The survey involved the visual inspection of the following areas of the building noting structural defects:

- Flat Roof
- All Elevations
- Selected balconies
- 4th Floor Walkway

2. Description

Goulden House is a six-storey big block of flats containing 269 flats. The site is enclosed by Shuttleworth Road to the North, Bullen Street to the East, Winder Road to the west and Home Road to the south. (Refer to photo 2.2) The balconies face an inner and an outer green.
The building was constructed in the early 70's in phases. It is constructed of a combination of load bearing masonry and reinforced concrete frame with flat roof. The edges of the floor slabs and beams are exposed on all elevations (Refer to Photo 2.1).

Photo 2.1: Goulden House Elevation on Winders Road

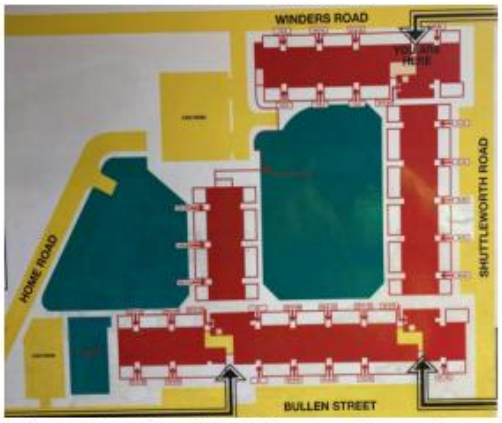

Photo 2.2: Goulden House: Footprint

3. Observation

3.1. General

The roof slab is covered with insulation and felt. The drainage inlets are clean and there is evidence of good drainage on the roof. There are however isolated cases of water ponding and a single case where filth is accumulating around the inlet and needs to be cleaned.
The reinforced concrete beams on all elevations are experiencing reinforcement corrosion which has resulted in spalling of concrete. The severity ranges from minor to severe. In some cases lumps of concrete have fallen off.
The 4th floor walkway is surfaced with asphalt which has uneven surfaces at several locations. Cracks have formed in the asphalt due to the elements. The cracks range from minor to very severe. In some areas the asphalt termination on the wall is peeling off.

3.2. Visual Defects

Table 3.1 gives a summary of the defects noted during the visual inspection. Where photos of the defects are available, the references to them in Appendix A are included in the last column of the table.

Table 3.1 Summary of Structural Defects

Area	Structural Component/ element	Location	Visible defect	Possible causes	Photo Reference in Appendix A
General	Communal terraces	5th floor adjacent Shuttleworth and Home Road wing junction	Rainwater ponding	Poor drainage of terrace/ blocked drainage inlets	Photo 3.3
	Side walls bordering staircases	4th floor communal terraces opposite flats 202 218 and 232	Several cracks on side walls	Movement in wall causing cracks in brittle finishes	Photos 3.4, 3.5 and 3.6
	Perimeter beam/slab edge	5th floor opposite flat 232	Spalling of concrete exposing reinforcement	Reinforcement corrosion	-
	4th floor sloping roof over staircase to sub entry 247-248	Underneath roof slab within stair well.	Horizontal crack in wall causing water ingress	To be investigated	Photo 3.8
	Perimeter	Elevation	Spalling of concrete	Reinforcement	-

