7. MATERIALS AND TECHNICAL INVESTIGATION

Materials were chosen to provide minimal long-term maintenance. Hardwearing materials on ground floor levels were chosen to withstand the wear and tear of children playing and increased foot plaster, more durable than paint.

Pre-cast elements were designed to speed up construction and to eliminate on-site shutter work. Pre-caste hollow-core Echo floor slabs are proposed. Pre-cast hollow core slabs 7200x899x150, to be laid onto load bearing brickwork. Echo floors are a simply supported, one directional, and structural slab panels with dimensions of 7200x899x150. Slab panels, with 50MPa concrete strength and a structural topping of 80mm, have Live Load capacity of 1.50Kn/m^2.

Standard small pane steel window frames must be used. Steel windows to respond to architectural language of the residential environment. Mono pitched roofs to be covered with 0.6 IBR profile metal sheeting.

Bubble foil or factory lite, 50mm, to be used in roofs to ensure interior climate control with white polyethylene side facing downwards and the foil facing upwards. Bubble foil with thermal resistance of 0.91m2.K/W.

Bubble foil reduces heat radiation by 95%, is tear resistant and flexible, waterproof and non-toxic and effective at temperatures ranging from -20 to 80 degrees Celsius. The white polyethylene side could be used as ceiling as well.

Rainwater to be collected by means of standard reinforced fibreglass water tanks, placed on typical stand tank stands.

Standard 330 and 220 load bearing brick walls are proposed.

Thermal properties of plastered brick wall:

R-value indicates the resistance to heat transmittance. Total resistance of external wall can be determined by calculating/adding the R-values of layers of the envelope elements.

Total air-to-air resistance of envelope is expressed as overall thermal transmittance or U-value.
(Grobbelaar, A 2006 : 210)

220mm brick wall, conductivity 0,84 W/m.K
15mm plaster, conductivity 0.6 W/m.K
Surface resistance Rsi = 0.14 Rso = 0.06m²K/W
Ra-a = Rsi + Rbody + Rso
Rbody = 0.220/0.84 + 0.015/0.6 = 0.287
Ra-a = 0.14 + 0.287 + 0.06 = 0.487
U=1/Ra-a = 1/0.487 = 2.054 W/m²K

Heat storage capacity of 220 brick wall

The amount of heat stored in a element is given by Q=m*c*DT
m = mass of material
c = specific heat of material (J/kgK)
DT = change in temperature due to addition of heat energy

For a 220 brick wall and rise of 1 degree Celsius, the amount of energy stored:
440*850*1 = 374kJ/m²

For a composite light weight steel panel, the amount of energy stored under the same circumstances, would be:
25*1000**1 = 25kJ/m²

High mass walls can absorb several times more energy compared to a lightweight steel structure. In direct sunlight, the light structure will heat up quickly and transmit the heat inside surface within half an hour. The high mass structure will need more time to heat. Time needed to transmit heat from one surface to another, is known as lag time.

- Lag time for a concrete roof slab or 220 brick wall = 6 hours.
- Lag time for a 330 brick wall = 11 hours.

(Grobbelaar, A 2006 : 210)

Higher thermal mass, promotes better thermal comfort for dryer regions such as Pretoria, Mamelodi.

Higher mass would be material of choice for better thermal inertia.

7.1 Structural Calculation

If considered the Floor Nominal Dead Load of 4.8kN/m²and Floor Nominal Imposed Load (Live Load) of 5kN/m² and 180kN/m factored load from upper storeys, the following formula could be used to determine suitable bricks and mortar for a 220 load bearing ground floor wall:

- Consider a 1m length of a 5m 220 wall with self weight of 22 kN/m²

Dead loads: Floor = 4.8 x 5 (floor span) = 24kN

Self Weight of walls= 0.220x3.5 (wall height) x22 = 16.94kN

Total = 40.94

Imposed load = 5x5 = 25kN

Factored/m run = 1.2xDL + 1.6xLL

1.2x40.94 + 1.6x25 = 89.13kN

Total load: 180 + 89.13 = 269.13 kN/m

Effective height = 2625mm

Slenderness ratio = 11.9

Plan area of wall = 5x0.220 = 1.1m²

Material safety factor = 2.9

fk= $\frac{2.9x269.13x1000}{0.93x1.0x1000.220}$ = 3.81MPa

Class I mortar with 14MPa bricks, or Class II mortar with 17MPa bricks would be suitable.

Pre-cast hollow core slab – Echo floor

- Pre-cast hollow core slabs are self-supporting up to 7.2-meter span.
- Hollow core slabs are placed on load bearing walls on top of damp proof as a slip layer.
- Slabs over 5.0m require a structural topping.
- Props are placed 1 meter apart.
- Steel is required in a structural topping on all cantilever panels.
- Twice the length of the cantilever must sit on the building.
- Slabs can be used as roof slabs, balconies, and external walkways of flat roofs with a reference 100 mesh in the screed/topping over the slab - Textured paint or tyroleen finish is used on the soffit of the slabs.
- Use 25MPA premix concrete for structural screed/topping.
- Props to be in place for 14 days after casting of concrete (Echo Floors : 1991).

