chapterseven

Technical Investigation

Introduction

This chapter conveys the technical investigation that was done for the dissertation. Precedents will be discussed, followed by the development of the structural systems, materiality, services and other systems. The main challenge of the technical investigation is the integration of many systems on a double storey inhabited bridge that spans just short of 30 meters.

The approach is to develop a structure that expresses the structural properties of the various elements. In order to compliment the main programme of the building, being architectural exhibition, the structure becomes an exhibition of architecture itself. Connections are expressed and act as elements that assist in the definition of the various spaces, this happens at all scales.

Aesthetically, the main aim is to use the horizontality of the design to keep it as un-obtrusive in its context as possible. The various structural elements, systems and services are all designed to complement the horizontality as far as possible. The integration of the structural, environmental and functional systems are kept as simple as possible, to avoid any interference with the linearity of the design.

In order to achieve this, the building consists of a series of layers, also linking up with the concept of foyers and the integration of various layers of spaces. A hierarchy of the systems developed as the design process developed. The structural system houses the other systems and is therefore the most important. The environmental systems, including amongst others, the water reticulation system, solar control, natural ventilation and natural daylighting are manipulated and designed to fit into the structural system.

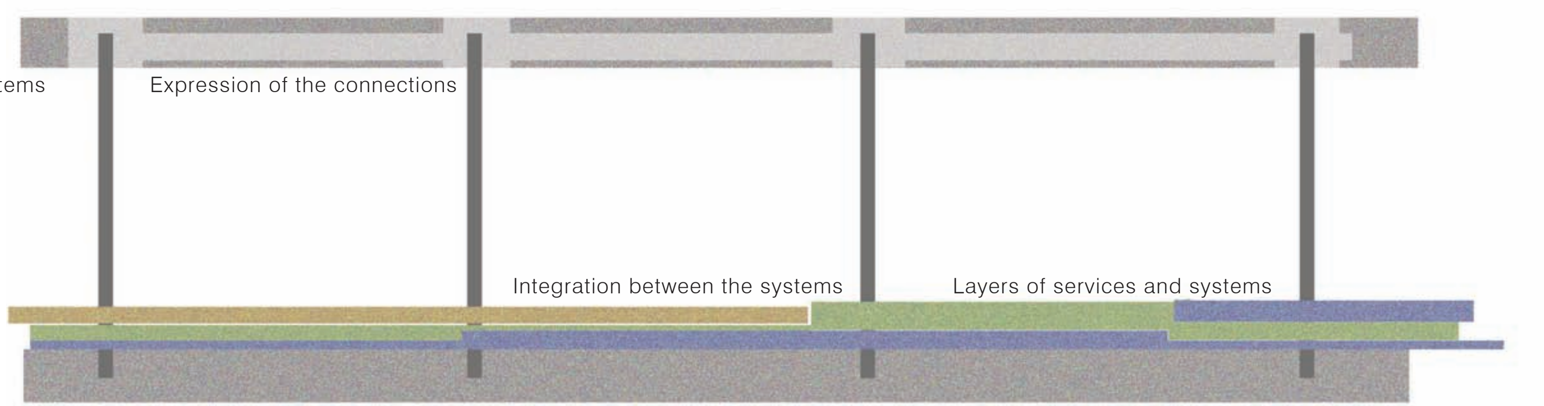

Figure 7.1 Conceptual idea for the tectonic of the building

Precedent: Land Formation One

Architect: Zaha Hadid

Programme: Exhibition spaces, restaurant, offices

Size: 845m²

Client: City of Weil am Rhein, Garden Festival 1999

Formation One is an exhibition space that sits in a park, but it does not sit as an object in the landscape. The shape of the building was derived from existing pedestrian movement patterns on the site. These movement patterns were manipulated, elevated and curved to create the exterior and interior geometry of the building.

The building can be approached from any side and the walkways allow the pedestrian to experience the building from more than one level, allowing views into the interior from the exterior.

The main exhibition space is predominantly double volume. It allows natural sunlight in, but no direct sunlight that can damage the exhibitions.

The linearity of the plan makes it possible for secondary and service spaces to be hidden as one does not experience them, but rather the linearity as one moves through the spaces.

The use of materials is manipulated; softer materials are used where there are openings in the facade. Protrusions from the facade further introduce entrances and openings on the facade.

The edges of the building are designed to unify with its context and environment. Thresholds are accentuated as part of the edge

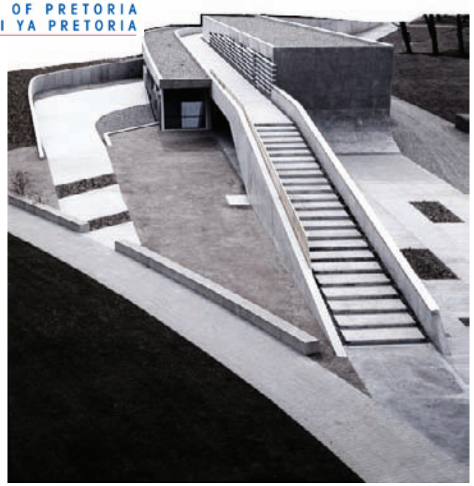
Figure 7.2 Elevated walkways


Figure 7.3 Naturally lit interior spaces


Figure 7.4 Exterior edges of the building4

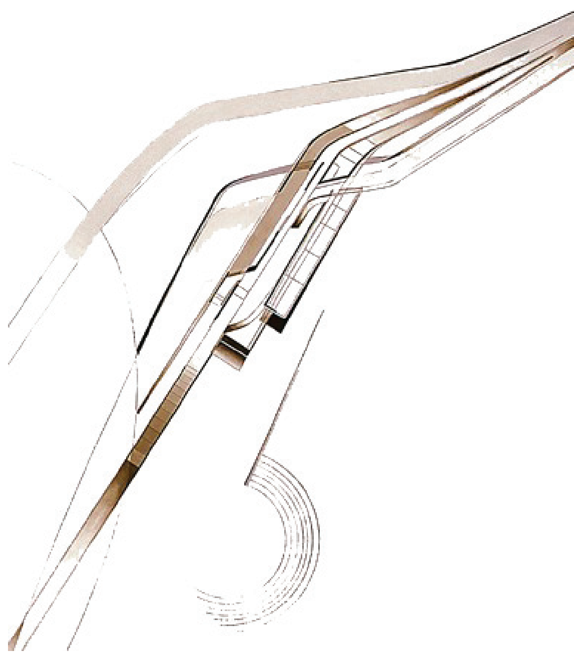
Figure 7.5 Linear plan extending into the landscape


Figure 7.6 Pedestrian experience of the building

Precedent: Ponte Vecchio

Architect: Neri da Fioravante (rebuilt)

Programme: Inhabited bridge

Location: Florance, Italy

Client: Cosimo I de'Medici (1565 corridor commission)

The Ponte Vecchio is one of Florence's most iconic landmarks. The inhabited bridge with its stone columns and planks was probably constructed in the Roman times (www. italyguides.it/us/florence).

The specific programmes of the spaces on the bridge change continuously, but the bridge's function as a public space remained throughout the centuries.

In the 1900's the bust of Benvenuto Cellini, the ingenious Florentine goldsmith and sculptor, was placed on the bridge. The celebration of designers within the public realm is used as precedent in this case.

The linking element of the bridge, linking the inner city of Florence to its eastern outskirts, contributes to the practical functionality of the structure.

The Ponte Vecchio is an appropriate precedent in this case as it is an inhabited bridge, that continuously adapts in terms of programme, links two urban spaces, is a truly public space and a landmark in the urban landscape.

Figure 7.7 The Ponte Vecchio inhabited bridge, Florence, Italy

Figure 7.8 Southern view of the Ponte Vecchio

Precedent: The Bauhaus

Architects: Walter Gropius, Carl Fieger and Ernst Neufert

Programme: "School of Building", design school

Location: Dessau, Germany

Client: City of Dessau

Figure 7.9 Inhabited Bridge at Bauhaus

The Bauhaus building in Dessau was completed in 1919. The design refines Walter Gropius's architectonic ideas that he first put into practice before WW1.

The different parts of the building are separated and each designed differently. The building can only be fully appreciated if the observer moves around the entire building as there is no central view point.

Figure 7.10 Transparent facade

The construction of the building is celebrated through the exposed connections and the edges that are accentuated where the glass surfaces overlap the edges.

Both the interior and exterior surfaces are painted in a light pallet, which contrasts vividly with the dark, continuous strip windows that define the facades. The large curtain wall facades allow for the building to appear transparent, especially at night time, as well as allowing ample natural light into the interior spaces during the day.

Figure 7.11 Interaction with street

Figure 7.12 Horizontality of facade

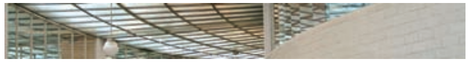

Figure 7.13 Natural lighting through roof

The accessibility of the structure, the way it is integrated with its context, compliments the simplicity of the final product.

The principles identified from the physical Bauhaus building have all played an integral part in the design of the BESC. Some of the most important design generators were to create an environment where architectural education and production can be showcased, as well as a structure that is accessible to all and can be approached from many sides.

Figure 7.14 Interaction with inhabited bridge

Figure 7.15 Events hosted at facility

Figure 7.16 Treatment of direct sunlight

The principles identified through this analysis assisted in the programme development as well as the physical attributes of the designed structure.

principles from the physical bauhaus building

showcasing architecture - transparency as principle

emphasis through composition and material use

individual design of different parts

hierarchy of spaces - functional separation of programmes

building can be approached and experienced from all sides

limited amount of defining elements on facade - accessible to all

inhabited bridge as part of the design

connection/foyer spaces

event spaces

colour pallet - light interiors and contrasts on facade

Quality of interior spaces


Figure 7.17 Approach from many sides


Figure 7.18 Interaction encouraged


Figure 7.19 An object in the landscape


Figure 7.20 Detailing of services


Figure 7.21 Protruding balcony


Figure 7.22 Experience on ground level


Figure 7.23 Quality of interior spaces

Precedent: Transportation Hub, New World Trade Centre

Architect: Santiago Calatrava

Programme: Transportation Hub

Location: New York, USA

Client: Port Authority of New York and New Jersey

In the design of the new Transportation Hub, as part of the New World Trade Centre, Ground Zero in New York, Santiago Calatrava envisions a luminous, cavernous design, that offers the commuter a sense of flight.

The functional heart of the transportation hub is a mezzanine level, below ground, that links the main arrival hall and PATH terminals. The space is designed to be a open space without any columns obstructing the commuters. A large Vierendeel truss, spanning over 30 meters, is used to create the required span.

Arthur Vierendeel developed a method to calculate the strenth of a truss without diagonal bracing, but only vertical bracing with rigid connections, in 1896 (http://users.telenet.be/karel.roose/vierendeel/vierendeel.html). The Vierendeel truss's connections are factory welded connections, to achieve the rigidity required to be able to resist the bending forces.

The Vierendeel truss used in the Transportation Hub is referred to as its spine. The first two segments of the spine was constructed on 8 March 2011. The design and construction process of a Vierendeel truss are so complex that Mr. Billy De Pasquale, main field opperator of the World Trade Centre Construction, stated: "you don't get many days like this," on the day the first two segments were erected.

Figure 7.24 Architectural presentation of Transportation Hub, NY

Services and Systems

The structure is divided into three parts: the northern wing is a masonry structure, recessed into the natural embankment on the northern side of Lynnwood Road; the bridge, a steel structure, mainly supported by four Vierendeel trusses; and the southern wing, a three storey masonry structure. Each part will now be discussed individually, with main challenges highlighted.

