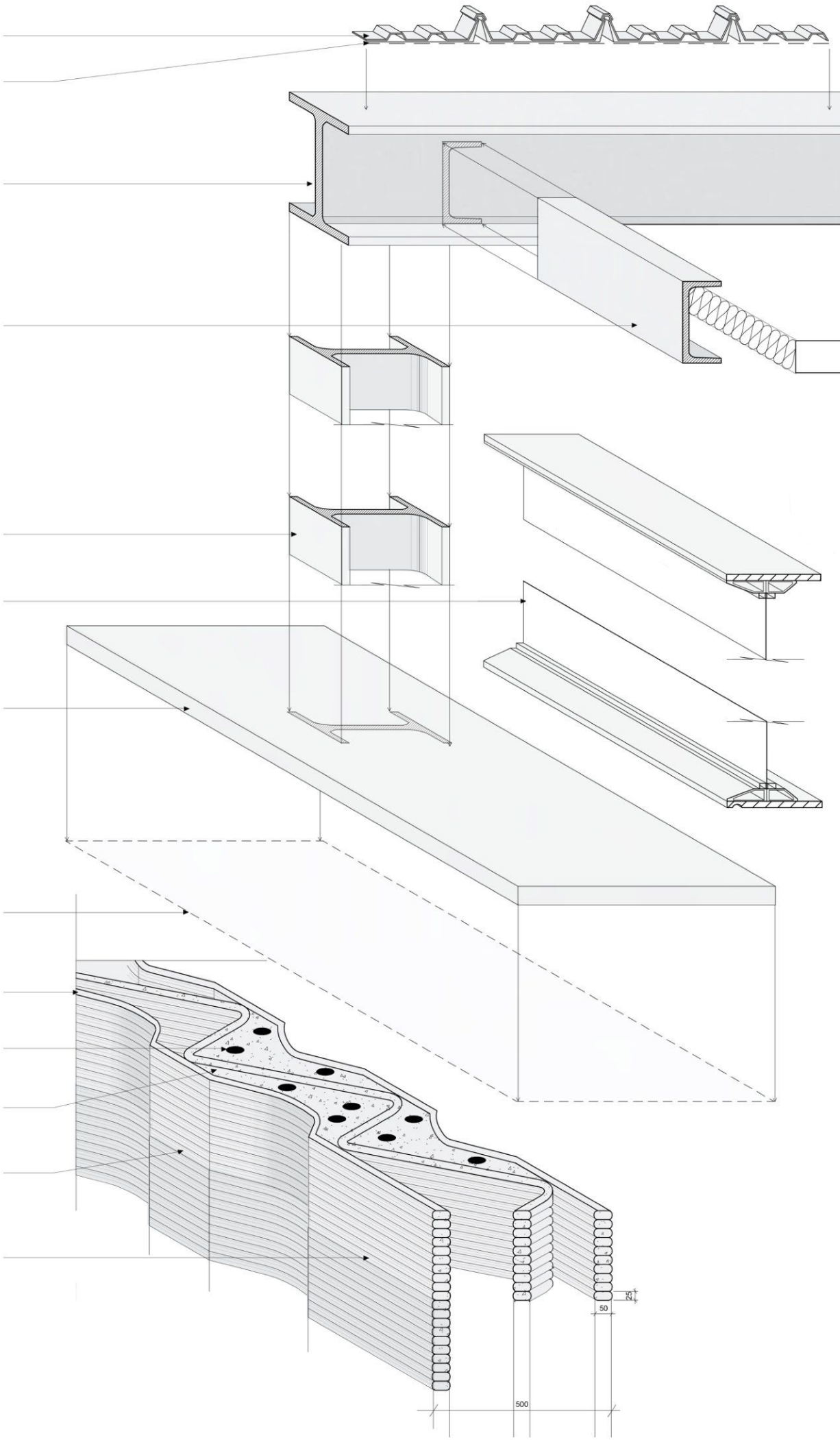
25 x 50 mm 3DCP CURVING LAYERS INSIDE THE ENVELOPE AS CONTINUOUS INTERIOR REINFORCEMENT

