CHAPTER 8

TECHNICAL INVESTIGATION

Chapter 8 Technical Investigation

8.1 Introduction

Designing in Maputo requires an understanding of the general building practices and available materials and techniques used in the vernacular sustainability. This has not been the focus of this dissertation but is inherent in the contextual approach as illustrated by John Norton's principles of sustainable design. .

Sustainable architecture is summarised into nine points by John Norton in his article for the Aga Khan Development network published in the *Habitat Debate*:

- *makes substantial use of locally available materials and local means of transport;*
- *uses resources that are available in sufficient quantity to satisfy a general demand and not damage the environment;*
- *does not depend on equipment that is not easily available;*
- *uses skills that can be realistically developed in the community;*
- *can be afforded within the local socio-economic context;*
- *produces a durable result;*
- *responds to and resists the effects of the local climate;*
- *provides flexibility to adapt to local habits and needs;*
- *can be replicated by the local community.* (NORTON, 1999: 60)

To achieve these targets as identified by Norton, the contextual understanding as identified in Chapter 3 is utilized as well as further exploration into the existing skills, materials and climate. This is done by exploration of the informal vernacular in the surrounding areas of Maputo. The majority of the contemporary vernacular architecture within the Maputo metropolitan would be classified as informal, but when observed it becomes apparent that although the built fabric is classified as informal, through photographic analysis it becomes apparent that the structures are not impermanent in their methods of construction and do have a distinct typology.

For the purposes of a contextually based design, current building techniques and availability of materials and skills must be considered.

The structural system of the design is based within the concept following the same threshold experience as proposed in the design with an attempt to continue the design ethos into the detail resolution.

Indoor environment quality is created by responding to the needs specific to the spaces and making informed decisions based on available climatic data. This topic includes that of ventilation , lighting and thermal comfort.

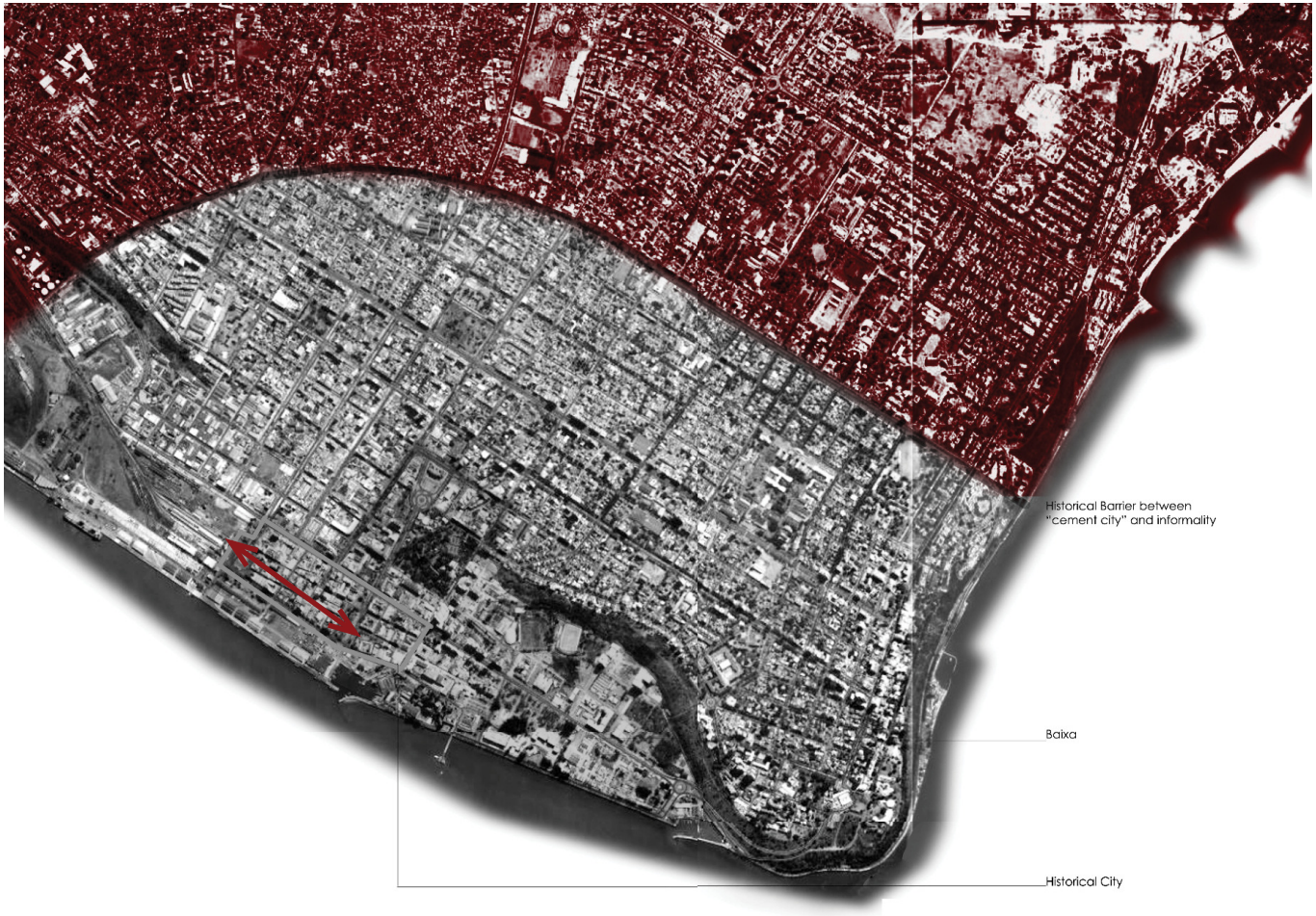

Figure 8.1 Map showing the extent of the historical boder between "cement city" and the informal settlements

8.2 Construction Precedent -

8.2.1 Combatentes

A site visit was taken to the outskirts of the cement city in Maputo, to observe the informal residential areas to gain an understanding of locally available materials in June 2011. It became apparent that the majority of structures were constructed using, concrete, concrete block masonry and corrugated sheeting, with various types of screens and shading devices.

Concrete frame construction.

The available concrete blocks are not considered structurally sufficient and thus there is a vernacular response by creating a concrete frame structure. The construction method is to create a reinforced concrete frame and then to use the concrete blocks as infill. This is sometimes plastered but is not a rule.

Figure 8.2 Photograph showing concrete masonry and concrete frame construction. Photograph by Author 2011

Concrete blocks.

The concrete blocks are built as precast bricks in various modules. While these bricks are available from retail enterprises, they can be constructed on site using sand removed during excavation. Small businesses exist within the informal areas creating these blocks and can be supported by a larger building project within the city.

Figure 8.3 Photograph showing a concrete block manufacuring within a houses yard. Photograph by Author 2011

Narrow edge- Cast in Situ concrete

The cast in- situ concrete seems much thinner than the South African counterpart. From the images it become apparent that the methods of casting allows a very narrow edge and fairly neat shuttering as per the local skill.

Figure 8.4 Photograph showing a man standing on a thin concrete edge. Photograph by Author 2011

Concrete Screens

It is not only steel screens used as ventilation and decoration but also decorative precast concrete air bricks of various designs. The concrete blocks would be more robust in terms of corrosion but create a heavier typology of skin.

Figure 8.5 Photograph showing Concrete air clocks as ventilation and decoration.Photograph by Author 2011

Figure 8.6 Photograph showing concrete frame construction with concrete block infill and steel screens as burgular bars and security doors. Photograph by Author 2011

Screens

Security and ventilation are both concerns within the informal areas and throughout the city. Welded steel burglar bars and security doors are apparent within Combatentes. Although the corrosive coastal climate would cause welded steel to rust, the local technical expertise can create beautiful and unique screen elements that are used throughout the city. The decision taken for this dissertation is that all structural steel should be galvanized to protect against corrosion from the coastal climate, but for the decorative, security and screening purposes welded and painted elements respond more elegantly to the context. Because they are not structural, they can be easily replaced if the corrosion compromises their function.

8.2.2 Red Location Museum of Struggle

Architect(s):Noero Wolff

Location: Nelson Mandela Bay

Year : 2006

The main entrance to the red location museum is dealt with by the articulation of the horizontal plane. The solid concrete extends over a timber pergola built using planed timber members in the horizontal plane resting on columns comprising of four pole elements. The effect created is that of layered transition.

The connection method employed on the horizontal members is that of steel brackets. These reflective surfaces create a glittering effect when the sun shines directly on them . The tectonic solution of the pergola with bracketed construction and separated detail of vertical to horizontal as well as floor to column joint is contrasted by the continuous of the concrete structure which meets the ground and soffit without a visible joint.