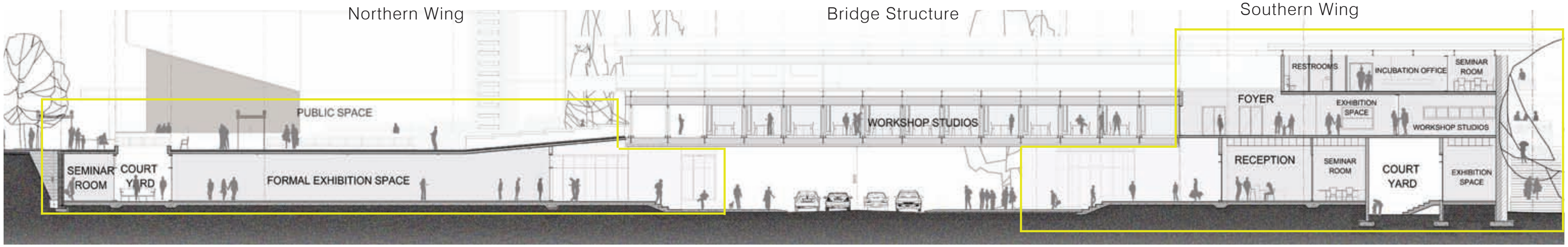

Figure 7.25 Three structural components of the BESC

The horizontality of the design is achieved through a flat public square that links a natural embankment on the northern edge with the bridge over Lynnwood Road. The space below the public square is excavated and the FES is designed to be below it. The northern wing is a regular masonry structure, with a retaining northern wall (Fig 7.26) and large glass facades on the southern edge that invite observers into the FES as they pass, as well as allowing natural southern light into the exhibition spaces. All wet work of the northern wing will be completed before construction starts on the bridge structure.

The link between the northern wing and bridge structure is a 150mm concrete sloped pedestrian walkway, seperated from the steel structure with a 40mm minimum expansion joint. The ramp should only be constructed once the steel structure has been erected and settled, this will allow for a seamless transition between the spaces.

The foundations of the northern wing are regular strip foundations. The roof of the FES, also the floor of the public square, is in-situ cast concrete, with pavers and storm water is managed through sloped screeds, as per the storm water plans.

Three courtyards (Fig 7.26) are designed to allow ample natural light into the FES. Due to the level difference between the public square and the FES, balustrades protect the pedestrians in the public square. The courtyards also allow for interaction between the different levels of the northern wing.

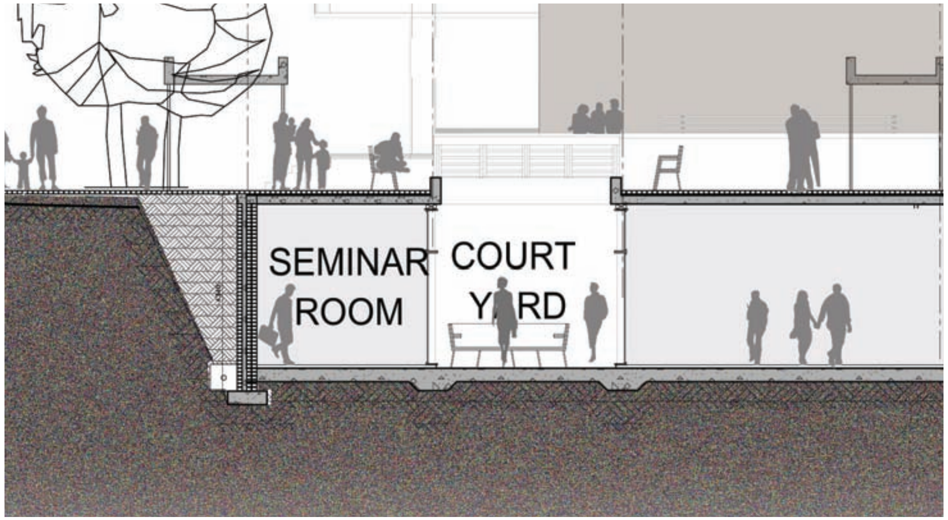

Figure 7.26 Section through northern retaining wall

Vierendeel truss:
an open-web truss with vertical members, but without diagonals and with rigid joints. (http://www.merriam-webster.com/vierendeel%20truss)

Bridge

The bridge consists of a steel structure with infill panels. The main structural elements are the four Vierendeel trusses that also act as the facades of the bridge.

The bridge is the main element in the design. Technically, the bridge is the main structural challenge and the approach is to resolve the different challenges through many different layers, coordinating the different layers to integrate into one functional unit.

The horizontality of the design is achieved through the linearity and the absence of protruding elements on the facades and roofs, resulting in a simple horizontal aesthetic on the exterior facades.

The most important layer or system of the bridge is its structure. Eight concrete columns are designed to support four Vierendeel trusses. The properties of the Vierendeel truss are discussed in detail, to clarify the specific structural choice and what implications it has on the design of the BESC.

Vierendeel Truss

The Vierendeel frame or truss, as it is more commonly referred to, consists of a top and bottom chord with rigid vertical bracing (Wickersheimer, 1987: 54), creating a series of rectangular frames (Fig 7.26). The shear force in a Vierendeel frame is transferred through bending moment in the joints and the vertical members, resulting in all members being combined stress members, with axial, shear and bending stresses.

The Vierendeel gains rigidity with increased depth (Ibid: 59). It is, however, heavier than regular cross braced trusses that can handle the same load, due to higher cross sectional areas of the members, in order to resist the bending moments through the rigid connections.

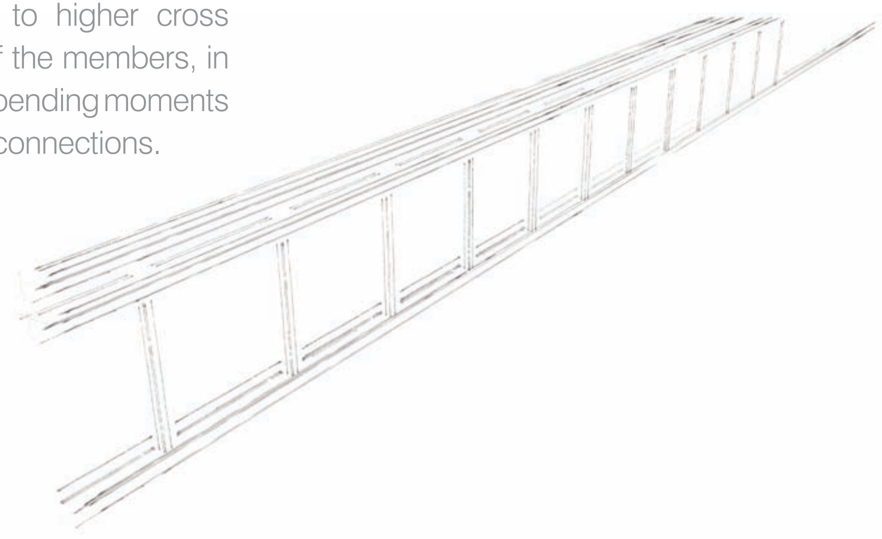

Figure 7.27 Vierendeel truss with horizontal chords and vertical, rigid supports

Design requirements

- The structure is to have long span capabilities (almost 30 meters);
- The structure should be economically viable;
- Speed of erection is important, not to effect vehicular activity in Lynnwood Road.

Opportunities

- The full expression of the entire structural system;
- Floor-to-floor structural depth;
- One truss can carry two floors;
- No additional materials required to resist torsion;
- The economy in transportation of materials.

Design considerations of the Vierendeel truss

Physical – transportation and modularity

Max height of truss: 3 200mm

Max length of component: 12 000mm

Maximum weight of component to be considered by engineer.

Structural – Optimal cross sectional area in top and bottom chord

Rigidity of connections is essential – it has been proven that a hybrid between rigid and pinned connections can be achieved and should be considered by the engineer for material economy.

The connections between Vierendeel Truss and concrete columns bearing the load should be bolted to allow for movement of the truss, due to live load, creep, shrinkage and temperature changes.

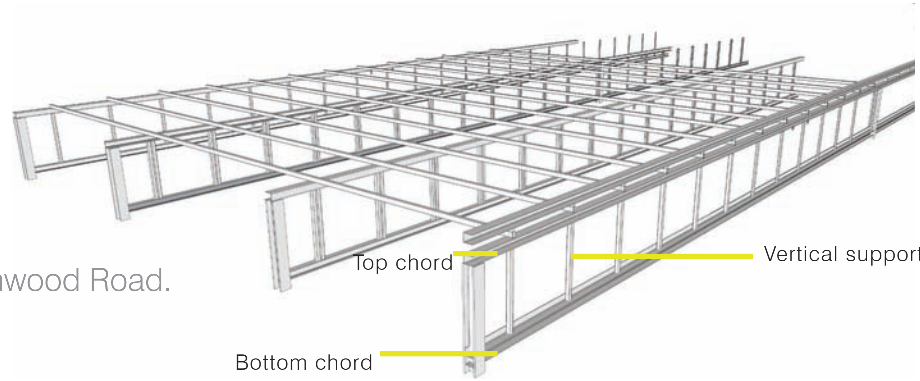

Figure 7.28 Four Vierendeel trusses, laterally braced to form one steel structure

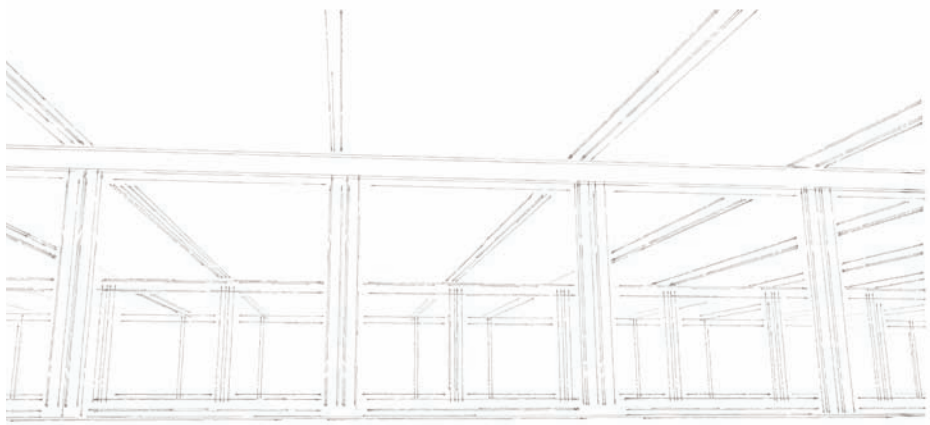

Figure 7.29 Rectangular openings in Vierendeel truss

Height of Lynnwood Road bridge

The maximum height of the truss is determined by the legal height of a truck carrying a load, in order to get the truss to the site successfully. According to the South African Road Ordinance, the maximum height of a truck load is 4291mm. The truck required to transport the factory assembled Vierendeel truss segment is 1400mm high, leaving 2891mm for the height of the load. According to the South African National Road Agency Limited (SANRAL), a special permit can be issued, allowing total heights of up to 5000mm. The trusses are designed to have a total height of 3550mm, making it possible for the factory assembled segments to get to site.

Advantages of the Vierendeel truss

- The facade is not ornamental;
- The structural elements do not have to be covered;
- It makes the structure lighter and cheaper;
- "The structure can become architecture";
- Unification of aesthetic expression, function and economy;
- No cross members, allowing rectangular openings for access (Fig 2.29).

Seconday structure

Additional lateral supports are required to connect the Vierendeel trusses, creating one integrated steel structure. The secondary structure consists of a series of I beams spanning between the Vierendeel trusses. The secondary structure is discussed as part of the Construction Process, in order to successfully communicate the relation between the primary (Vierendeel) and secondary structures.