T32 STEEL REBARS AS REINFORCEMENT IN COLUMNS, FIXED TO REBARS IN FOUNDATION

500 mm WIDE 3DCP REINFORCED CONCRETE COLUMN WITHIN WALL ENVELOPE

500 mm WIDE 3DCP WALL IN LAYERS OF 25mm PRINTED ON TOP OF REINFORCED CONCRETE RAFTER SLAB

IN SITU CONCRETE MIX 36.8% CEMENT, 3% PERILITE, 44.9%
SAND, 14.1% WATER, 0.8% SUPERPLASTICEZER, 0.4% ACCELERATING ADMIXTURE, 0.1% SODIUMSILICATE TO BE MIXED ON SITE AND PLACED INTO PUMPING MODULE

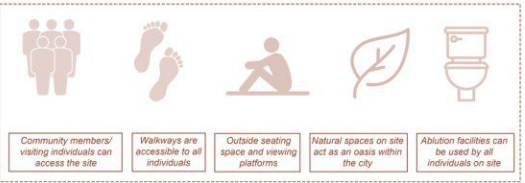


DETAIL 2 *AXONOMETRIC EXPLODED VIEW OF 3DCP WALL AND ROOF SYSTEM*

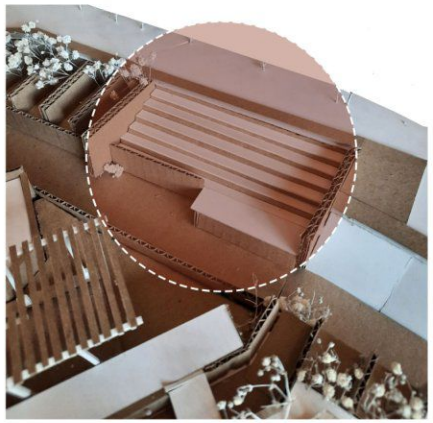
SCALE 1 : 5

MOVEMENT

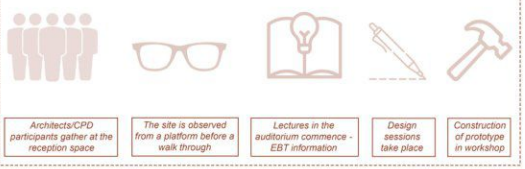
PUBLIC USERS



Community members/ visiting individuals can access the site	Walkways are accessible to all individuals	Outside seating space and viewing platforms	Natural spaces on site act as an oasis within the city	Ablution facilities can be used by all individuals on site



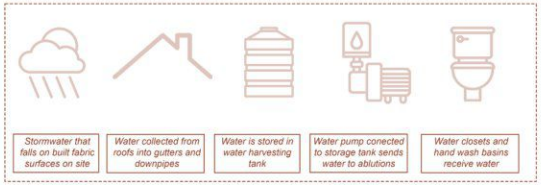
PROGRAMME USERS



Architects/CPD participants gather at the reception space	The site is observed from a platform before a walk through	Lectures in the auditorium commence - EBT information	Design sessions take place	Construction of prototype in workshop