7. 2 Housing Support Centre

For purposes of the Housing Support Centre, a reinforced concrete frame structure with masonry brick infill is proposed. Cast-in-situ slabs 255m, one way, with reinforced concrete columns, 440x220 to be suitable for this building. Columns carry all vertical loads to foundations in compression with column layout on a 5m grid.

Slab thickness determined by L/20 for one-way slab.

Column alignment and spacing on a 5m grid would be structurally ideal for gathering of loads and descending vertically in compression.

For cantilever slabs a 500mm R8 stirrup with steel Y16-20 is recommended (Echo Floors: 1991)

Pedestrian walkways on first and second floor should be constructed of composite slabs. BMT profiled steel decking with a 110 r/c slab to be used.

0.6 IBR profile sheet metal is used to continue the architectural language of the environment. White polyethylene with thermal resistance of 0.91 M^2K/W should be used.

Steel mesh/ expanded metal fixed to a mild steel frame is used for balustrades and security gates.
For the workshop section of the support centre, a steel construction frame with lightweight steel panel and masonry infill is used. A steel construction is used for this section of the building, due to its open and adaptable character and the recyclability properties of steel.

7.3 Market Area

A steel construction with lightweight steel panel, IBR profiled roof sheeting and masonry infill is used. The market area comprises of trading units, secured with a mild steel frame and expanded metal security gates.

A covered walkway gives access to the Housing Support node. IBR profiled sheeting supported by a mild steel frame, are used.

7.4 Ventilations Options

Natural ventilation is generated by pressure differences in and around the building. Pressure differences from air movement are generated by air temperature and wind.

Temperature driven ventilation - stack effect - uses natural buoyancy of the hotter air to rise and displace cooler air. Stratification occur - hotter air rise, cooler air at bottom move in.

Design factors affecting ventilation:

1. Reduction of plan depth and increase openness of section to facilitate cross-flow and vertical flow.

2. Optimum orientation of rooms to prevailing breeze and linkage between leeward and windward side.
3. Maximise skin opacity through number and size openings, horizontal versus vertical stacking of openings.
4. Reduction of internal obstructions.
5. Increase exposure to airflow effects.
6. Open able bottom and top louvers/windows to allow cooler air to flow in at bottom, while hot air to rise with stack effect and escape through top windows (Hyde, R. 2000 : 75)

7.5 Passive Building Model

The building aspects of climate modification in terms of the Housing Support Centre can be classified as a passive model. The passive model makes use of natural energy in the environment, building form and fabric to modify climate. No plant or equipment is used to modify the climate.