Infill

The infill is added to the structural layer. The infill can also be divided into several groups, the main groups being the Formica Solid Core wall panels and the Slimdek floor and roof systems.

Due to the different thermal capacities of the different materials, most panels are separated from the structural steel with spacers that allow for movement, without damaging other elements. The spacers between the materials act as another 'layer' added to the design; and it facilitates the integration of the different materials.

The infill components inside the steel structure should only be installed after the steel structure has settled, to avoid unnecessary cracking of the members.

The services and systems on the bridge are designed to integrate with the infill panels.

The aim of the infill layer is to create the desired aesthetic and practical functionality as well as complimenting the horizontality and linearity of the design.

Figure 7.30 Composite light weight concrete flooring and roofing system

Slimdek floor and roof systems

Slimdek (Fig 7.30) is an engineered floor and roof solution, designed to offer minimal depth light weight concrete slabs for use in multi storey steel structures. The system is designed to be integrated with the services of a structure, making it more cost effective. The Slimdek systems can handle grids of up to 11 x 11 meters.

The Slimdek is used as both floor and roof structures in the design. It consist of G275 spelter galvanized steel roof sheeting, and light weight concrete. The 75mm deep light weight concrete slab is cast after sheeting and service conduiting is in position. Units shall butt joint on the centre line of the supporting steel beam and be fixed to the beam by means of 20mm hammer drive galvanized steel screws, according to the structural engineer and manufacturer's specifications.

Slimdek total depth of 150mm minimum is covered by minimum 40mm screed (Fig 7.31), to slope at minimum 1:80 to full bore or similar water outlets. The final finish of the flooring systems is polished, self leveling, epoxy resin, cast in blocks of no larger than 1500mm x 1500mm and sealed with elastic waterproof clear silicon, to absorb the movement of the steel structure.

According to Andrew Orton's The way we build (1987, 22-34), cold formed steel decking with composite concrete topping has a typical depth of 100 - 150mm, typical span of 2-4m and typical L/d ratio of 25 - 30. For fire protection, concrete needs to be thicker than 40mm. In this system the dimensions are: Length = 3000mm, depth = 150mm and the ratio L/d = 20. This is well under the recommended ratios. The Slimdek system has a two hour fire rating.

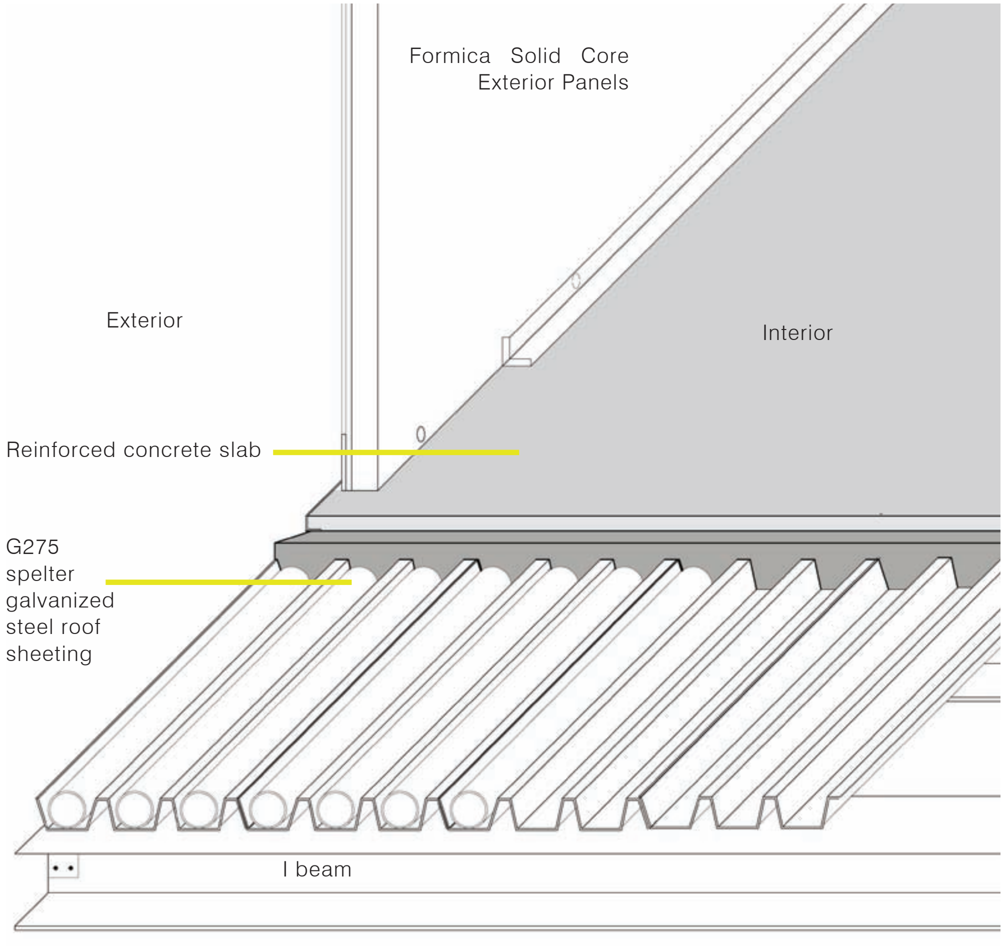

Figure 7.31 Slimdek detail

Formica Solid Core Exterior Grade Paneling

PG Bison Formica exterior grade Solid Core panels are specified as the infill paneling. It is a self-supporting, water resistant, prefinished decorative product, with high resistance to mechanical, chemical, heat and environmental damage. The exterior grade is specifically used where ultra-violate lighting and environmental damage is critical.

The exterior side of the panel has an acrylic sheet overlay for UV protection and acoustic sheeting under the acrylic layer. All the cutting should be done with carbide tipped tools only, as specified by PG Bison. Chipping should be avoided by using a scoring blade. The panels are to be glued to the steel structure with polyurethane based adhesives, according to the manufacturer's specifications. The polyurethane adhesives are flexible and will allow the Formica boards to move with the steel structure, in order to avoid cracking of the panels. All sides are to have polypropylene seals, to insulate the interior spaces, but allow the structure to be able to absorb the movement of the steel structure.

On the two inner facades of the bridge structure, on the Bridge Level, the Formica Solid Core Panels are purpose made panels that can open (Fig 7.32). The panels are supported by heavy duty hinges, factory welded to the 100 x 100 x 10mm square tubing that act as the vertical support of the Vierendeel truss. The panels run on galvanized swivel gate wheels over the Slimdek floor finish, see DETAIL 3 (see page 164-165).

Figure 7.32 Perspective indicating openable Formica panels on inner facades of Bridge Level structure

Figure 7.33 PG Bison Solid Core Formica Panels

Operable wall systems

Advanced Equipment, Type 5MS operable walls are designed to be stored in PG Bison Formica Solid Core Containers, situated on the eastern side of the Production Studio.

The walls are top supported by 148 x 89 x 11mm pre-painted mild steel hollow core square tubing, welded to the underside of Vierendeel horizontal chords. The square tubing acts as guide-rails for the movable wall panels, as specified by the manufacturer.

The maximum height difference between the finished floor level and the underside of the guide rail is 2150mm.

Each panel is individually suspended and operated manually, to allow maximum flexibility of the system. The inner facades of the bridge structure are designed to allow the operable panels to penetrate the facade, into the circulation space as well as the Workshop Studio spaces on the western side (Fig 7.33).

The panels are designed to accommodate exhibitions, making it possible to redesign the space as often as required. This system, together with the operable facades of the two spaces, define the bridge circulation space and create the opportunity to turn the entire bridge structure into one urban exhibition room. The movement of the observer as well as the experience can be manipulated through the positioning of the different panels.

No tracks are required on the floor, as each panel is equipped with two trolleys, making it more versatile without jeopardising the linearity of the overall design.

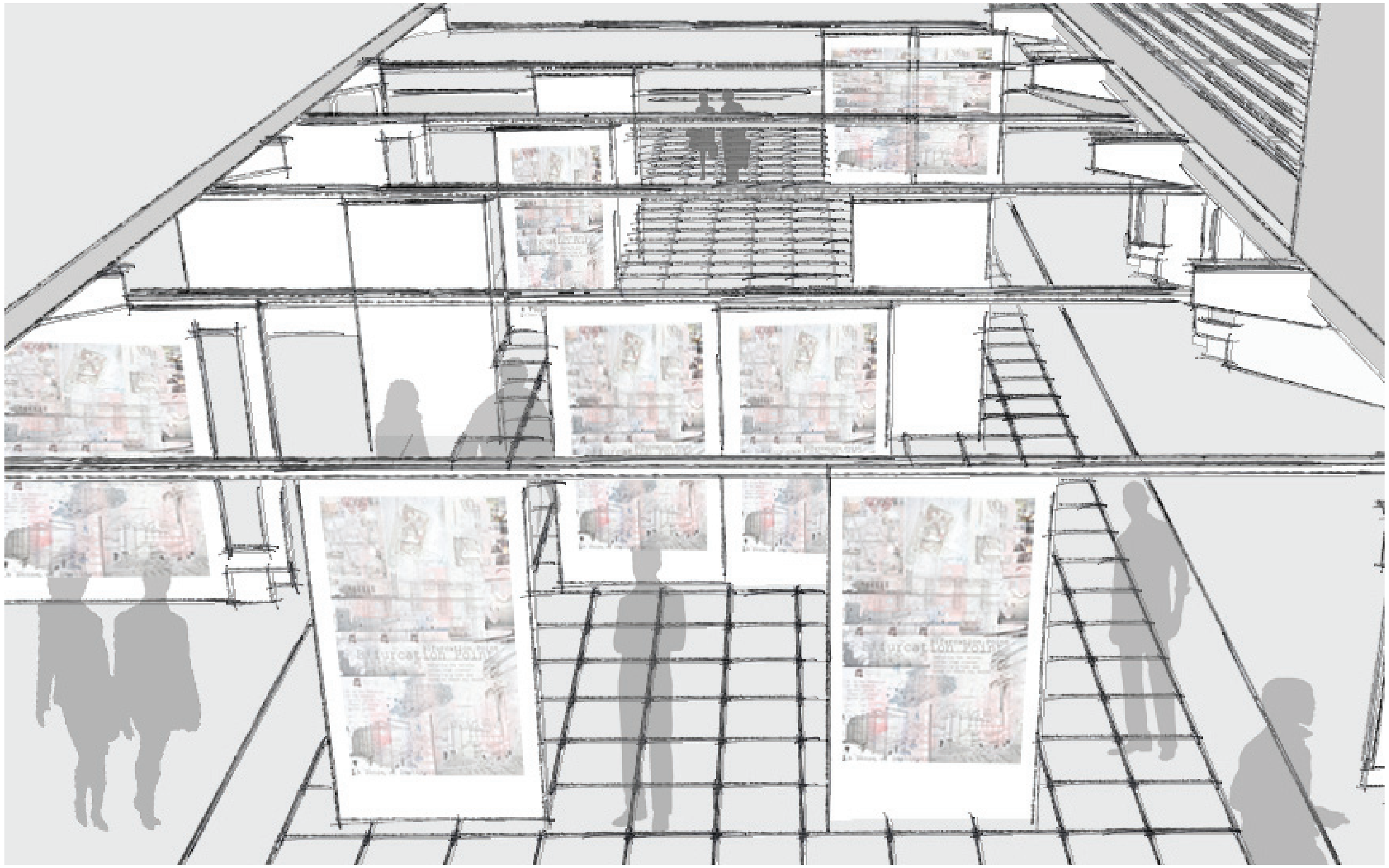

Figure 7.34 Operable wall panels moved into circulation space for public exhibition

Acoustics

The main reason why Boukunde was drastically altered in 1973, is because the noise generated by Lynnwood Road penetrated the glass curtain wall southern facades of the original building, making the studio spaces too noisy. In order to maintain an acceptable noise level, the bridge structure needs an acoustic system.