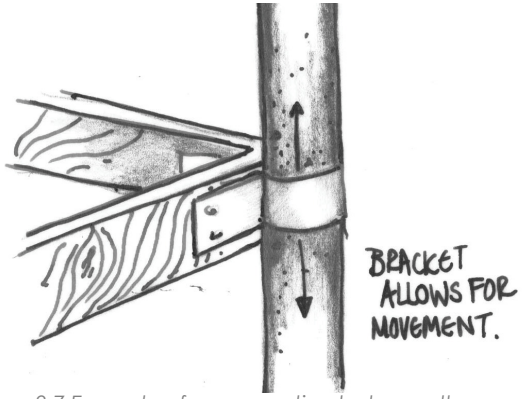

Figure 8.7 Example of a connection between the timber and concrete. Sketch by Author 2011

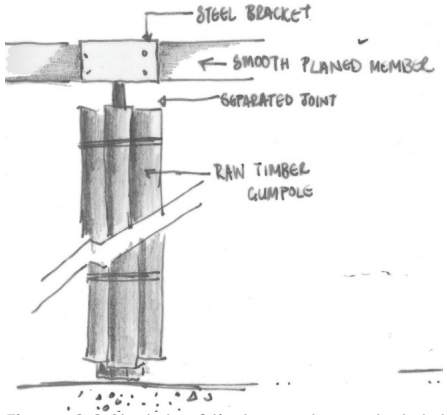

Figure 8.8 Sketch of timber column sketch by Author 2011

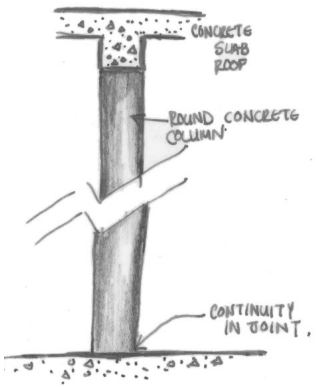

Figure 8.9 Sketch of concrete column and its connection to the ground and roof. Sketch by Author 2011

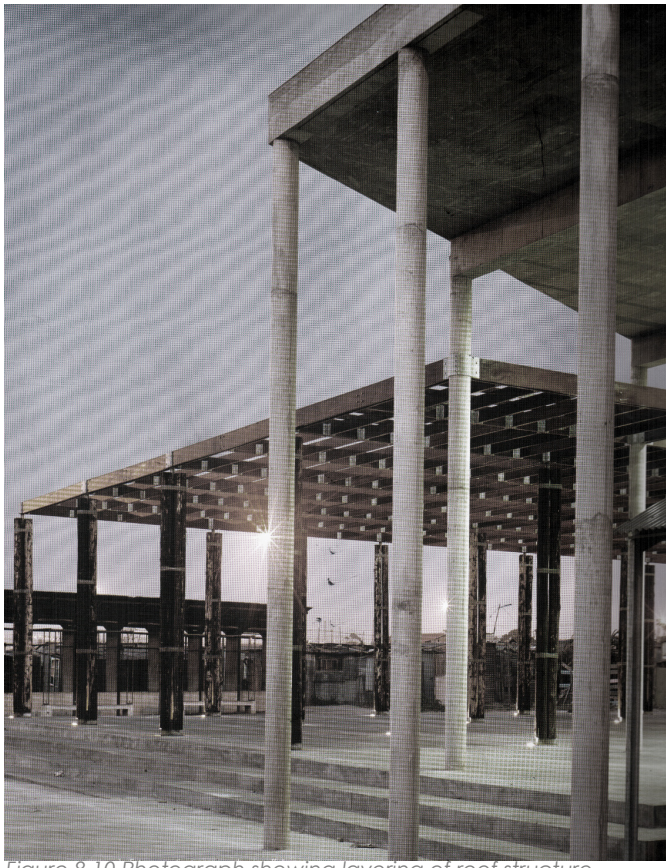

Figure 8.10 Photograph showing layering of roof structure. (DECKLER et al, 2006; 44)

Figure 8.11 Photograph showing roof extensiona and underlay (DECKLER et al, 2006; 43)

Figure 8.10 Collage showing materials to be used. By Author 2011

8. 3 Materiality

The choice of materials had been based on the contextual analysis not only of *Rua de Bagamoyo* but also in the existing vernacular surrounding the formal city. The contextual approach allows locally available materials to be specified with certainty that local labour will have had experience in the construction techniques standard to these materials. The Major structure will therefore be constructed using Cast in-situ concrete with masonry infill. The Roof Structure has been determine to be a flat structure with tapering edge will also be cast in situ. Additional materials for structure include galvanized steel sections to support timber elements.

Many types of timber are available in Mozambique but the sustainability of available timber products vary in value. Illegal logging in Mozambique presents many concerns due to its environmental impact. A search was conducted in September 2011 through the Forest Stewardship Council (FSC) to find a certified timber supplier. It was found that an FSC office exists in the city of Beira but no certified products were found.

The department of Forestry in Mozambique states; "Due to unregistered production, the present extraction rate of the most valuable Mozambican timber species may be between two and four times its sustainable potential. Further research is needed to forecast the impact of this overexploitation on future supply." (Gatto, 2003: 2) A table of production found in the same document shows the Maputo Province as having the lowest production of timber in the country.

Mpumalanga province in South Africa borders Mozambique and contains two of the sustainably certified Forests in South Africa. Having searched the FSC database, three timber suppliers were identified within the province. Although South Africa and Mozambique are different countries and the political boundaries prevent these materials from being considered local, but based on the proximity to the site, the timber grown in

Mpumalanga is essentially more local than that from either Zambezia province or Beira.

Having made the decision to specify South African timber, South African timber standards and sizes can be used as well as the treatment techniques that occur prior to installation, such as copper-chrome-arsenic (CCA)Treatment.

Figure 8.11 Map showing proximity to Mpumalanga and other Mozambican provinces. Adapted from Google maps 2011

Province	Area of productive forest (FP, ha)	Potential for sustainable extraction, m^3/year	Annual harvest potential per hectare of FP (m^3/ha·year)
Maputo	488,213	3,503	0.007
Gaza	1,437,162	13,141	0.009
Inhambane	1,752,026	20,790	0.012
Sofala	2,168,358	93,573	0.043
Manica	1,046,734	21,369	0.020
Tete	1,135,698	28,898	0.025
Zambézia	3,074,324	88,014	0.029
Nampula	1,822,636	54,410	0.030
Cabo Delgado	2,958,895	67,592	0.023
Niassa	3,851,351	108,946	0.028
Mozambique	19,735,397	500,236	0.025

Source: adapted from SAKET 1994

Figure 8.11 Table of timber production per province in Mozambique. (Gatto, 2003: 2)

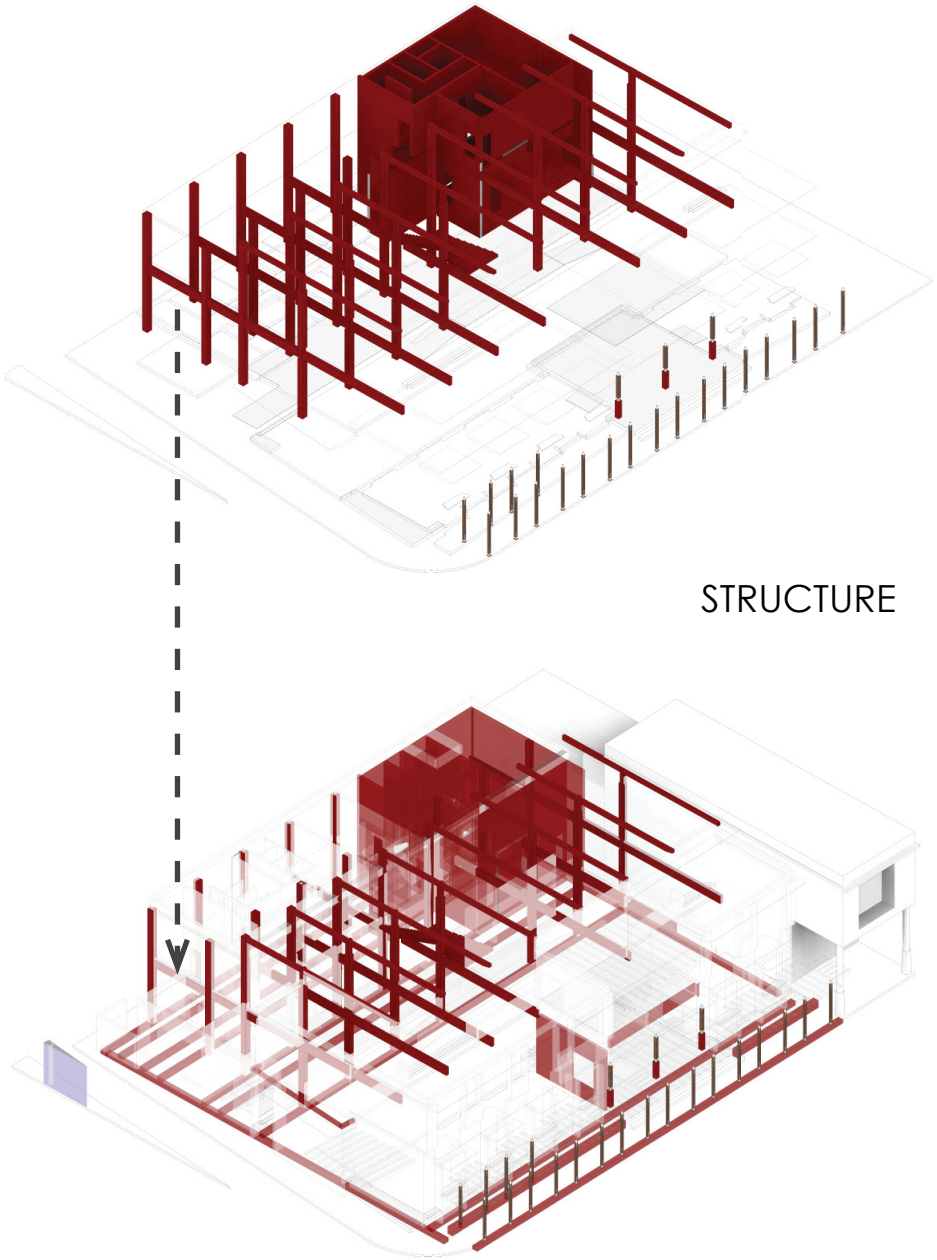

Figure 8.12 Diagrammatic 3- D view of structure and skin

8. 4 Structure

Based on the vernacular precedent, the structure is that of a concrete frame and using a concrete block masonry infill. Due to the concept of transition and layers of habitable threshold, the nature of the structural elements should alter in transition with the atmosphere of the space to compliment the transition.