	beam/slab edge	adjacent Ball Court at 5th floor	at corner and side of beam	corrosion	
	Slab edge	5th floor, top of fire stair well adjacent Ball Court	Vegetation growth	Moisture ingress	Photo 3.7
	Corner of perimeter beam/slab	Floors 1, 2 and 3, Adjacent stairwell adjacent Ball Court	Spalled concrete cover exposing reinforcement	Reinforcement corrosion	-
Roof	Winders Road Wing	Midway	Depressions in roof surface. Evidence of rainwater ponding. Filth around inlet	Uneven roof surface for effective drainage	Photos 3.1 and 3.2
Elevations facing outer green	4th Floor slab edge/beam	Adjacent sub-entry 109-114	Spalled concrete cover exposing reinforcement	Reinforcement corrosion	-
	3rd floor slab/beam	Adjacent sub-entry 109-114	Crack at corner	Reinforcement corrosion	-
	4th floor balcony slab edge	Adjacent sun-entry 115-120	Spalling of concrete cover exposing reinforcement	Reinforcement corrosion	-
Elevations facing inner green	3rd floor beam /slab edge	Adjacent fire stairwell Block B	Chip at corner	Reinforcement corrosion	-
	First floor perimeter beam/slab edge	facing bike shelter A	Spalled concrete cover exposing reinforcement	Reinforcement corrosion	-
	2nd floor beam/slab Adjacent down pipes.	Sub-entry containing flat 121	Loss of concrete at the top on opposite sides	Reinforcement corrosion	-
	4th floor	Sub-entry containing flat 116	Spalled concrete cover exposing reinforcement	Reinforcement corrosion	-
	4th floor slab/beam	Sub-entry containing flat 109	Concrete spalling at levels 1, 2,.3 and 4 on both sides at entry point.	Reinforcement corrosion.	-
	2nd and 3rd floors beam/slab	Adjacent flat 127, above store shed	Spalled concrete cover exposing reinforcement	Reinforcement corrosion	-
	4th floor beam/slab	Above flat 127	Severely spalled concrete at bottom left corner of top lintol.	Reinforcement corrosion	Photo 3.26
	1st floor slab/beam	Adjacent flat 128	Spalled concrete exposing reinforcement	Reinforcement corrosion	-
	4th floor slab/beam	Between entrance to flats 128& 129/	Multiple spalling of concrete	Reinforcement corrosion	-

		131 & 130			
	3rd Floor balcony parapet	Between entry to flats 131&130/133 &132	Two flaking bricks	Weathering	-
	2nd and 3rd floors	Adjacent ground floor flat 78	Bricks damaged with drilled holes	works undertaken to insert cables.	-
	2nd floor slab/beam	Adjacent sub-entry containing flat 56	Spalled concrete	Reinforcement corrosion	-
	3rd floor beam	Adjacent to sub-entry containing flat 56	Spalled concrete at corner of cantilever	Reinforcement corrosion	-
	3rd floor beam/slab	Between entrances to flats 50 and 56	Spalled concrete	Reinforcement corrosion	
	5th floor slab/beam	Between entrances to flats 50 and 56	Spalled concrete	Reinforcement corrosion	
	2nd and 3rd floor slab	Adjacent sub-entry containing flat 44 near down pipe	Cracks in concrete. Repair works carried out in the past but cracks have reappeared	Reinforcement corrosion	
	Ground floor	Brick wall at entrance to flat 44	Hole in brick work at bottom right.	Created by removal of pipe which was not reinstated	Photo 3.30
	5th floor balcony and roof slab/beam	Between flats 44 and 38	Spalled concrete exposing reinforcement	Reinforcement corrosion	Photo 3.11
	5th floor slab/beam	Between sub-entry containing flats 32 and 38	Spalled concrete cover exposing reinforcement	Reinforcement corrosion	-
	5th floor beam	Adjacent sub-entry to flat 32	Corner of concrete beam cracked.	Reinforcement corrosion	-
	3rd and 5th floor slab/beam	Fire stairwell between flat 32 and stairwell	Spalled concrete cover exposing reinforcement	Reinforcement corrosion	-
	2nd floor slab/beam	Entrance to flats 1 and 2	Cracks in concrete	Reinforcement corrosion	-
	5th floor slab/beam	Between flats 1/ 2 and 3/4	Spalled concrete adjacent flats 1 and 2 area.	Reinforcement corrosion	-
	3rd floor slab/beam	Between flats 5 and 6 and fire escape stairwell	Spalled concrete cover exposing reinforcement	Reinforcement corrosion	-
Winders Road	1st floor balcony cantilever	Adjacent entry to flats 26-28	Cantilever with diagonal crack at the	Reinforcement corrosion	Photo 3.33