As part of the floor structure of the bridge, a second layer is added in the form of a hanging roof. The roof consists of 1500 x 1550 x 50; 0.8mm thick galvanized steel pre-painted Superseal 500 roof sheets, with double interlocking clips that are fixed to the underside of the Vierendeel trusses between the flanges, according to the manufacturer's instructions. Instead of creating thermal mass to control the acoustics, a double floor system, with acoustic sheeting and a cavity is used to control the noise levels.

The acoustic sheeting is a three layered acoustic sheet that is torched onto the Superseal 500 roof sheeting. The installation process will be discussed later.

Furthermore, all the Formica Solid Core Exterior Panels have acoustic sheets as part of the material composite. All glass windows and panels are double glazed and consist of tempered safety glass, double coated with low-E, are dual-sealed and injected with Argon gas. The double glazing does not only keep out the noise, but also protects the work that is exhibited from excessive solar radiation.

The interaction between the different systems is detailed in DETAIL 2 (see page 162-163).

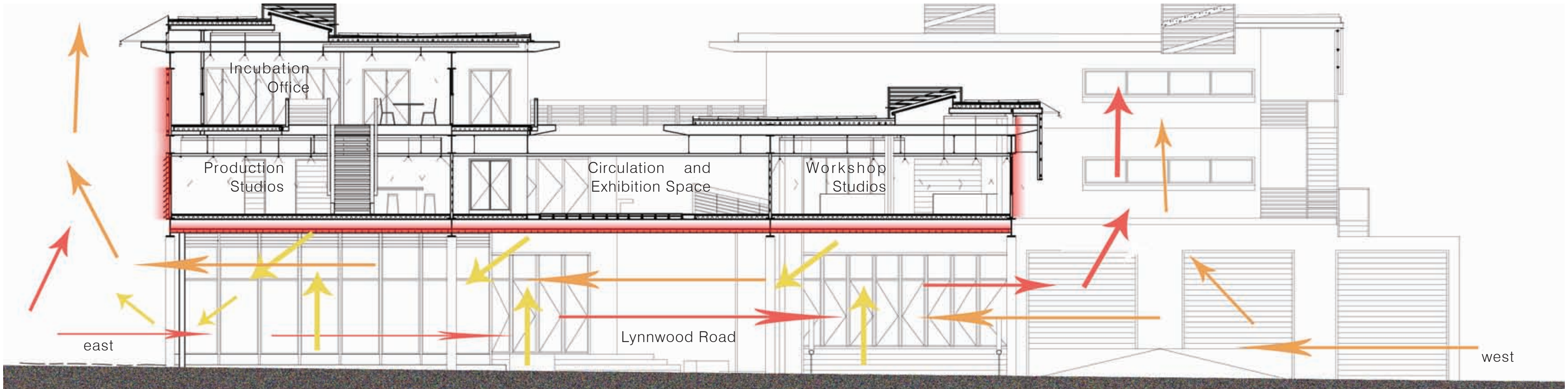

Figure 7.35 Diagram indicating the structure's ability to deal with excessive noise levels

Southern Wing

The southern wing is a three storey masonry structure that defines the southern edge of the design intervention. The linearity on ground level is achieved through the incorporation of two pedestrian walkways linking the northern and southern wings. On the bridge level the pedestrian walkway continues into the masonry structure with two flights of steel staircases connecting the pedestrian with the ground level.

Construction of ground level can continue while the steel structure is being erected, but the floor of the bridge level can only be cast when the exact height of the steel structure floor is determined. A minimum 40mm expansion joint is required between the steel structure and the masonry structure, according to the structural engineer Mr. Carl von Geyso. The expansion joint between the bridge and the southern wing will act as the threshold into the new space, this is merely a line, there is no level difference between the two spaces. The roof of the southern wing is exactly the same as the steel structure's roof, only the expansion joints separate the two. As stated earlier, the roof is a Slimdek composite light weight concrete roof. The concrete roof is then used to house PV flat solar panels.

The structure consists of 230mm masonry brickwork with Slimdek being the horizontal elements. Slimdek has a maximum span of 11meters x 11meters, making it the most economic and feasible option to use as flooring and roofing structure.

The two incubation offices on the Top Level are linked with a bridge structure, this allows for interaction between the bridge level and the top level. This link also assists in defining the foyer space below it. This space acts as a combined foyer into the Restaurant, Workshop Studios, Production Studios and South Campus as a whole.

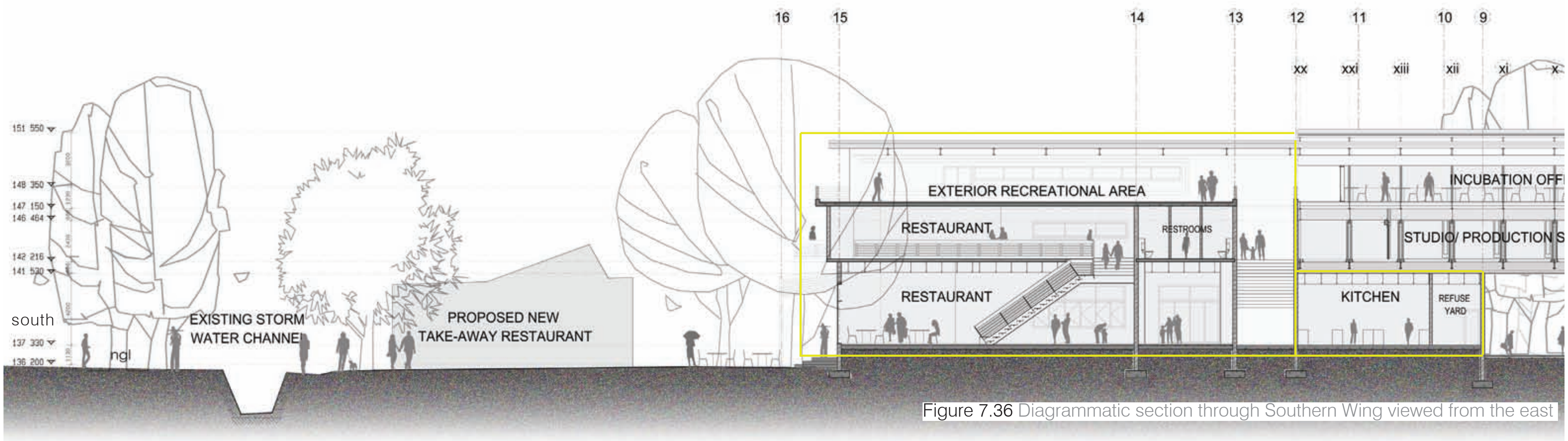

Figure 7.36 Diagrammatic section through Southern Wing viewed from the east

Water reticulation

A zero run-off policy has been accepted in the urban framework of this dissertation. The storm water should therefore be managed and re-used as far as possible. The proposal is to collect the storm water in four reticulation tanks, situated on opposite sides of Lynnwood Road and opposite sides of the Bridge structure.

The University has large open green spaces that are currently irrigated by hand. The water accumulated from the new BESC is collected and should then be used for irrigation purposes. The four tanks are all below ground in structures, as stipulated by the manufacturers (Refer to DETAIL 6, page 170 - 171).

The tanks have basic filtering systems built-in, as well as solids traps to avoid blockages in the pipes.