The columns and structure includes the re-inforced concrete "redline" service core housing the ducting and redline circulation spaces.

8.4.1 Columns

The concept plan shows how smaller and more slender vertical elements placed closer together create a restriction of visual access while retaining a lighter feeling environment. As the elements are spaced further apart they become heavier they need to be to retain the structural integrity as well as the visual transition from the lighter more populated street to the heavier and more enclosed services spaces. The public private relationship through a series of thresholds manifests on plan by having the lightest smallest members closest to the street to create a visual barrier as a user approaches as the user is closest and views the building obliquely the lightness of elements becomes apparent. Following the transition from public to private the columns become heavier and further apart finally resulting in walls.

As the transition from street into private space occurs so the visual obscuring and veiling is reduced so the user experiences a heightening feeling of discovery as each layer is passed.

In a sectional exploration of the structure, the transition from the lightest element (timber column resting on a steel member with visual disjunction between planes) to the most solid (walls continuing directly into slab) occurs in various layers so one distinction between such as in Red Location (Refer to 8.2.2) would not be sufficient the heavier them is extended upwards from the ground plane in the various layers of transition.

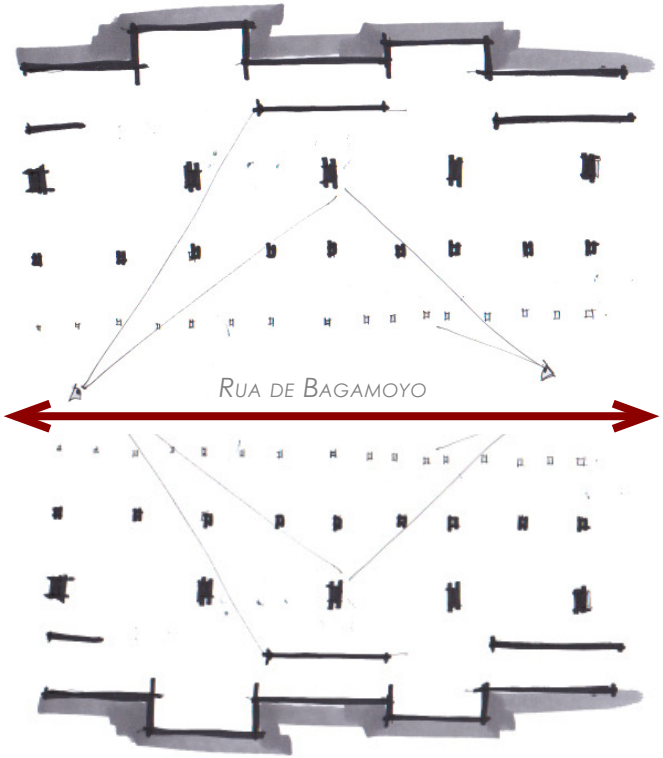

Figure 8.13 Diagrammatic plan showing transitional nature of column structure

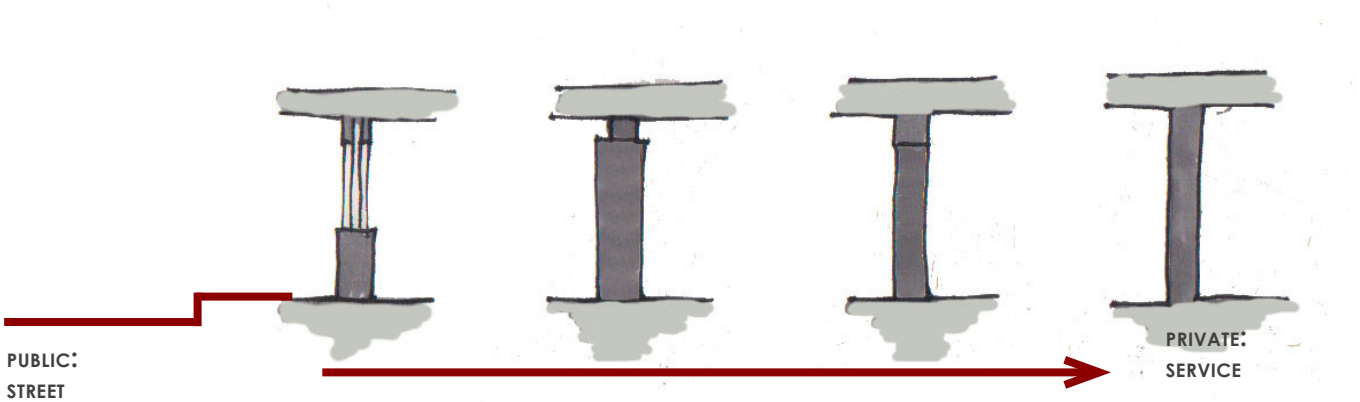

Figure 8.14 Sectional diagram showing progression of column into the private

Figure 8.15 Section through gaming facility showing pppposition of transitonal columns and threshold barriers.

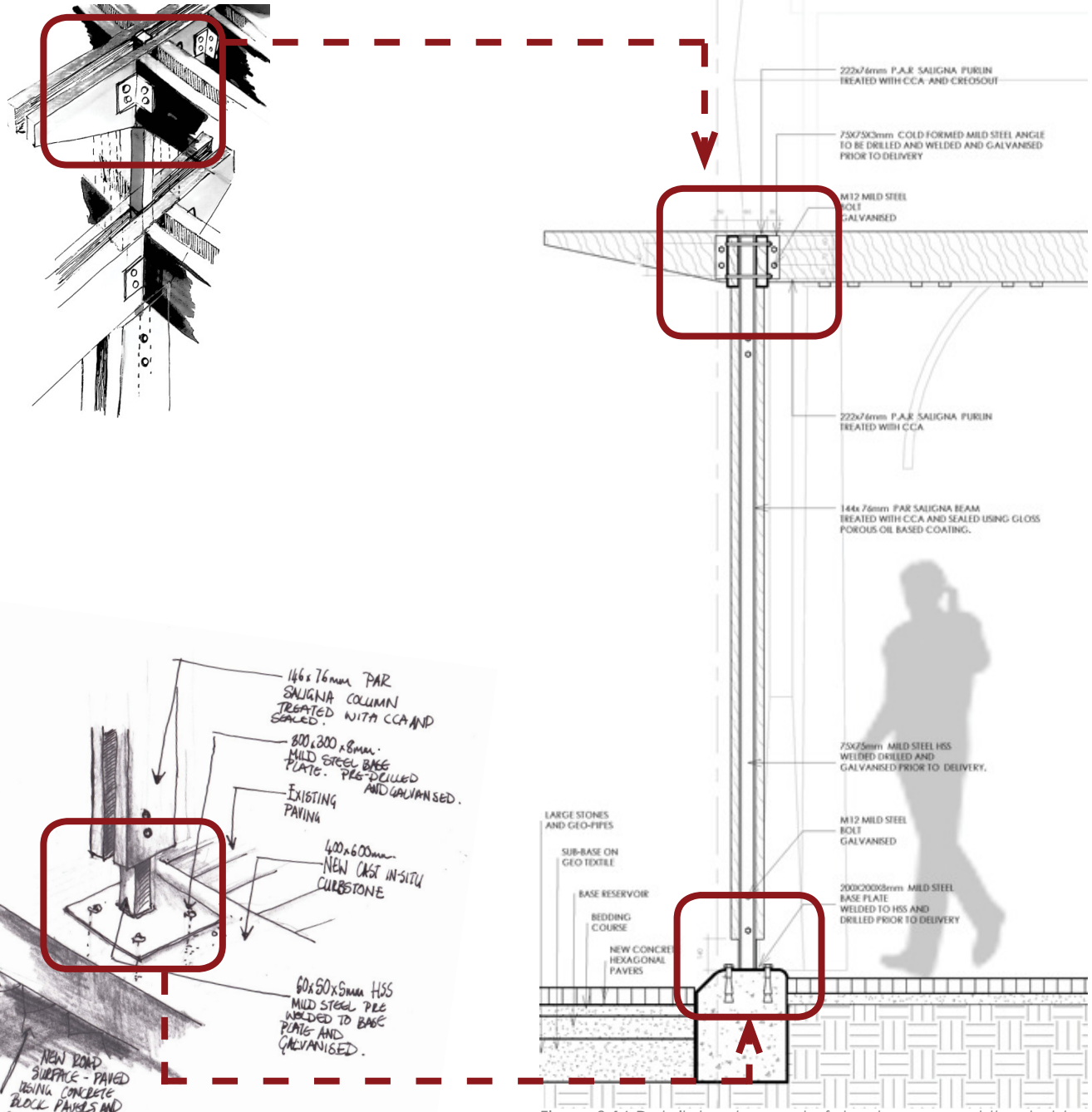

Figure 8.16 Detail development of street- pavement threshold

Street to Pavement Thresholds

The first Column and transitional point occurs at the junction between street and pavement This junction on the ground plane is celebrated by raising the structure onto a steel section as the column becomes the support for a pergola shading structure. The slenderness of timber is due to the conceptual diagram creating numerous lighter elements.