Elevation			top which appears to have been repaired in the past		
	Ground floor lintol	Below entrance A signpost	Spalling of concrete to the side and at the corner.	Reinforcement corrosion	-
	4th Floor RHS of entrance A	Balcony slab edge/beam between entrance A and flat 24.	Spalling of concrete cover exposing reinforcement	Reinforcement corrosion	-
	4th floor slab/beam	Above entrance to flats12-11	Spalled concrete above entrance 12-11	Reinforcement corrosion	-
	4th floor beam/slab	Above entrance to flats 12-11	Spalled concrete cover exposing reinforcement		-
	2nd floor beam/slab	Between entrance to flats 8-7 and end of block	Spalled concrete cover exposing reinforcement	Reinforcement corrosion	-
	Transformer room door lintol	Corner of Winders Road and Goulden House approach	missing Brick cladding to lintol missing	Loss of bond between concrete and mortar.	
Shuttleworth Road Elevation	Ground floor beam above "Shuttleworth Road" signage	Adjacent Shuttleworth Road junction with Winders Road.	Fine vertical crack in beam at top of window	Thermal/ shrinkage crack	Photo 3.34
	2nd floor brickwork	Between Gate and flats 31-36 entrance above 2nd floor beam/slab	Part of brick missing and another brick flaking	Attempt to install fixing in the past. Flaking may be due to weathering.	-
	2nd floor beam/slab	LHS corner of entrance to 37-42 adjacent to down pipe.	Spalled concrete; Repairs have been undertaken previously but it appears further spalling has occurred.	Reinforcement corrosion	-
	1st floor corner of beam/slab	Entrance to flats 43-48	Cracked concrete. Evidence of repair works but has cracked again.	Reinforcement corrosion	-
	1st Floor slab/beam	LHS of entrance to flats 49-54	Cracked concrete; Repaired but has cracked again.	Reinforcement corrosion	-
	1st floor brickwork	RHS of entrance to flats 49-54	Flaking brickwork	Weathering	-

	1ST floor slab/beam	Adjacent entrance to flats 55-60	Crack at corner	Reinforcement corrosion	-
	1st floor brickwork	Rear of flats 63-65	Loss of pointing	Weathering	-
	3RD floor brickwork	Flank wall to flats 63-65	Broken and dislodged bricks.	Could be due to removal of ties fixed into the wall.	Photo 3.35
	2nd floor brickwork	Flank wall to flats 63-65 facing Shuttleworth Road	Location where boiler exhaust pipe is inserted. Bricks dislodged	Damage caused by boiler installers and not reinstated.	Photo 3.36
Bullen Street Elevation	1st floor slab/beam	Adjacent to entrance to flats 63-65 at corner of Shuttleworth Road and Bullen Street	Spalling of concrete	Reinforcement corrosion.	Photo 3.29
	4th Floor slab/beam	Between Entrance B and flat 77	Spalling of concrete	Reinforcement Corrosion	-
	5th Floor Slab Beam	Between Entrance B and flat 77	Spalling of concrete	Reinforcement Corrosion	-
	5TH Floor	Between entrances B and entrance to Flats 80-79	Vegetation growth on wall	Moisture ingress	-
	1st Floor beam/slab	LHS of Entrance B.	Spalling of concrete exposing reinforcement in beam and diagonal crack in slab at corner of slab	Reinforcement corrosion. Diagonal crack requires monitoring and further investigation which is not part of the scope of this survey	Photo 3.37
	1st Floor slab	LHS of Entrance to flats 80-79 adjacent downpipe	Spalled concrete leaving a hole at slab bottom corner. Evidence of past repair works.	Reinforcement corrosion	-
	5th Floor Slab	Between Entrance C and entrance to flat 85	Spalled concrete	Reinforcement corrosion	-
	Roof slab edge	Above entrance C	Spalled concrete	Reinforcement corrosion	-