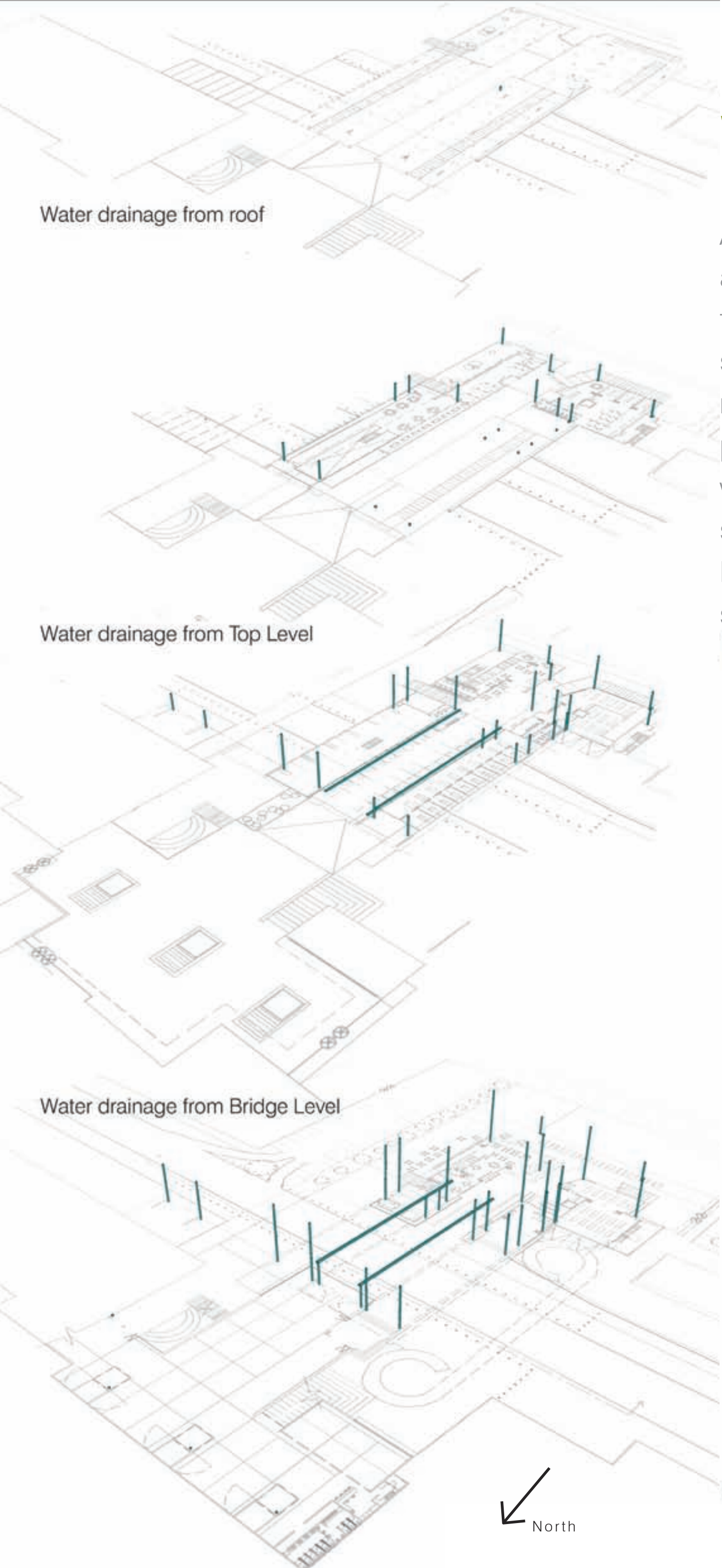

Figure 7.37
Diagrams indicating water drainage from the different levels

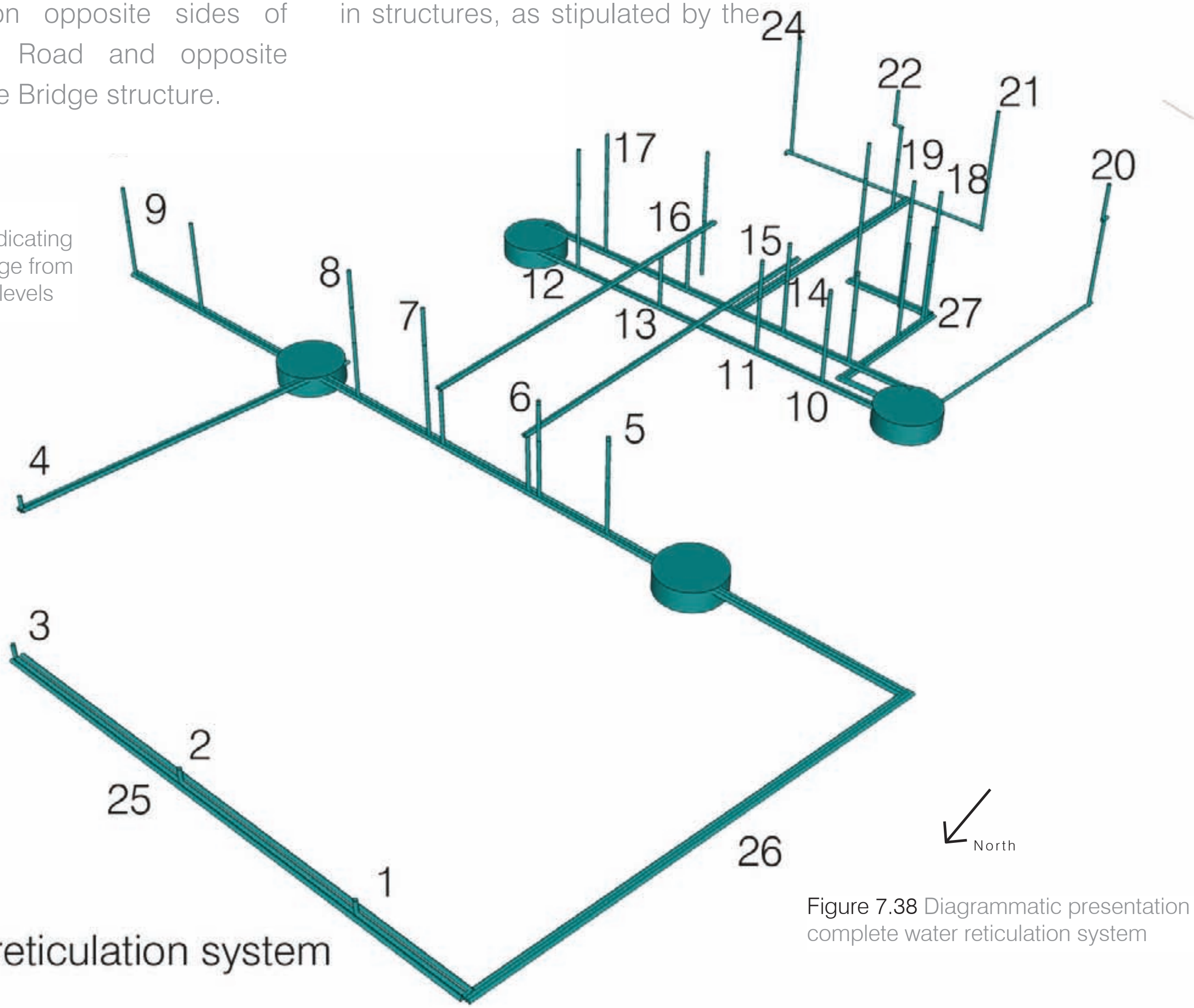

Figure 7.38 Diagrammatic presentation of complete water reticulation system

The storm water is collected on all hard surfaces, and then taken to the nearest storm water reticulation tank. For aesthetic and functional purposes, 200mm diameter exposed galvanized downpipes have been used. It was established that the largest area that can be served by one downpipe is just over 220mm^2. The screed layouts, as indicated on the Roof Plan, are designed accordingly.

Storm water management		Min downpipe dimensions	
Total Footprint Area		5307m^2	
		Area required	Radius (min)
1	52m^2	7280mm^2	48mm
2	52m^2	7280mm^2	48mm
3	52m^2	7280mm^2	48mm
4	204m^2	28560mm^2	95mm
5	64m^2	8960mm^2	53mm
6	145m^2	20300mm^2	80mm
7	224m^2	31360mm^2	99mm
8	90m^2	12600mm^2	63mm
9	218m^2	30520mm^2	98mm
10	77m^2	10780mm^2	59mm
11	213m^2	29820mm^2	97mm
12	90m^2	12600mm^2	63mm
13	213m^2	29820mm^2	97mm
14	65m^2	9100mm^2	54mm
15	57m^2	7980mm^2	50mm
16	113m^2	15820mm^2	71mm
17	73m^2	10220mm^2	57mm
18	111m^2	15540mm^2	70mm
19	111m^2	15540mm^2	70mm
20	67m^2	9380mm^2	55mm
21	78m^2	10920mm^2	59mm
22	86m^2	12040mm^2	62mm
23	96m^2	13440mm^2	65mm
24	96m^2	13440mm^2	65mm
25	1356m^2	189840mm^2	245mm
26	365m^2	51100mm^2	128mm

Figure 7.39 Rain water accumulation areas, for downpipe sizing

Storm water management calculations:

Downpipe sizing calculations:

Area x 140 = x
x = (Pi) x r^2
x/(Pi) = r^2

example -

213 x 140 = 29820mm^2
29820/3.14 = r^2
r = 97mm

All downpipes to be 200 mm diameter galvanized steel, draining into subsurface gutters sloped at min 1:80 to the rain water reticulation tanks, for irregation.

Gutters and downpipes specifications

Gutter and downpipe sizes determined by roof area per downpipe, Pretoria's summer rainfall statistics (max. 132mm in wet months) according to SANS 10400-R.

GUTTERS
1,0mm galvanised steel gutters according to SANS 357/4998. All gutters according to rain water management schedule.
All gutters to have angles, stopped ends and outlet nozzles where required, according to manufacturer's specifications.

GUTTER BRACKETS
40 x 6,0mm thick steel brackets to be hot-dipped galvanized after manufacture.

INSTALLATION:
Lay gutters in galvinized mild steel brackets to min. fall 1:80 to outlets, screwed to steel structure at min. 1000mm centres.

Fix downpipes to vertical elements of steel structure or walls of masonry structure (positions as indicated on plans), 200 mm away from finished wall surface, seam towards wall when relevant, with 200 x 1.6 mm galvanized mild steel clamps, bolted around pipe in two halves, and with 6 mm diameter galvanized steel spiral nail driven into wall at least twice per downpipe lenth and max. 2 m centres.

Storm water reticulation on Bridge

The rain water that falls on the Bridge Level pedestrian walkway is one of the main storm water challenges, as the surface should be 100% level to accommodate the operable walls.

The Slimdek flooring ends three meters from the Vierendeel Truss on either side of the pedestrian walkway (Fig 7.40). A 500 x 45 x 6 mm mild steel removable grating with easy clean solids traps separates the Slimdek from the 500 x 500 x 50mm stucco creed concrete pavers. The pavers are placed on T-sections that span between the lateral supports I beams of the steel structure. The pavers are placed on spacers to allow water to seep through. The water is then collected on the hanging roof structure with the acoustic sheeting on. The hanging roof is sloped at an angle of minimum one degree to allow the water to flow from the middle of the bridge, towards the sides where it is collected in a gutter and then taken to the reticulation tanks.
An overflow is designed where the hanging roof meets the Vierendeel truss; this is done to avoid any water ever pushing up into the interior space of the Bridge Level.

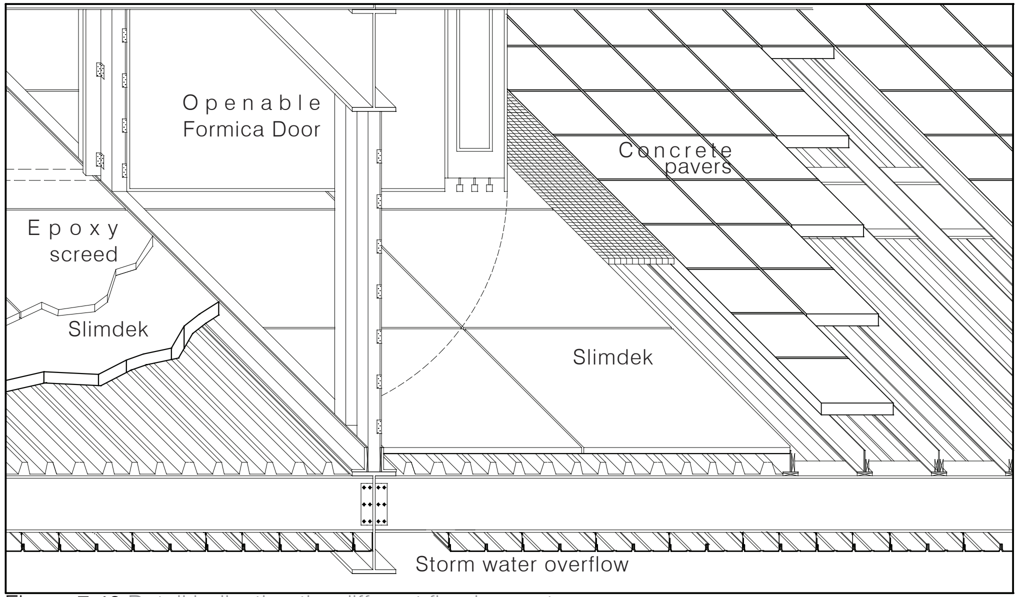

Figure 7.40 Detail indicating the different flooring systems

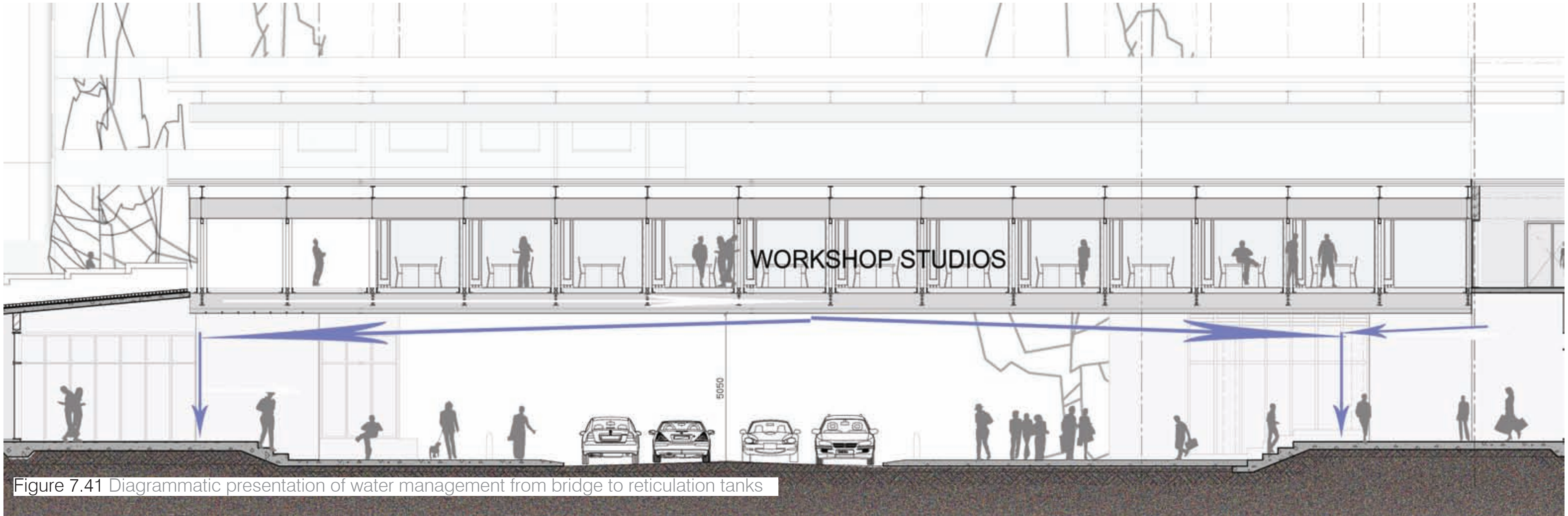

Figure 7.41 Diagrammatic presentation of water management from bridge to reticulation tanks

Electrical services

To keep the horizontality and simplicity of the facade, flat photovoltaic collectors are placed on the Slimdek roof structure. A total area of 1500m² will be covered in photovoltaic panels. A battery storage room is designed on the southern end of the incubation office. Large louvres on the southern facade allow for natural ventilation in the battery storage room, and the roof will keep the batteries dry.