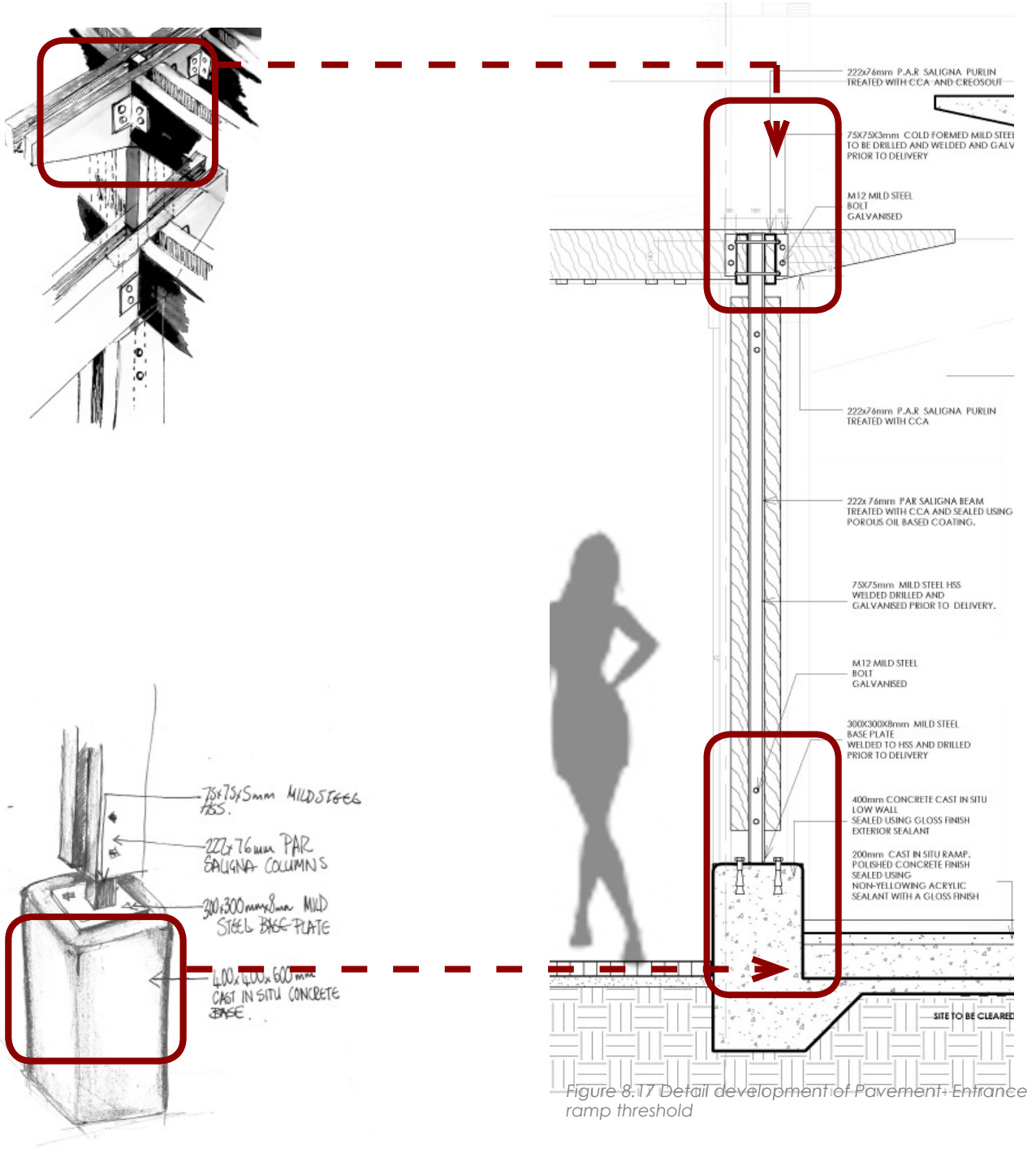

Figure 8.17 Detail development of Pavement- Entrance ramp threshold

Pavement to Ramp

As the columns become more solid from the ground upwards the low wall acts as a base for the columns on the other side of the pergola structure. The connection to the ground is still celebrated only it is not the ground connection but that of a low wall base.

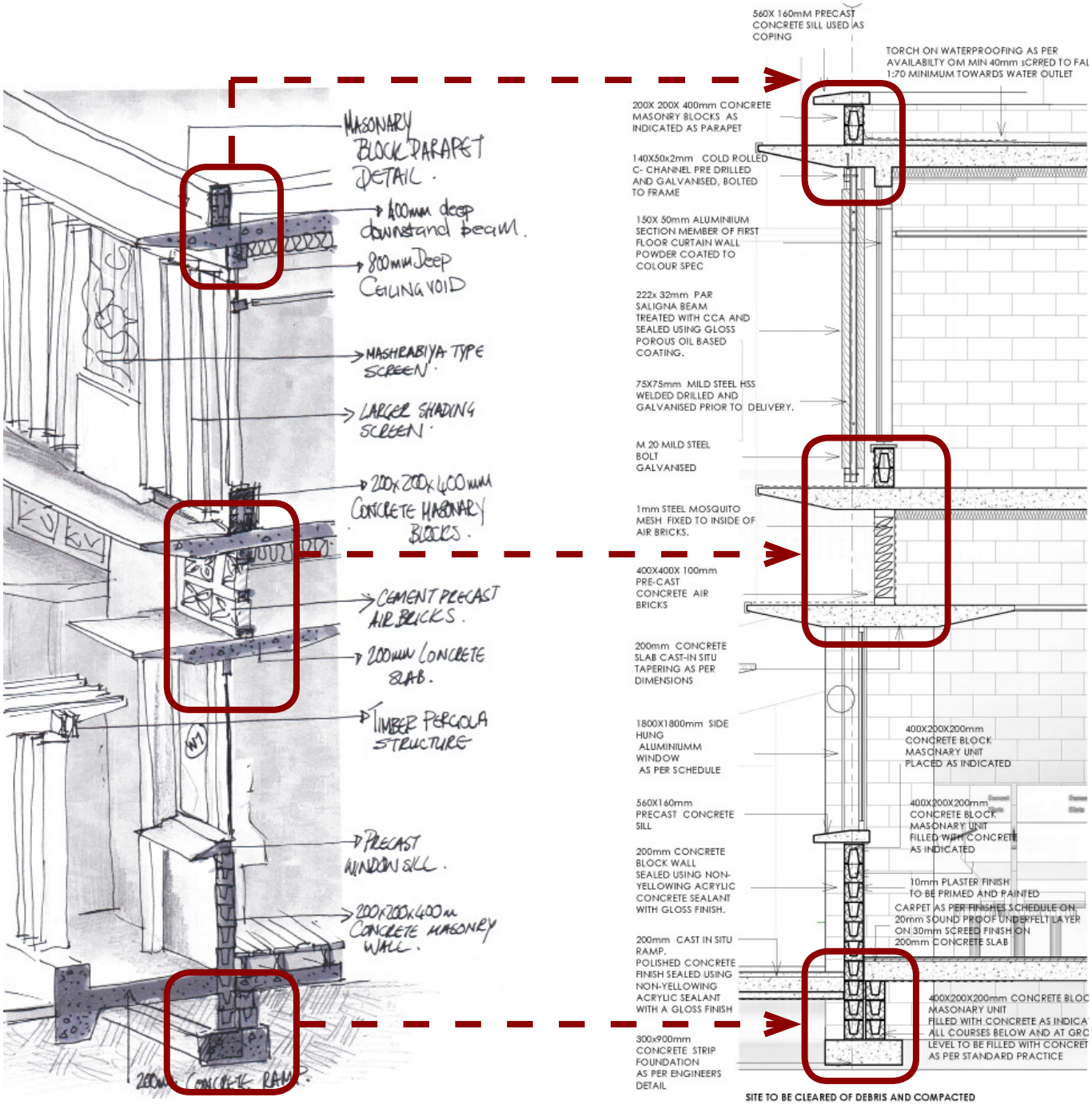

Figure 8.18 Detail Development of inside-outside boundary

INSIDE- OUTSIDE

The permeation of the line between the inside and outside is dealt with in layers of screening, shading and solid, Visual access is required into the space but also the reflective quality of glazing as a relationship to the outside.