	1st floor slab	Between entrance C and entrance to flat 97	Spalled concrete	Reinforcement corrosion	-
	1st floor slab	LHS of entrance C	Multiple cracks and bulging in concrete cover	Reinforcement corrosion	Photo 3.27
	4th and 5th floors and roof slab	Above entrance to flats 99 and 100	Spalled concrete	Reinforcement corrosion	-
	4th Floor slab	Between entrances to flats 100-99 and 102-101	Spalled concrete	Reinforcement corrosion	-
	4th and 5th floor slab	Recessed bay between Flat 77 and Entrance B	Spalled concrete exposing reinforcement	Reinforcement corrosion	Photo 3.28
Selected Balconies	Flat [redacted]	Lintel to living room windows and door	Spalled concrete and drilled holes	Reinforcement corrosion. Drilled holes for fixing ties not reinstated	-
	Flat [redacted]	Underside of living room ceiling adjacent balcony lintel	Cracks in paintwork. Damp patch	moisture ingress from roof.	Photo 3.31
	Flat [redacted]	Balcony upstand supporting brick parapet	Spalled concrete	Reinforcement corrosion	-
	Flat [redacted]	Lintel to living room windows and door	Severely spalled concrete	Reinforcement corrosion	Photo 3.32
	Flat [redacted]	Balcony upstand supporting brick parapet.	Spalled concrete	Reinforcement corrosion	-
	Flat [redacted]	Lintel to living room	Drilled holes to insert ties not reinstated		-
	Flat [redacted]	Lintel to living room	Ties left in place. Spalling of concrete at LHS	Reinforcement corrosion	-
	Flat [redacted]	Upstand and lintel	Spalling of concrete	Reinforcement corrosion	-
4th Floor Walkway	Asphalt surfacing to walkway	General	uneven surface and cracks ranging from medium to severe.	Weathering	Photo 3.25
	Asphalt surfacing and termination on walls	Adjacent entry to flats 198-200	Asphalt severely cracked and termination on wall peeling off.	Weathering	Photo 3.24
	5th floor slab	Between entrance to flats177-182 and 183-188	Concrete spalling	Reinforcement corrosion	Photo 3.23

	5th floor beam	RHS entrance to flats 177-182	Spalled concrete at bottom and top corners	Reinforcement corrosion	Photos 3.21 and 3.22
	5th Floor Beam	Adjacent to entrance to flats 165-170	Diagonal crack in top of beam	Reinforcement corrosion	Photo 3.18
	Column	Adjacent to entrance to flats 165-170	Long crack at base	Reinforcement corrosion	Photo 3.19
	5th Floor beam and column joint	Adjacent to entrance to flats 171-176	Severe spalling of concrete to beam	Reinforcement corrosion	Photo 3.20
	5th Floor slab	Between flats 190-194 and 195-197	Concrete spalling from slab edge. Fine crack in slab	Reinforcement corrosion	-
	5th Floor slab	Adjacent entry canopy to flats 198-200	Spalling of concrete to edge of 5th floor slab on LHS	Reinforcement corrosion	-
	Corner column	Adjacent entry to flats 198-200	Crack at slab and column joint	Reinforcement corrosion	
	4th floor column	Adjacent entrance to 264-269	Crack at top of RHS column	Reinforcement corrosion	Photo 3.39
	4th floor column	At RHS of entrance to flats 249-251	Severe crack at base and medium crack at the top.	Reinforcement Corrosion	Photos 3.16 and 3.17
	Masonry top of 5th floor slab	Between entrance to flats 264-269 and fire escape stairs	Missing bedding to brickwork	Poor workmanship and/or deterioration of mortar	
	4th floor column	Infront of entrance to flats 252-257	Crack and spalled concrete at base of column	Reinforcement corrosion	Photo 3.15
	4th floor lintol	Over storage window facing inner green opposite sub entry to flats 227-230	Badly spalled concrete to bottom RHS corner of lintol.	Reinforcement corrosion	Photo 3.38
	4th floor balcony beam	Facing green adjacent to stairwell to flats 247-248. Visible through stair landing window.	Crack in top corner of beam	Reinforcement corrosion	Photo 3.12
	4th floor balcony beam	Facing green adjacent stairwell to flats 208-209. Visible	Crack in top corner of beam	Reinforcement corrosion	Photo 3.13

		from stair landing window.			
	4th floor balcony beam	facing green adjacent stairwell to flats 216 and 217. Visible from landing window.	Spalling of concrete on beam surface exposing reinforcement	Reinforcement corrosion	Photo 3.14