The accumulated energy will then be used to sustain the artificial lighting that is required in the Workshop Studios, Production Studios and Incubation Offices. The electrical services are distributed through PVC conduting that is placed into position as part of the Slimdek systems. The conduiting is placed in position before the light weight concrete is cast.

The electrical services therefore run inside the floors and no additional suspended ceilings or floors are required to hide the services.

In some areas, where there are suspended ceilings, the fluorescent lighting is recessed into the ceilings in order to keep the spaces as light and clear as possible.

Fluorescent lighting casts very little direct shadows, resulting in defused, continuous lighting, ideal for work areas. Down lighters are used in specific areas where continuous exhibition will take place.

The photovoltaic panels will be used as much as possible, but the municiple connection will act as a backup.

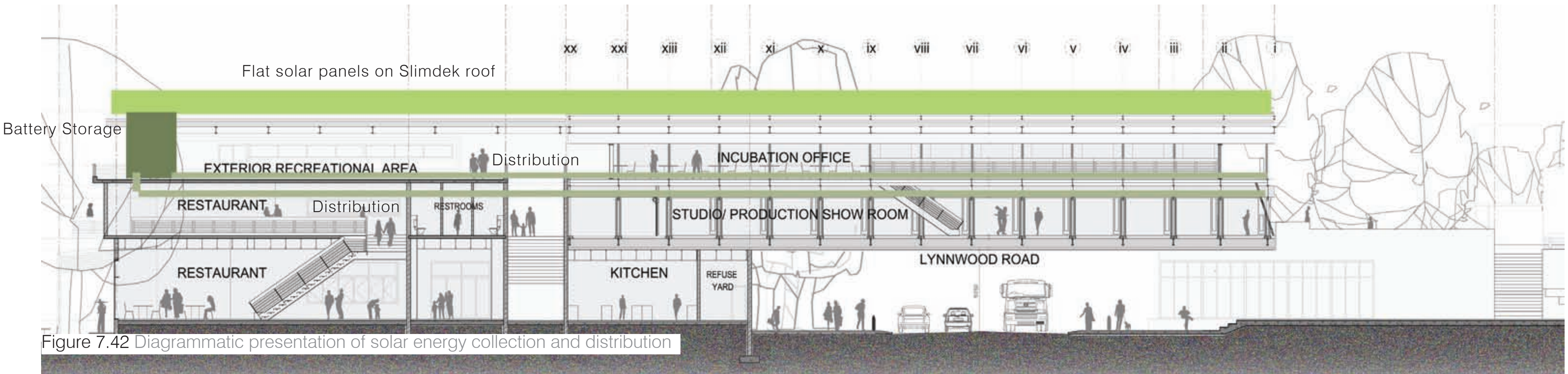

Figure 7.42 Diagrammatic presentation of solar energy collection and distribution

Passive systems

Orientation

The building, as a linear structure, is orientated with its shorter elevations north and south and the longer elevations east and west.

Solar control and natural lighting

The spaces are designed to have as much as possible natural sunlight with as little as possible direct sunlight. On the eastern and western facades large billboards are provided to create a double facades that block unwanted direct sunlight (Fig 7.43), yet allows reflected light into the interior spaces. The inner skin of both facades have large, not openable, double glazed windows. The windows are openings in the facade that allow in natural daylight, but keep out the noise generated by the vehicular traffic on Lynnwood Road, through double glazing, and cannot be opened to avoid any unhealthy gasses entering the interior spaces.

In the FES a roof window is designed to allow in natural defused northern light. The windows are openable to allow hot air to escape through the roof. On the southern facade of the FES, large double glazed windows allow in natural southern light, create curiosity in the passerby and keep out all unwanted noise generated under the bridge.

Natural light also enters the Production Studios and Workshop Studios from the main circulation space.

Intelligent roof lights are designed on the roofs. SolaQuad is an intelligent skylight system that provides controlled day lighting and a very high level of insulation. .The double glazed windows have an opaque face that is rotated to the sun to control the amount of sunlight and solar heat gain transmitted through the panels. The skylight is openable to allow hot air to escape through the roof.

The solar control and natural lighting systems are passive systems implemented to keep the running cost of the building as low as possible, as well as lower its carbon footprint.

Ventilation

Natural ventilation is achieved through the many openings and operability of the different elements in the design.

In the Workshop Studio on Ground Level some of the workshops that are presented might involve working with heavy machiney and by implication the gasses and dust produced when working with such equipment. Due to the required height of the bridge, the interior spaces on Ground Level, south of Lynnwood Road exceeds 3800mm. A mechanical ventilation system, that will only be used when necessary is hidden with a suspended ceiling.

The success of a restaurant is influenced by thermal comfort. A heating, ventilation and air conditioning system is therefore designed into the Restaurant. Another suspended ceiling on Ground Level of the Restaurant is therefore required.

All other ventilation happens naturally through openings on the facades.

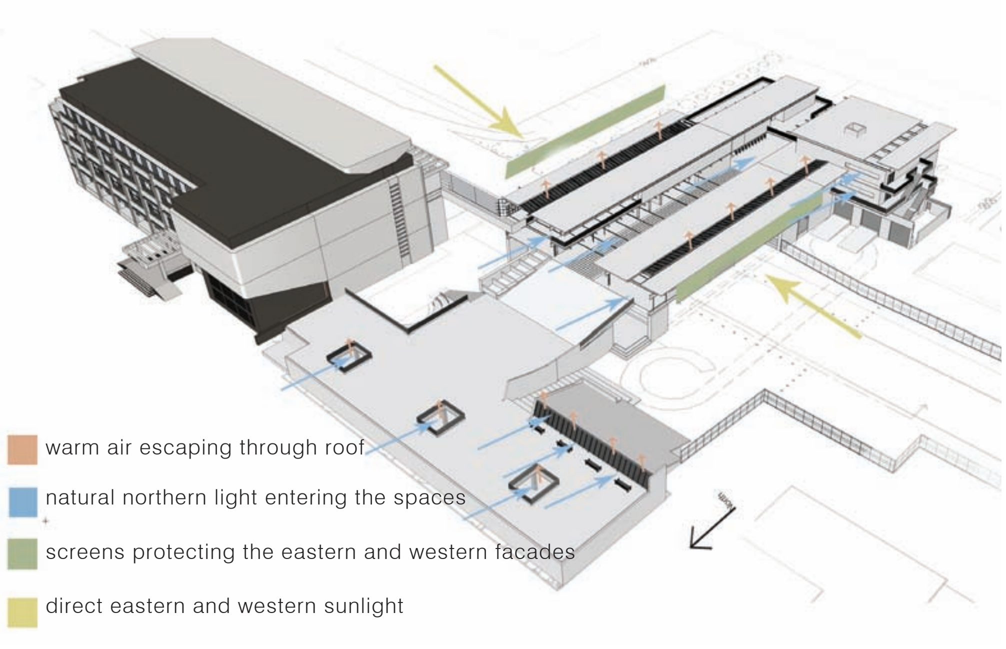

Figure 7.43 Summary of passive systems

Construction process

The different layers of the technical aspect of the design have now been established. The integration of the layers and how they function to create a unified structure is discussed in terms of the construction process. In order for the diffent systems to function successfully, the construction process should be integrated.

Four storm water reticulation tanks are incorporated into the design to collect rainwater for irrigation on both campuses. All construction on storm water reticulation tanks to be completed before construction on the structure above ground commences.

The wet work on Ground Level should commence, starting with the northern retaining wall.

The concrete columns (Fig 7.43) as indicated on the plans are to be completed and leveled before delivery of the Vierendeel Structural System.

Concrete columns sizing calculation:
typical h/d = 20-25
for buckling: h/d > 14
h/d = 4287/ 450
      = 12.25

The concrete columns are to be designed by a structural engineer, and should have a minimum width dimension of 350mm.

The height of the column is determined by the minimum height to the underside of bridge, as discussed earlier. Adler's "Metric handbook" confirms that 5000mm is the minimum height of a bridge. The column heights are determined by these regulations.

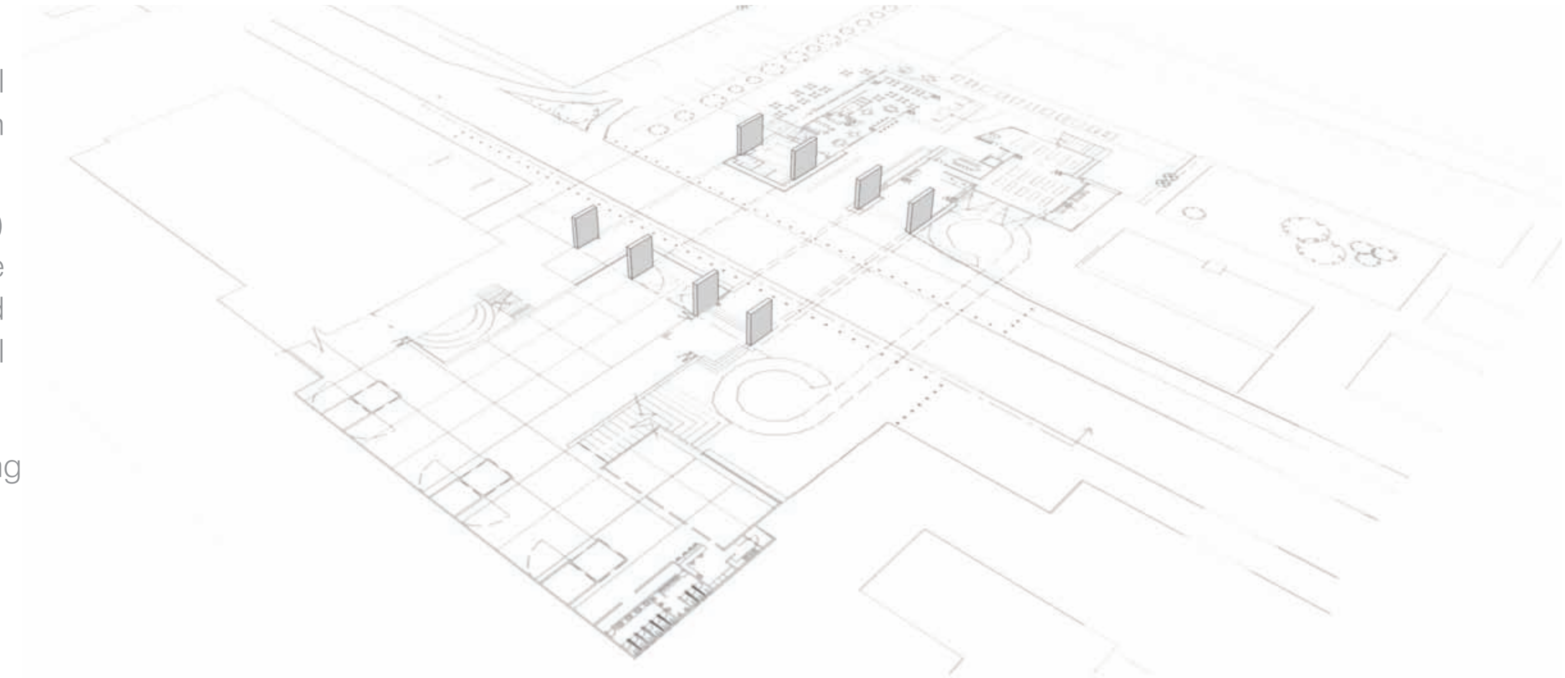

Figure 7.44 Position of concrete columns on Ground Level Plan

The two centre Vierendeel Trusses to be erected first (Fig 7.44), and then the two exterior trusses.