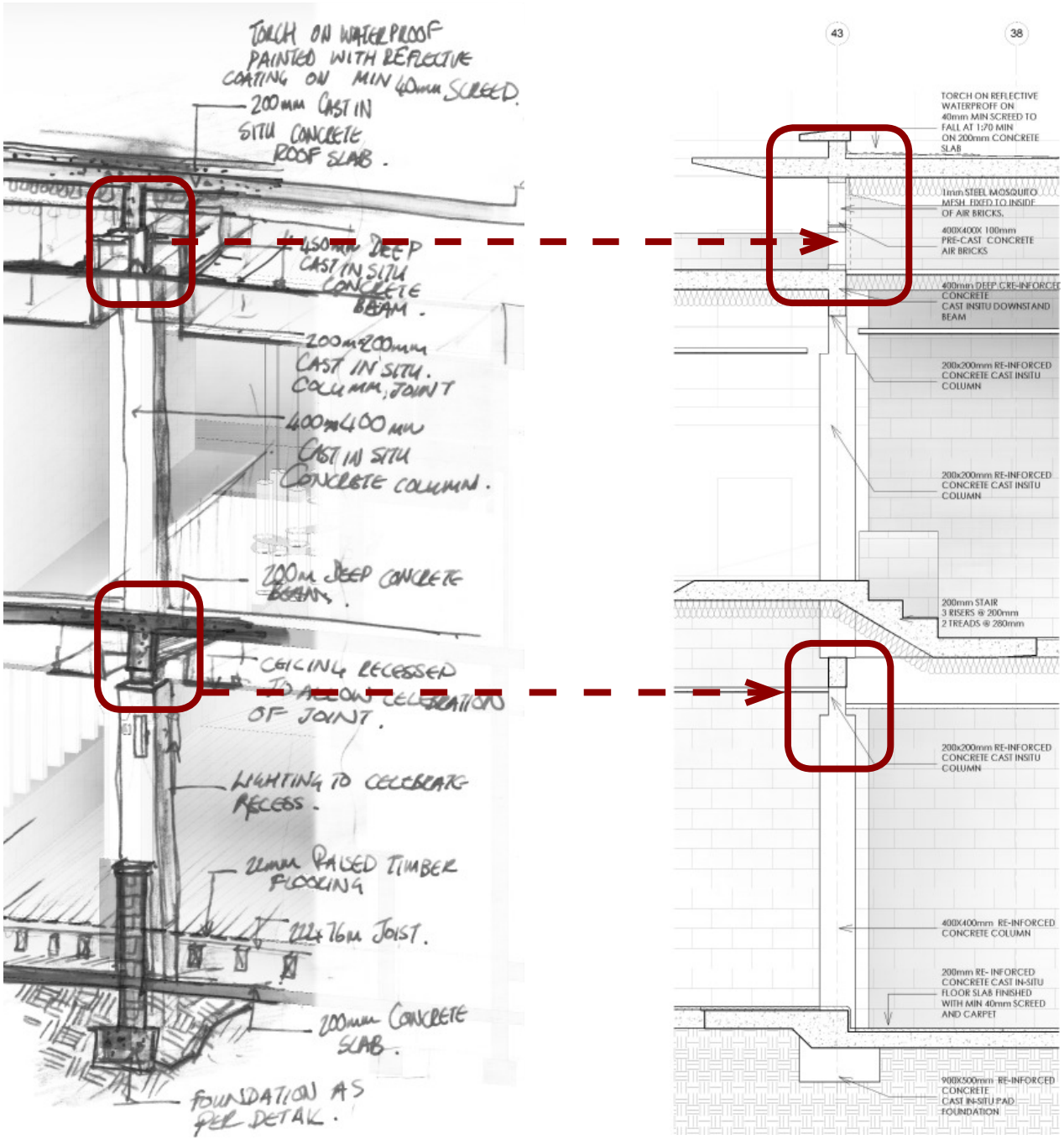

Figure 8.19 Detail development of the solid concrete columns as threshold between interior spaces

Continuity of column

The internal columns that meet the ground plane with no visible joint employ the technique of recessing the top section of the column to celebrate the transition from vertical to horizontal. This is expressed by the cutting back of the ceiling and the implementation of up-lighters to highlight the recess.

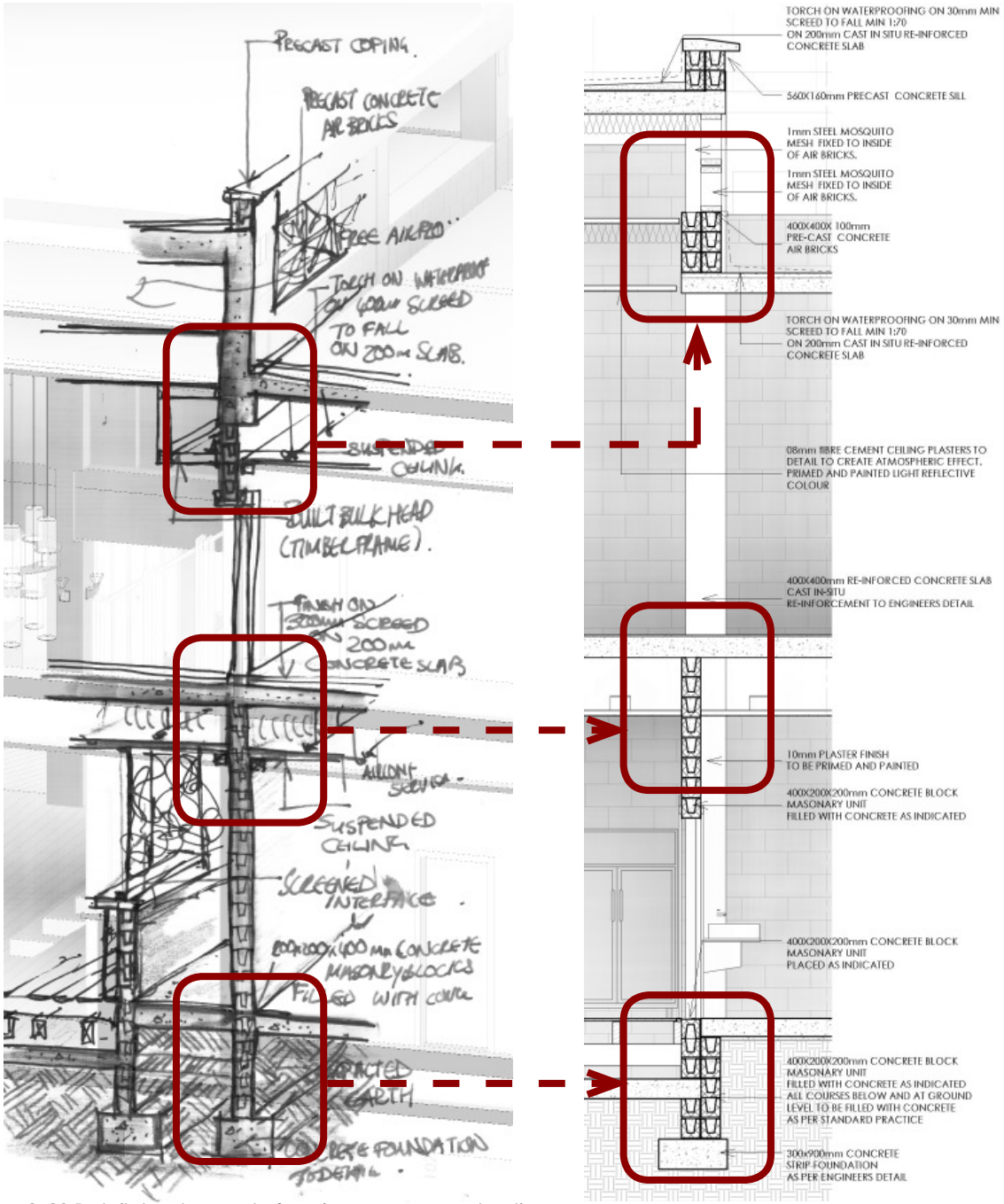

Figure 8. 20 Detail development of services spaces construction.

Service Space

The service space has a direct relationship to the vernacular and is constructed purely of concrete framing and masonry block infill. The walls within their concrete frames act as structure and the need for columns is negated.

Conceptually the wall is the most continuous of the junctions as it has the ability to extend itself along the barrier line it creates.

8.4.2 Beams

Most of the beams within the casino structure will be hidden by the ceiling but those running perpendicular to the street will be the deeper beams as they have a shorter span and will therefore carry most of the load. The connection of beam to column as described in the previous section will need to be celebrated and visually accessible. This is achieved by the stripping away of the ceiling at the junction to create a shadow line void as well as the placing of up-lighters on the column to highlight this connection.

The beams running perpendicular to the street taper as they reach their culmination on the street side creating a feeling of lightness and elevation with the implied continuation of the line to enclose the street as a room.