Figure 7.1 Housing Support Centre with Ventilation Strategies

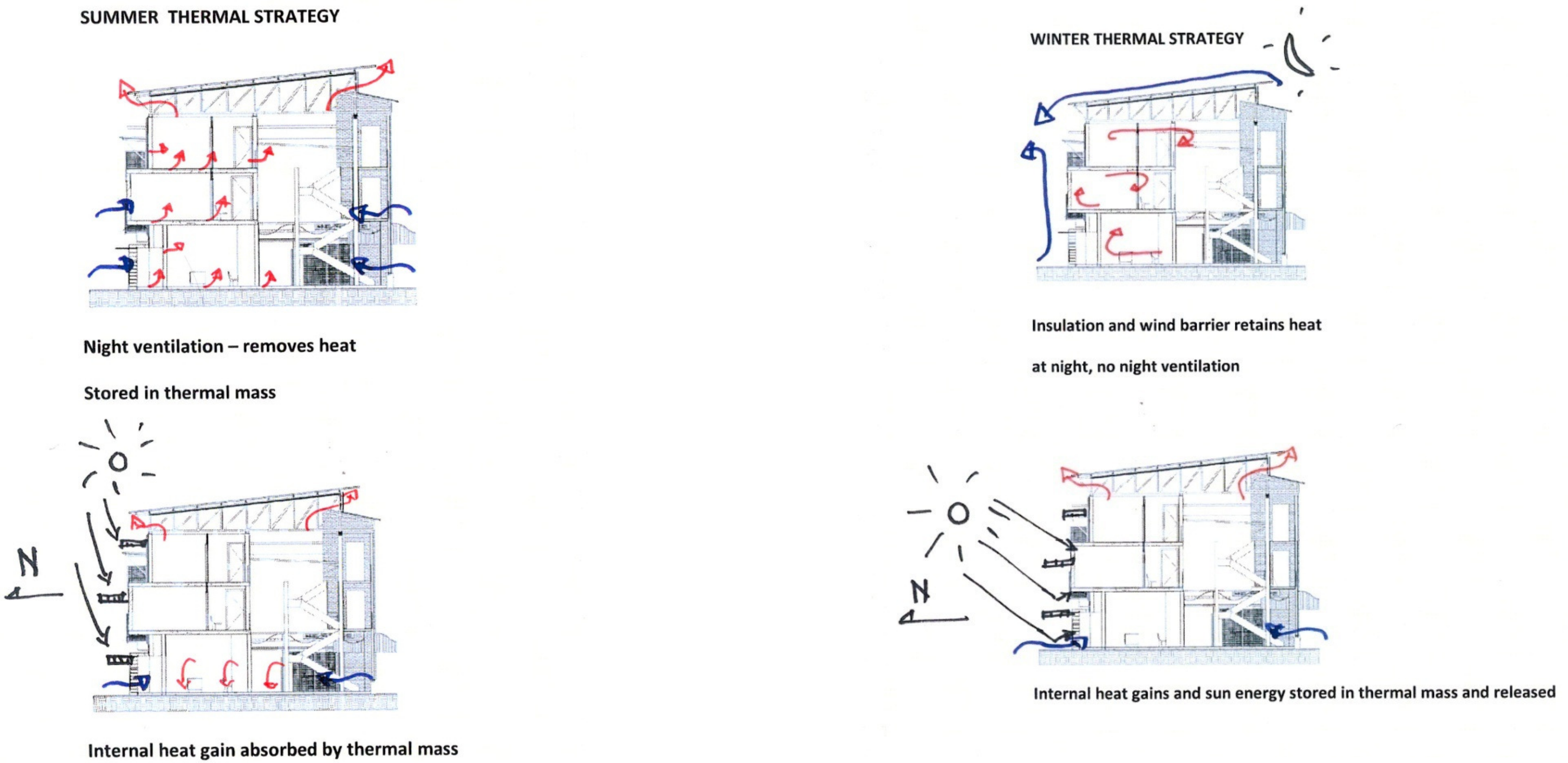

Figure 7.2 Summer and Winter Ventilation Strategies (ARG Design, 2008:79)

7.6 Solar Water Heating

All residential units and Housing support Centre to be provided with a 150l Solar Heating System. Insulated storage tanks to be mounted to outside wall above balcony and Solar Heat Collector Panels mounted over the top of a mild steel frame structure of the balcony, facing the equator. Solar panels to be connected on a mild steel roof rail and clamp, bolted to steel frame above balcony with stainless steel bolts, washers and nylock nuts. The collector panels fulfil the dual function of providing shade and weather protection for the balconies in top floor.

Insulated storage tank with solar heating panels

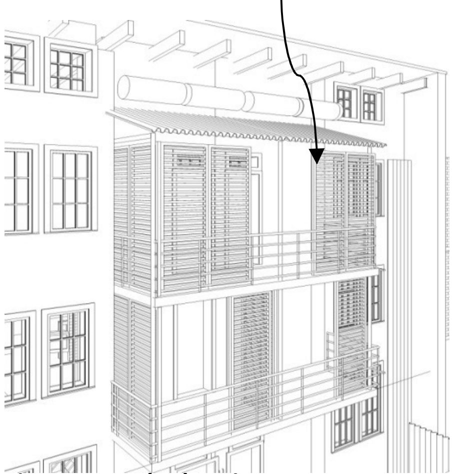

Figure 7.3 Solar heating strategy

7.7 Rain Water Harvesting

Each top storey unit to be fitted with a standard 2000l reinforced fibreglass water reservoir for harvesting rainwater. Rainwater should be used for WC, gardening and exterior use.

7.8 Energy Efficiency

The thermal qualities of a typical 30m2 second floor rental unit with western exposure are determined for a typical summers afternoon at 15h00. Three different material options with different thermal qualities are taken in consideration:

Option 1: (32m2 unit)

- 0.6 IBR profile sheet metal roof, painted in dark colour, or unpainted
- dark, unplastered exposed 200 brick wall,
- think pink/mineral wool roof insulation,
- standard ceiling board,
- 800-roof overhang.

Maximum internal day temperature: 30.5

Minimum internal day temperature: 12.7

Option 2: (30 m2 unit)

- 0.6 IBR profile sheet metal roof, painted white,
- 15m plastered wall finish,
- 220 plastered cement brick wall,
- light coloured painted exterior walls,
- 50mm metalized factory lite roof insulation,
- 800-roof overhang.

Maximum internal day temperature: 27

Minimum internal day temperature: 10.5

Option 3: (30m2 unit)

- Same as option 2'
- Western facade with sun shading panels that block out 50% of western sun

Maximum internal day temperature: 26.8

Minimum internal day temperature: 10.5

Option 3 provides the best option for residential design in Mamelodi. Option 2 provides better winter thermal qualities, although option 3 offers the best option, taking in consideration the longer summer than winter climate in Gauteng.

(Energy Analyses Programming, IMECH Consulting, October 2008)