Pre-manufactured component with max dimensions of 12000 x 3200mm arrive on site and is placed on the first 100% level column by crane. The component is initially kept in position with temporary scaffolding until bolted connections are according to engineer specifications. The next segment is also placed on temporary scaffolding and lifted by crane into position until a 100% penetration weld is achieved (can take up to 24 hours). This process is repeated until the truss is fully supported by the concrete columns.

Vierendeel Girder:
typical depth = 1000 - 3000mm
typical span = 6-18m
typical L/d = 4-12
Rigidity obtained with depth increase
L = 29 435mm
d = 3200mm
L/d = 9.19

I beam as shear support of Vierendeel:
typical depth = 120 - 300mm
typical span = 3 - 12m
typical L/d = 25-35
Bolted to flanges on Vierendeel
L = 11915
d = 381
L/d = 31.27

Bottom chord I beam as shear support of Vierendeel:
typical depth = 120 - 300mm
typical span = 3 - 12m
typical L/d = 25-35
Bolted on top of concrete columns
L = 29 435mm
d = 686mm
L/d = 42.9

Even though the L/d is higher than the typical ratio, according to the engineer, Mr Carl von Geiso, it is still well within the safety limits and the capability of cold formed mild steel to carry itself over such a distance.

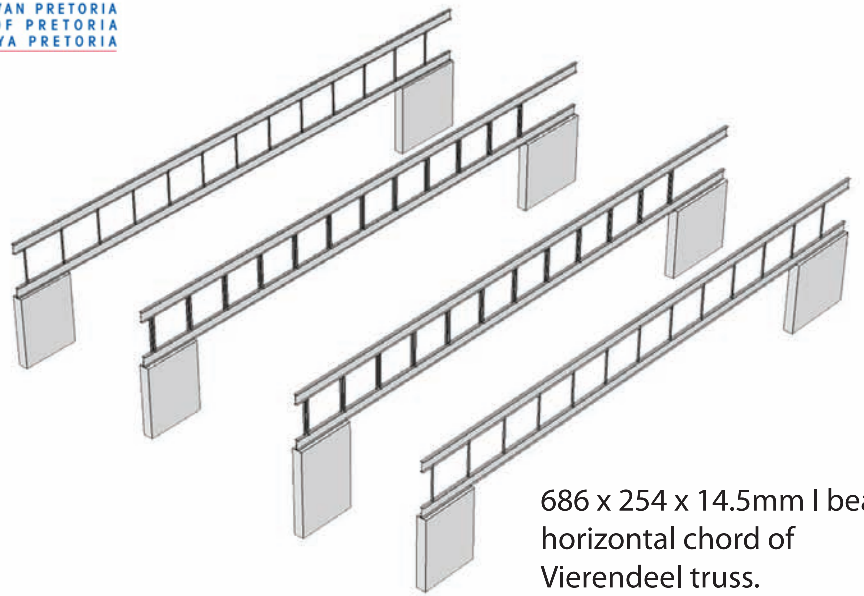

Figure 7.45 Four Vierendeel Trusses in position on concrete columns

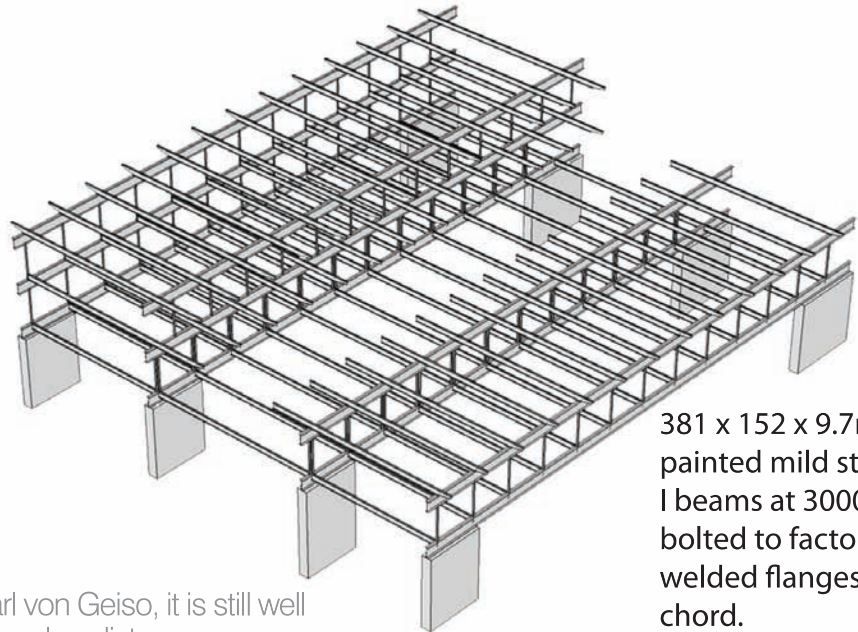

Figure 7.46 I beams bolted to Vierendeel Trusses for lateral support

Vertical Bracing of Vierendeel: hollow core sqaure tubing:
typical height = 2 - 8m
typical h/d = 20-35
For buckling: h/d > 20
d = 100
h = 2428
h/d = 24.28

148 x 89 x 11mm pre-painted mild steel hollow core square tubing welded to underside of Vierendeel horizontal chord, as recommended by the structural engineers. Square tubing to act as guide-rail form movable wall panels.

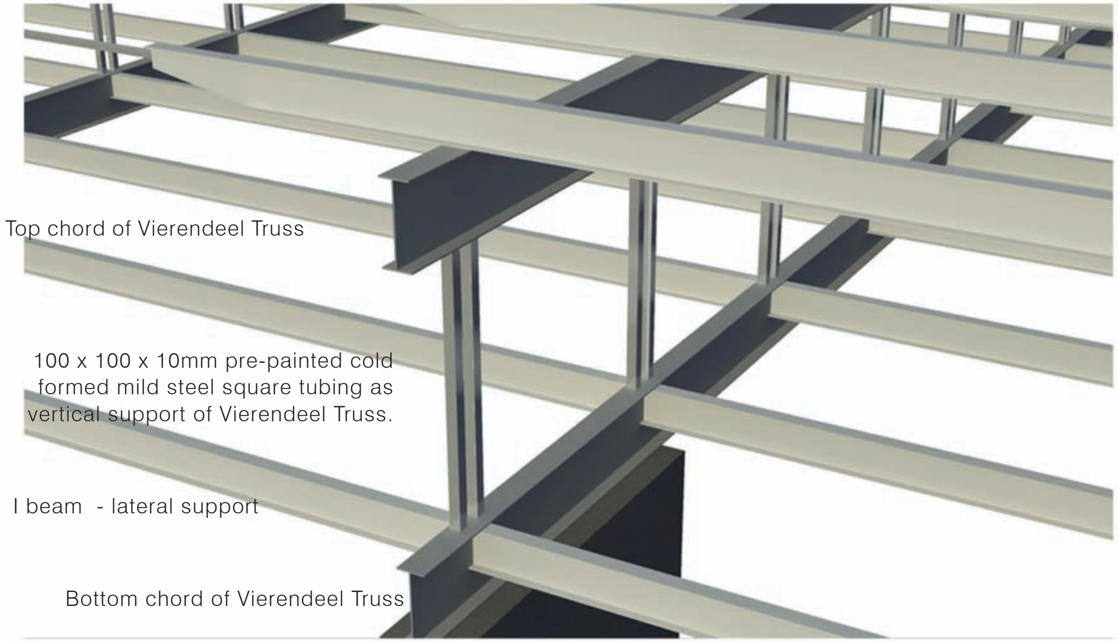

Figure 7.47 Steel structure detail

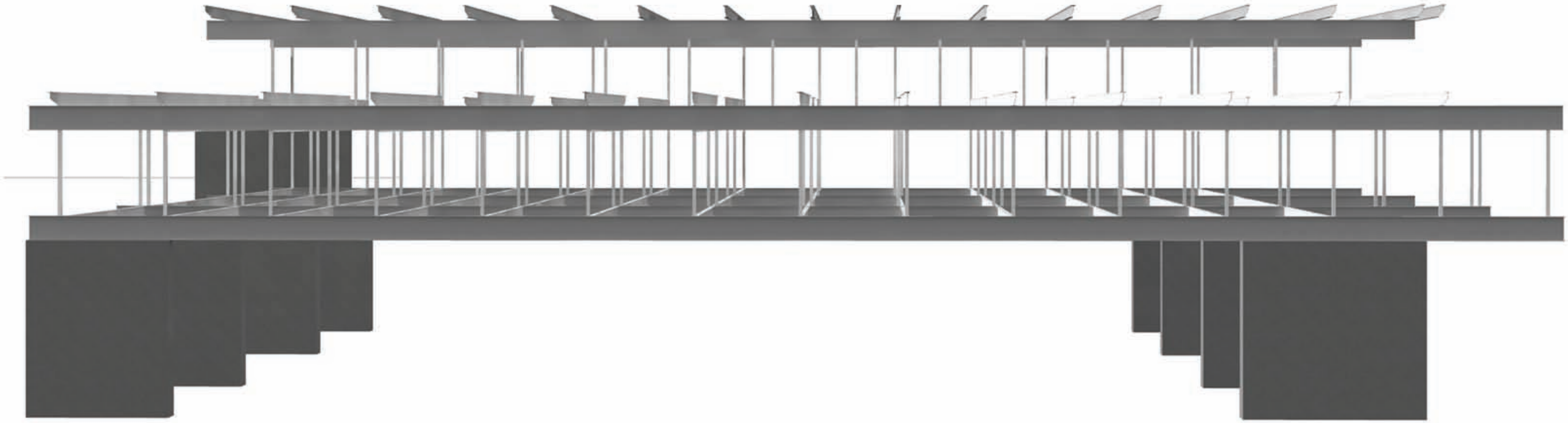

Figure 7.48 Western view of structural steel system

After the steel structure has settled, the infill can be erected and the wet work can continue on the northern and southern wings.

The three structural components are separated with two minimum 40mm expansion joints, sealed with polyurethane seals to accommodate the movement of the separate structures.

BRIDGE FLOOR CONSTRUCTION:
After the main steel structure is completed the hanging roof should be bolted to the underside of the lateral support I beams of the structure. The AcoustiPack acoustic sheets are then torched onto the hanging roof. The Slimdek roof sheeting is then fixed to the lateral support I beams, followed by the conduiting and the reinforcing placed into position after which the concrete is cast. The concrete tiles that complete the walkway is only placed on top of the spacers and T-sections, so it can easily be removed for cleaning purposes.

After the structure is completed the steel staircases and billboards are installed. The steel staircases are separate structures, custom made, according to DETAIL 8 and DETAIL 9. The structures are mechanically bond to the masonry structures and bolted into position where it connects to the steel structure.