WATER

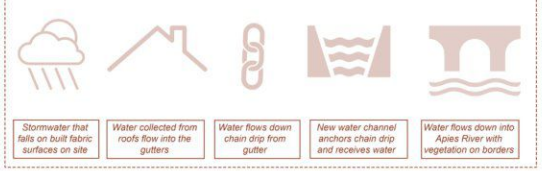
ABLUTIONS



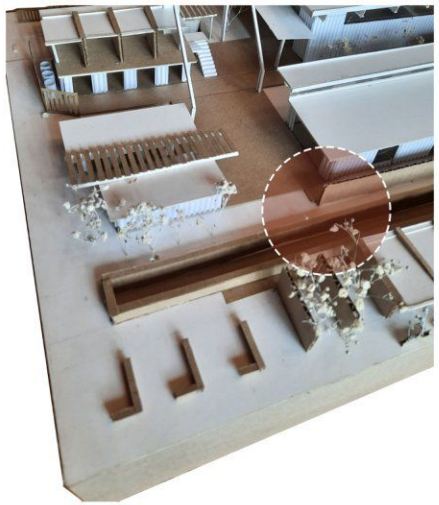
Stormwater that falls on built fabric surfaces on site	Water collected from roofs into gutters and downpipes	Water is stored in water harvesting tank	Water pump conected to storage tank sends water to ablutions	Water closets and hand wash basins receive water

WATER IS COLECTED FROM ROOFS INTO GUTTERS AND DOWNPIPES

WATER CHANNEL TO RIVER

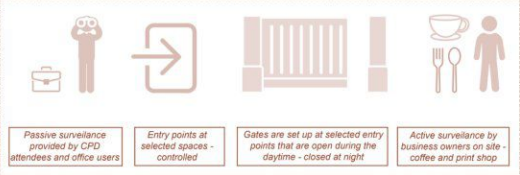


Stormwater that falls on built fabric surfaces on site	Water collected from roofs flow into the gutters	Water flows down chain drip from gutter	New water channel anchors chain drip and receives water	Water flows down into Apies River with vegetation on borders

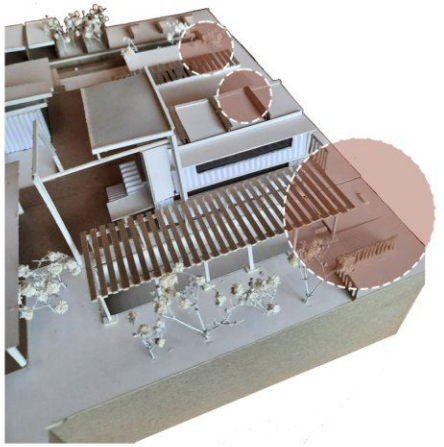


SECURITY

SURVEILANCE & ENTRY POINTS

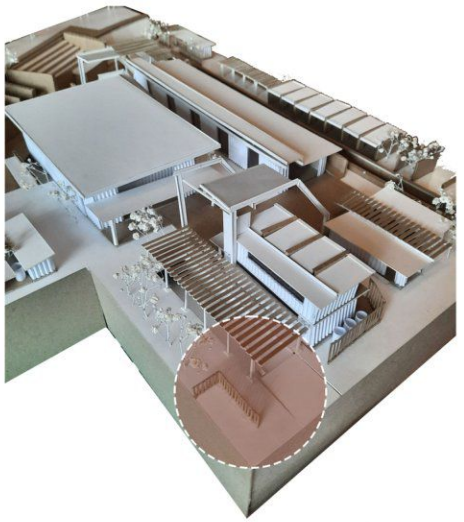


Passive surveilance provided by CPD attendees and office users	Entry points at selected spaces - controlled	Gates are set up at selected entry points that are open during the daytime - closed at night	Active surveilance by business owners on site - coffee and print shop



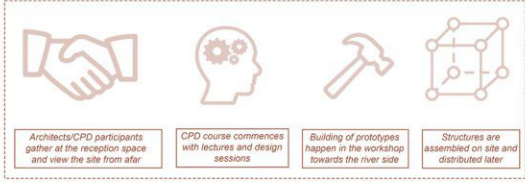
WASTE

Minimal waste from construction at the workshop and waste from the cafe is sent to waste area on site	Waste is sorted into different containers - recycling occurs on site. Minimal waste is sent away	Waste collection services come to site. Construction waste material can also be brought to site



PRODUCTION

CPD PROJECTS



Architects/CPD participants gather at the reception space and view the site from afar	CPD course commences with lectures and design sessions	Building of prototypes happen in the workshop towards the river side	Structures are assembled on site and distributed later