8.4.3 Foundations

Most of the land around the historic Baixa is reclaimed land but for the historic core. As *Rua de Bagamoyo* is one of the original streets, it falls within the original solid land. The new intervention has a maximum of two storeys at anyone point therefore negating the need for pile foundations. It is proposed that a simple strip footing should be sufficient but this will require reinforcement for the walls. The columns will require a deeper pad foundation

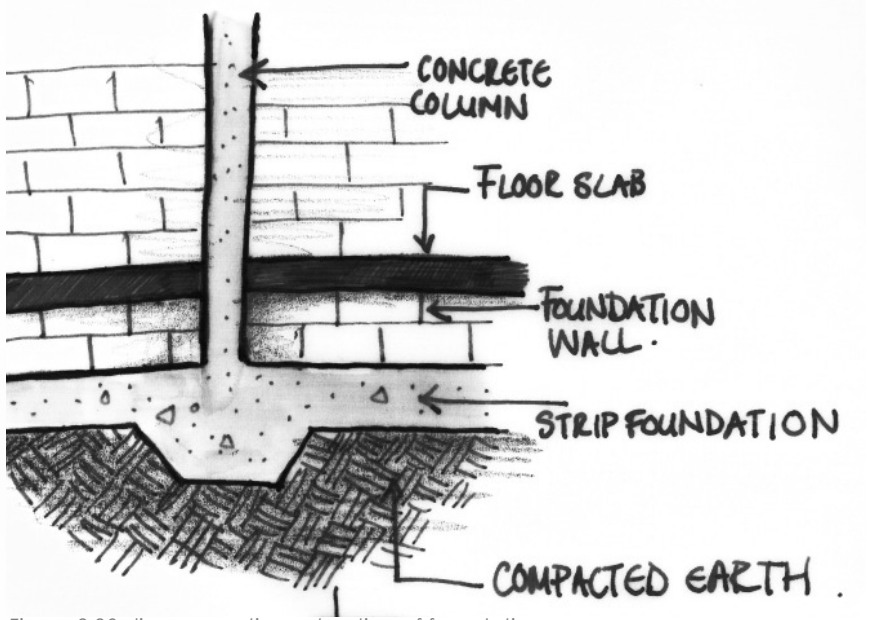

Figure 8.20 diagrammatic exploration of foundation

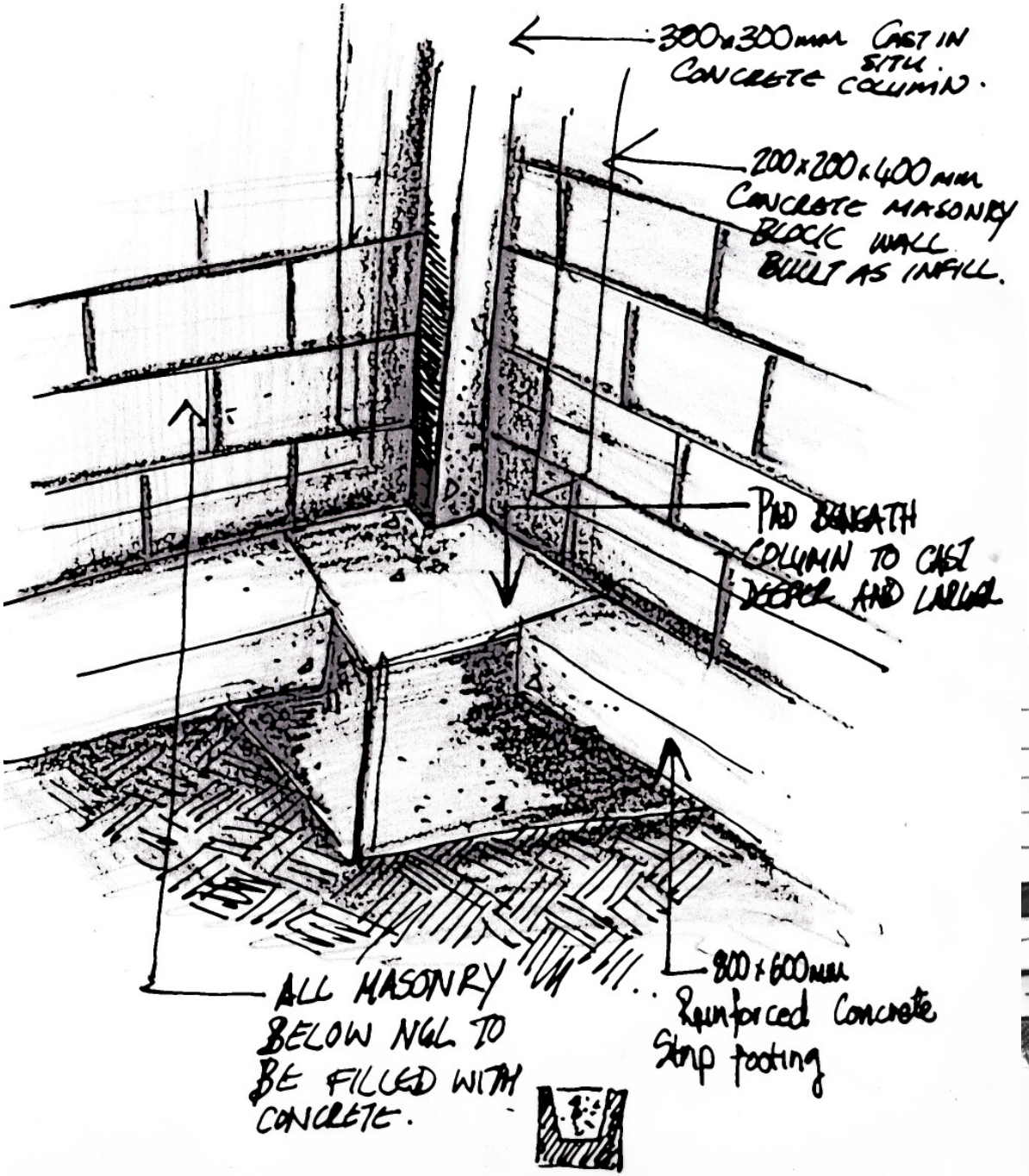

Figure 8.21 3-Dimensional sketch to show thickness of foundation beneath columns

8.5 Skin

Where the thresholds are demarcated on plan, a simple wall of concrete blocks is too heavy a response to signify a veiled visual access and transition. They are therefore only used for the enclosure and service spaces. Therefore screens are used for spatial definition. Learning from the existing heritage and the prevalence of the sex workers , the complexity of privacy in the profession calls for an exploration of privacy and how this is achieved.

Precedents in Islamic architecture were considered such as the "mashrabiya" screens. The mashrabiya is a screen found usually on the first or second floor of secular and residential buildings.

"Mashrabiyas were veils drawn against the outside world and behind their cool shield of latticework those inside did recline in shaded privacy while gazing out at the tumult of the streets below. And yes, they were also a haven for women whose need for privacy in older cultures did give rise to the exotic, if exaggerated, legends of the hidden harem." (FEENY, 1974)

From the beginning the mashrabiya developed into an eminently practical architectural feature that for centuries served, at one and the same time, as window, curtain, air conditioner and refrigerator. (FEENY, 1974: 32)