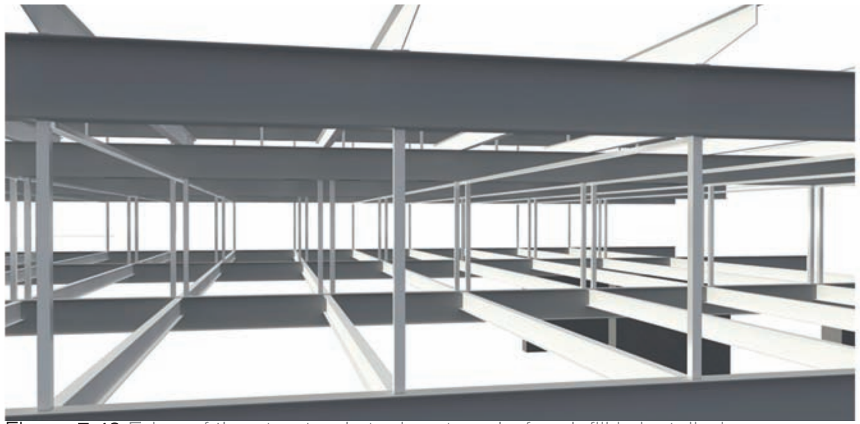

Figure 7.49 Edge of the structural steel system, before infill is installed

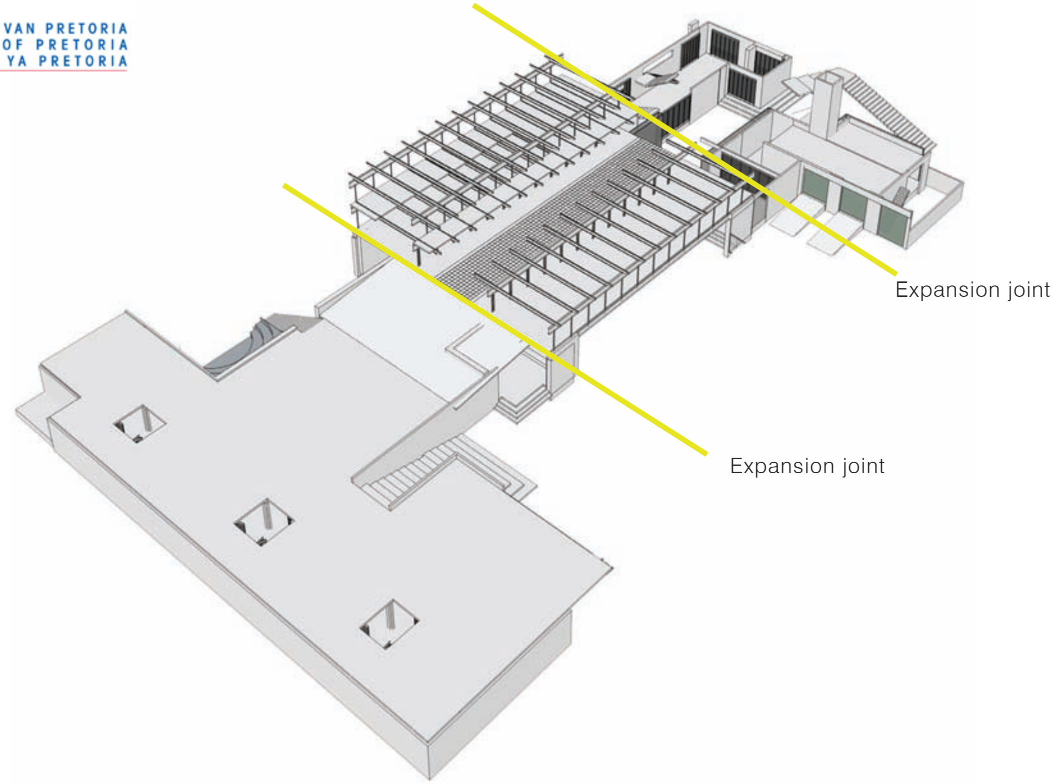

Figure 7.50 Wet work on northern and southern wings after steel structure is in place

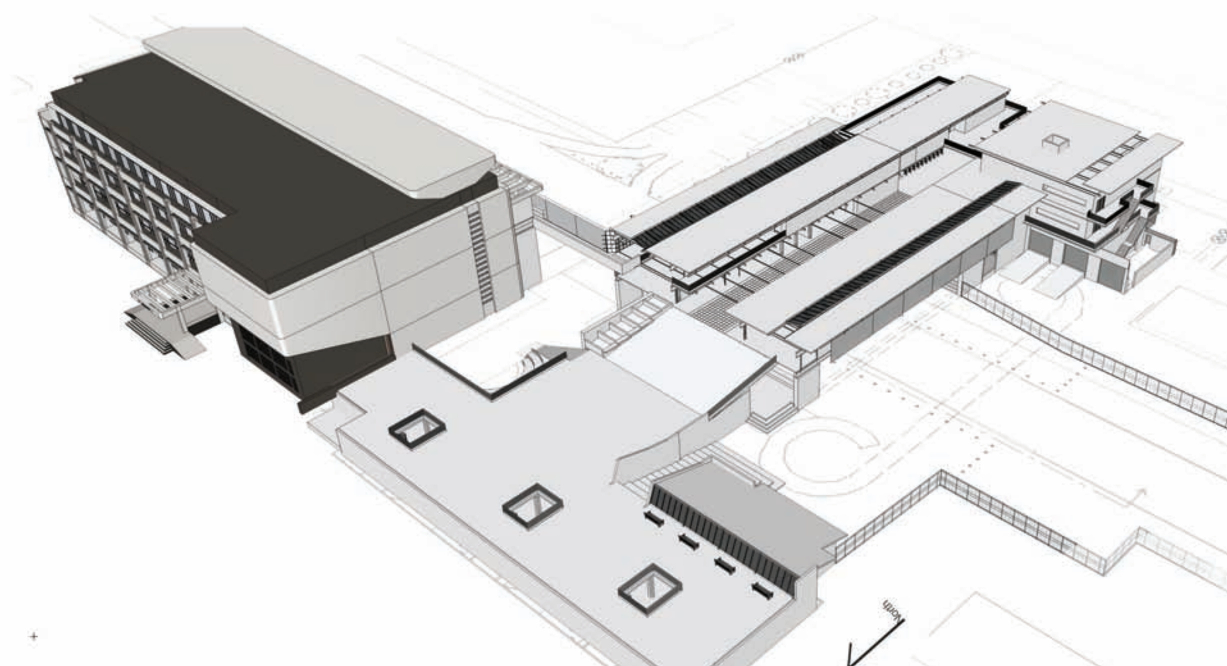

Figure 7.51 Complete structure with masonry wings, steel structure and infill panels

Connection between BESC and Boukunde

The Top Level of the BESC has a walkway that links directly with Boukunde. As stated previously, the identity of Boukunde as a modern icon in the landscape should be respected.

The proposed intervention is a foyer into Boukunde similar to the existing foyer on the northern facade. The new and existing foyers are similar in proportion, dimensions, function and aesthetic.

The new foyer is designed to be structurally independent, standing on four large columns, with an expansion joint separating it from the existing Boukunde structure.

The structure consists of in-situ cast painted concrete, the aesthetic should match that of Boukunde completely.

The eastern billboard continues up to the foyer, acting as a balustrade and allows the connection between the BESC and the new foyer to be unintrusive to the identity of Boukunde.

Two aluminium framed glass door panels, that match the front door of Boukunde, are to be installed, connecting the second floor studios directly with the incubation offices on the Top Level of the BESC.

The connection to Boukunde is designed to be able to accommodate change. The extension of the Boukunde building is inevitable and the foyer suggests where the extension could take place; the foyer can be extended to the eastern corner (not effecting the corner though) and closed down to provide more studio spaces. This can be done on all levels, allowing Boukunde to keep its identity and provide ample space for the growing number of students.

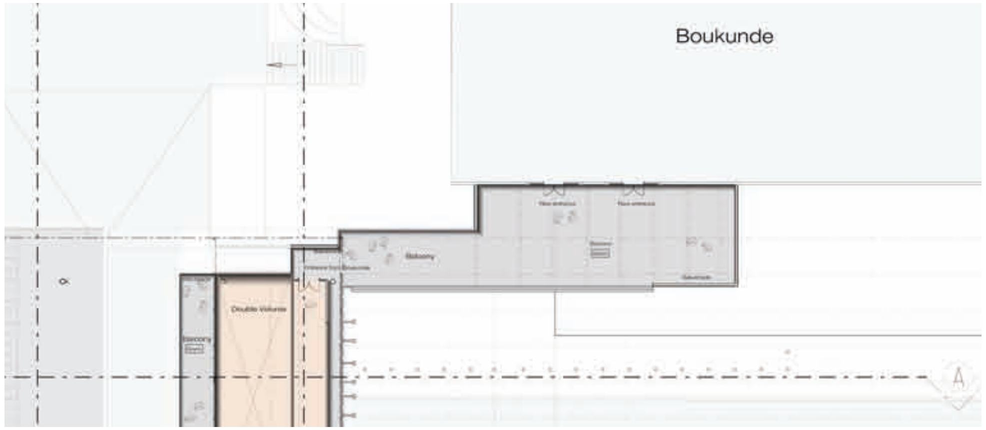

Figure 7.52 New openings on southern facade of existing Boukunde building

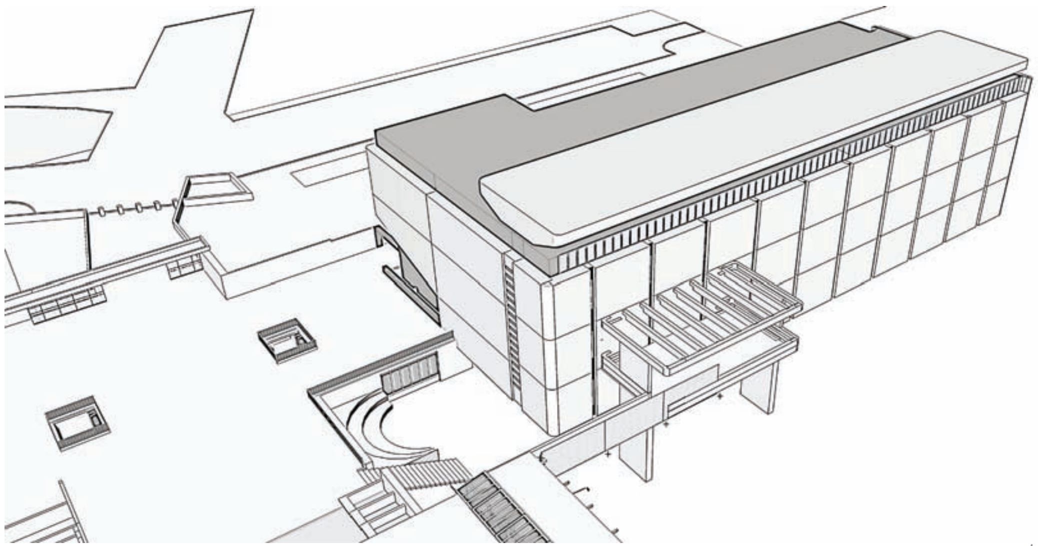

Figure 7.53 Connections between BESC and Boukunde

Conclusion

All the technical aspects of the services and systems had to be seperated in order to explain them systematically But in reality the integration of the different layers of systems and services was never separated during the design process.

The simplicity of the facades and the linearity of the design enables the structure to read as an object. The expression of the connections, services and systems is done in such a way that it compliments the iconic image of the design.

The interdependancy of the various services and systems creates a unified structure that functions as one system. Implying that one system does not come to its full potential without the others. This can be related back to architecture's dependancy on both theory and practice for existence

The layered tectonic resolution can therefore be traced back to the concept of foyers, linking different entities with simmilar intentions.