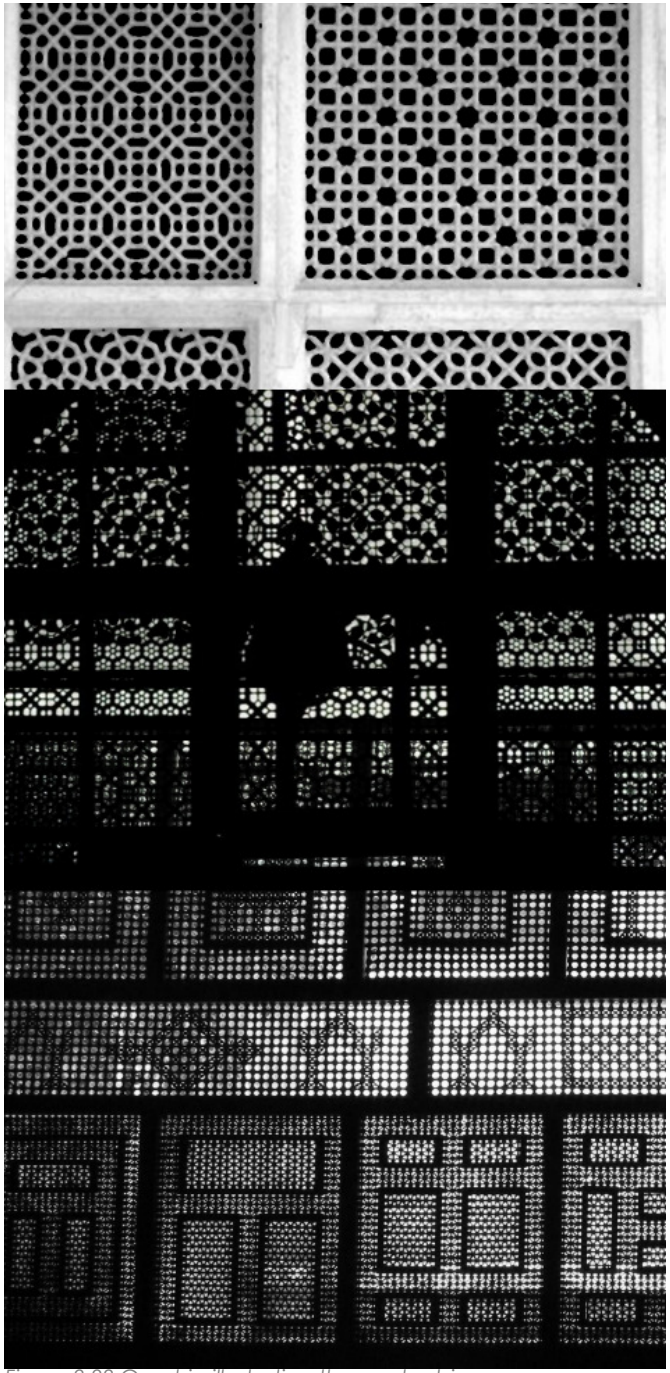

Figure 8.22 Graphic illustrating the mashrabiya

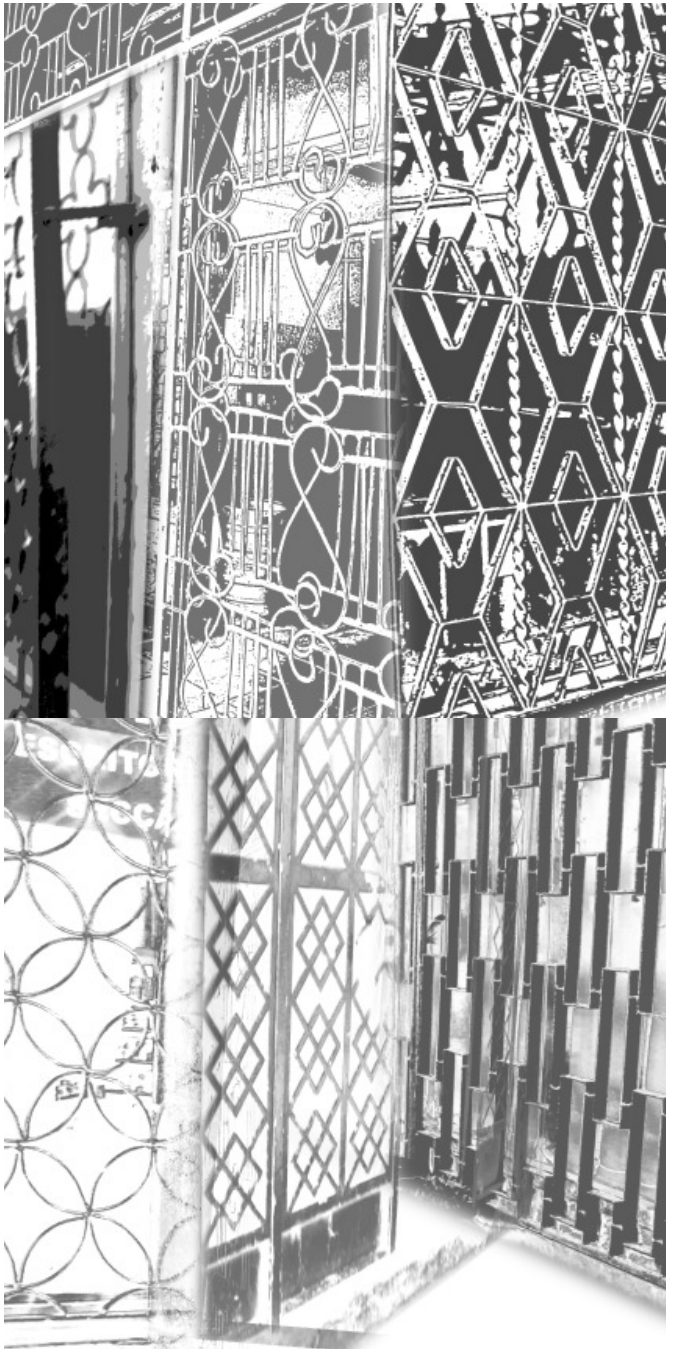

Figure 8.23 Collage of decorative screens and burgular bars found within Rua de Bagamoyo

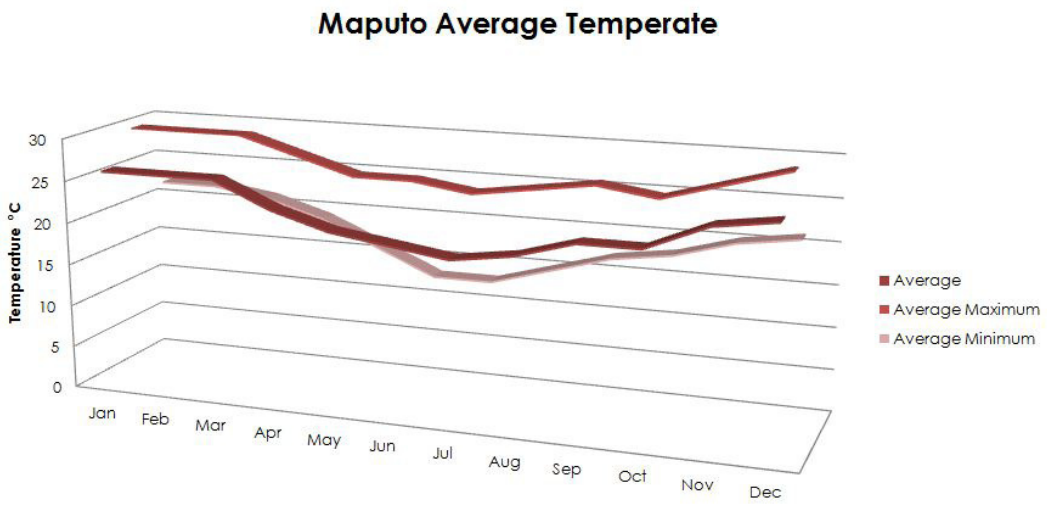

Figure 8.24 Maputo average temperatures graph. Generated by Author

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Relative Humidity PM	66	65	67	63	61	57	59	60	63	66	67	66
Relative Humidity AM	72	73	75	72	71	70	71	68	65	65	67	69

Figure 8.25 Humidity table image by B. SNOW 2011

8.6 Service Systems

8.6.1 Thermal Comfort and ventilation

The nature of the three major programmes in the space require different requirements for thermal comfort and ventilation. Where the Sex- workers facilities can be naturally ventilated and may have an allowance for varied temperatures, the gaming spaces need to have a very controlled thermal system, allowing the proprietor to create a constant temperature within the space for a twenty four hour period. Climatic data for Maputo shows that the average temperatures and maximum temperatures are above the general comfort levels. To create a comfortable and controlled temperature within the casino space it becomes necessary to cool the air, and control the ventilation rates within the space. The market environment is almost completely open therefore cooling is achieved by shading alone.

The maximum temperatures during summer coupled with the high humidity rates create uncomfortable spaces in general and almost unbearable conditions for tourists who are not used to such a climate. The spaces within the gaming space should therefore reduce humidity and temperature. The psychometric charts indicate a specific comfortable temperature and humidity based on the climatic data specific to Maputo. This is determined at between 23- 25 degrees Celsius allowing for the variance within the spaces.

The monthly averages in temperature show very little variance in temperature as the climate allows for warm to hot conditions throughout the year. The table showing humidity values gives indication of the possibilty of uncomfortable space.

Artificially ventilated spaces are required to allow for the control of thermal comfort and ventilation required. Provision is made for a plant facility, maintenance access and large ceiling voids (600-800mm) are allowed for HVAC ducting and piping of fresh air. HVAC is notorious for energy usage and load placed on the electrical grid, but for this type of controlled environment is the most feasible solution.

Different types of HVAC systems exist and some are more environmentally responsible, than others the type identified for this particular building is the absorption chiller. Evaporative coolers were explored as a possibility but were rejected due to the high humidity in Maputo. Geo- thermal techniques were also noted, but would require a large amount of earthworks in a historical area with very small building footprints and narrow streets.

"Absorption Chillers, while an active design solution, have a fairly low environmental impact when compared to other refrigeration devices. Absorption chillers produce a refrigeration effect through use of a heat source, as opposed to the more commonly encountered compressor- driven machines that use electric power to generate a cooling effect." (KWOK and GRONDZIK, 2007: 175)

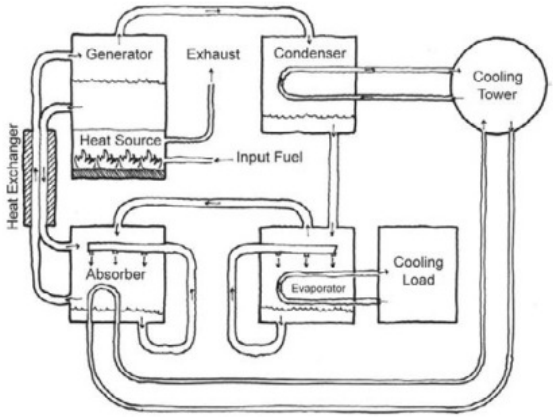

Figure 8.26 Diagram showing the workings of an absorption chiller. (KWOK and GRONDZIK, 2007:76)

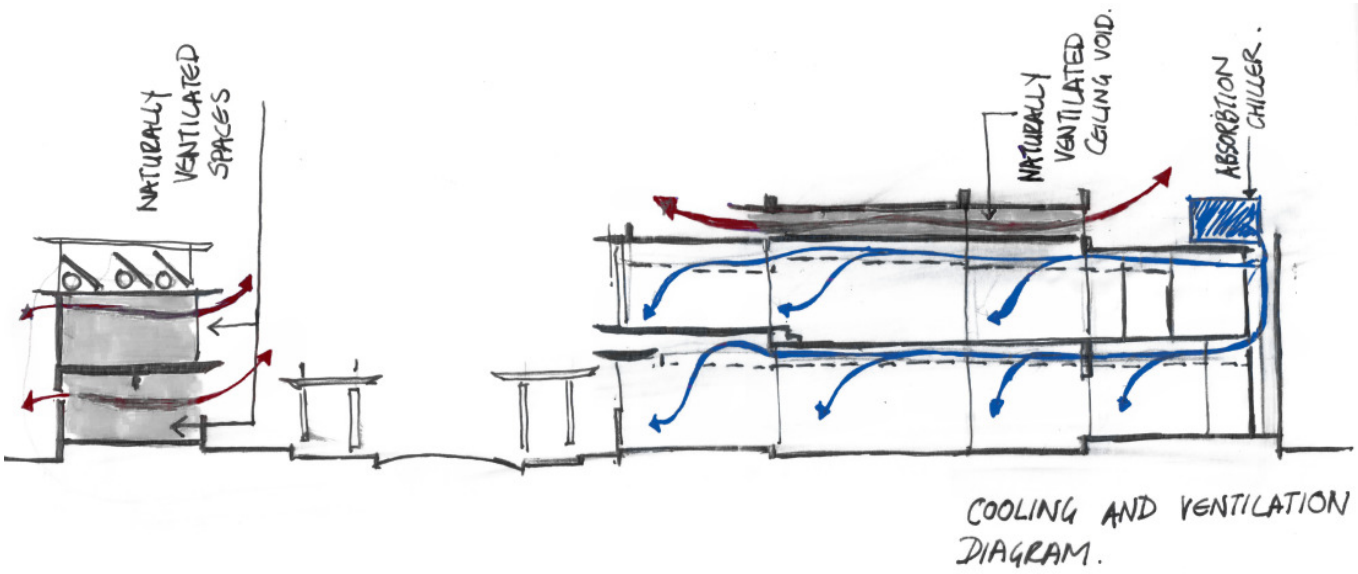

Figure 8.27 Diagrammatic section showing HVAC system

PASSIVE ASSISTANCE

To reduce the load on the air-conditioning and ventilation systems. Insulation, shading and allowing for passive cooling in the roof is proposed. The largest and most exposed roof slab is raised with an air tight ceiling below. This void is insulated from the rest of the building and is opened on two sides , North and South allowing the coastal on-shore and off-shore winds to ventilate the space, removing the heat load of the thermal mass created by a concrete slab roof.

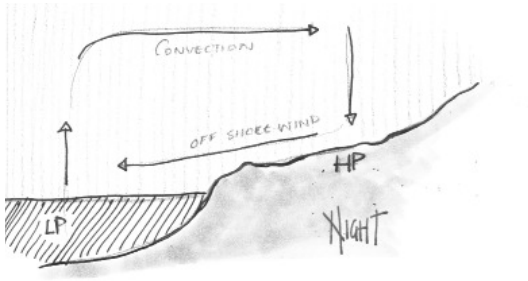

Figure 8.28 Sea breeze diagram at night.

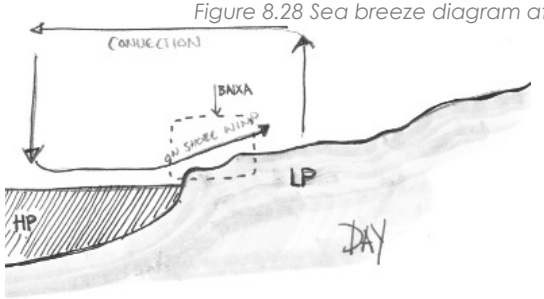

Figure 8.29 Sea breeze diagram at day.

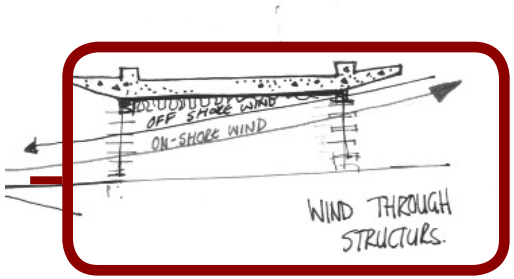

Figure 8.30 Diagrammatic section showing raised roof slab.

Figure 8.31 Section Showing air movement space to allow sea breezes to cool the thermal mass of the roof slab.

8.6.2 Lighting

The creation of uniformity within the gaming space in terms of lighting is a symbolic and conceptual response to the existing duality between night and day as mentioned in the problem statement. The uniformity created is intended to create a constant lighting level over time but still allow for the variance in place.

This means the level of illumination should be constant for a 24 hour period as is required by a gaming space so as to allow the patrons to lose track of time.

Conceptually this constant level of the lighting within the space allows for the continuity required to create a 24 hour precinct.

This is achieved by screening the light in to the space and filtering the levels of illumination during the day, but connecting day-night switches to the artificial lights to allow them to match the lux levels.

Because of the diurnal pattern and the movement of the sun in the sky, the pattern created by the shadows created by the shading screening on openings will move around the spaces and surfaces.

Allowance for movement of atmospheric lights on timers to recreate the patterns over the night hours must be installed.

Task lighting is also provided to specifically light table games.

As indicated in the conceptual sections in Chapter six*(refer to section 6.3)* differences in direct and reflected light create different effect and enhance spaces in different manners. Casino equipment, signage and actual lights create the direct light and the light coloured and reflective surfaces reflect that. To create the richness and cavernous feeling required in the gaming, the finishes are considered according to this concept. By using darker timber with a red stain (only saligna is used because it is the most accessible renewable hardwood available therefore a stain is required to achieve colour variances) for the floor surface this colour absorbs light, but the sealant should be reflective to enhance the richness and glamour of the space. Rich and dark carpets are also specified for the table spaces, the carpets not only absorb light but also the sound.

Slots and circulation spaces are finished with timber flooring which is a hard surface allowing for some light reflection but also the sound of pedestrian movement on the floors is used to enhance the vibrancy and complexity, where the intimacy of the table spaces is enhanced by the sound absorption capacity of carpets.

The ceilings and lighting elements are placed in such a manner that task lighting is direct but all other light is either screened and obscured or reflected off other surfaces.

8.6.3 WATER

Four shower facilities are provided in the sex- workers facilities as there is no specific time for the use of the facilities it is difficult to determine how long and how much hot water would be required. At an estimation of twenty women, that places a load of 5 showers per unit. The green building handbook estimates one shower at 40 l per use. (GIBBARD, 2009: 127) That means a requirement of 8000 litres of warm water per day . Storage of such large amounts of water in geysers would be expensive and not feasible resulting in the last showers being cold. The water temperature does not have to be constantly hot and during summer cooler water would be acceptable.

A constant water heating system is then required that heats the water as it passes into the shower, similarly to a direct- fired gas heater. Image direct fired gas heater.

Having employed a large and expensive HVAC system in the Gaming across the street the waste heat generated is then used to supplement the heating of the water which is then run in an insulated pipe beneath the street prior to the installation of the new surface. Solar water heaters then receive the pre-warmed water which will heat it further. The water then moves on into the four 200l storage geysers that will account for only 25% of the required warm water, but even if the weather is not conducive to heating, it will still be warmer, due to the waste heat from the absorption chillers waste.

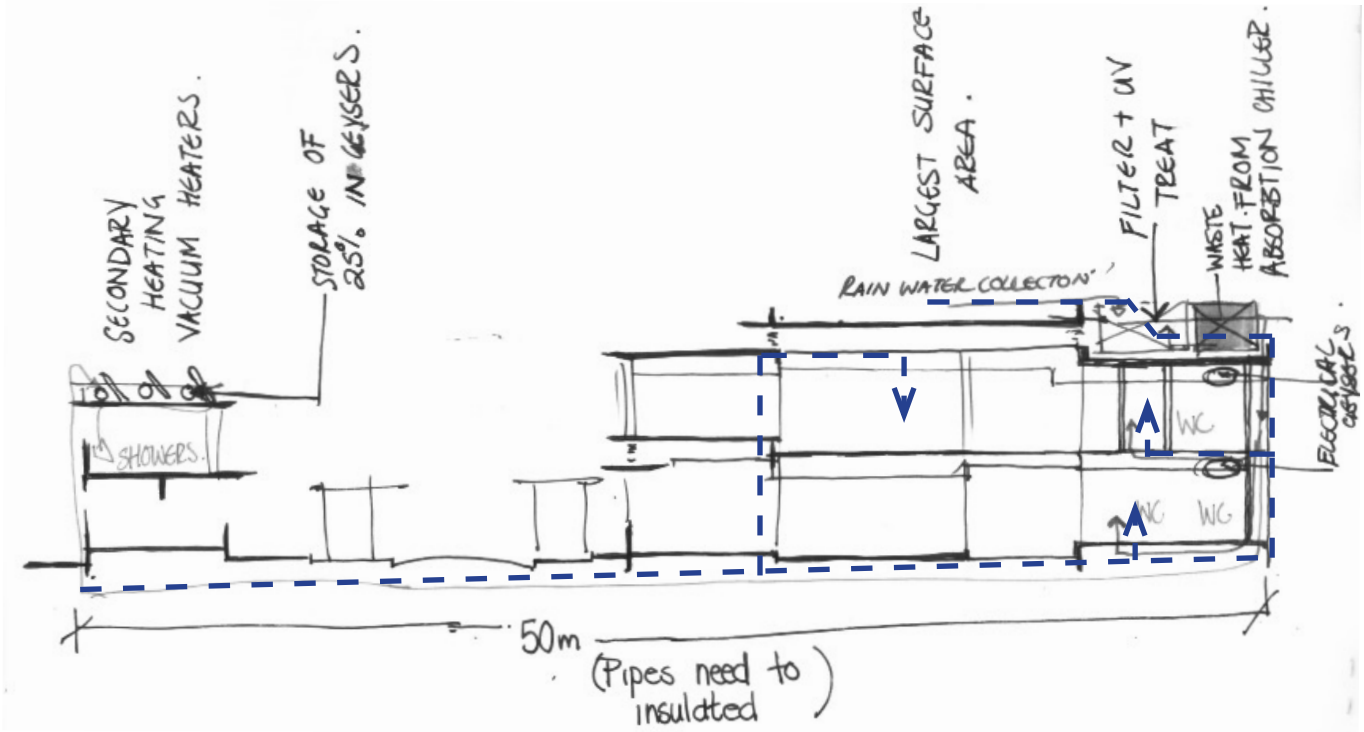

Figure 8.32 Sectional diagram showing movement of water