4. Conclusion and Recommendations

4.1. Spalling Concrete

This is the major defect affecting the building at present.
The form of construction of Goulden house partially exposes the reinforced concrete floor slab and beam to the elements. Over the years the exposed surface has been subjected to a phenomenon called carbonation. Carbon dioxide dissolved in water creates an acidic environment which penetrates the concrete. With time the acidic environment reaches the reinforcement resulting in the loss of the passivating layer surrounding the reinforcement. This starts the corrosion process. Corrosion expands the steel molecules by up to ten times their original size. This places stress on the concrete causing cracking. Cracking allows moisture and oxygen a direct access to the steel which further accelerates the corrosion causing concrete to spall off.
The spalling of concrete from the exposed surfaces is therefore evidence that the concrete has been subjected to carbonation which has penetrated to the reinforcement. The spalling ranges in severity from minor to severe. In some instances, lumps of concrete have fallen off from height. It is still likely that in areas with severe spalling this could happen with potential to cause harm to the residents.
Concrete repair works can be undertaken to address the problem. Depending on the degree of spalling the whole surface of local repairs can be undertaken. The process involves testing of the concrete to determine the depth of carbonation and cutting back the concrete to remove all concrete that has been affected. Next the reinforcement is grit blasted to remove all corrosion to the bright metal. The reinforcement is then coated with anti-rust material. Finally, the concrete is repaired using cementitious material such as Fosroc Renderoc products.

4.2. Cracks in Concrete

The cracks in concrete in some of the beams may be due to reinforcement corrosion. Monitoring can also be undertaken to determine whether they are live or historic.

4.3. Severely Damaged Columns on 4th Floor Walkway

The Column in front of sub entry to flats 249-251(Refer to Photo 3.17 in Appendix A) and the column adjacent to entry to flats 165-170 (Refer to Photo 3.19 in Appendix A) are severely damaged at the base. Urgent attention should be given to repairing these columns before they become dangerous. The lower sections of these columns may need to be rebuilt.

4.4. Cracks in Side Walls to Communal Terraces on the 4th Floor

Similar pattern of cracks can be seen where the side walls to the terraces are rendered. The cracks appear to be in the render. Movement of the brick walls could have caused the brittle finishes to crack. Further intrusive investigation will be required to establish the cause of the cracks and undertake repair works. Repair works should be undertaken before the terraces are open to the residents.

4.5. Asphalt Surfacing on 4th Floor Walkway

As mentioned in section 3.1, the surface is uneven in many areas. The asphalt has cracks ranging from minor to very severe (Refer to photos 3.24 and 3.25 in Appendix A). The termination on the walls has cracked with holes formed in it and peeling off. The severity of the cracks may have compromised the watertightness which should be investigated.

4.6. Defects in Brickwork

Generally, the brick work is in good condition. There are however isolated cases listed in Table 3.1 where defects such as dislodged bricks, flaking bricks, holes created due to drilling and loss of mortar occur. These can be easily repaired.

5. Appendix A: Photos

Photo 3.1: Roof surface showing evidence of rainwater ponding

Photo 3.2: Filth around drainage inlet

Photo 3.3: 5th floor Communal Balcony Evidence of rainwater ponding

Photo 3.4: 4th Floor Communal Terrace opposite flat 202 showing cracking of side wall

Photo 3.5: 4th Floor Communal Terrace opposite flat 218 showing crack in side wall

Photo 3.6: 4th Floor Communal Terrace opposite flat 232 showing crack in side wall

Photo 3.7: 5th floor side elevation adjacent Ball Park. Vegetation growth

Photo 3.8: Sloped Roof over stairs to sub entry to flats 247-248: Horizontal crack in wall beneath slab. Evidence of moisture ingress.

Photo 3.9: 2nd floor slab adjacent flats 128 and 129 Loss of concrete at slab recess leaving brickwork unsupported.

Photo 3.10: Side elevation facing Ball Court showing hole in brickwork underside of 4th floor slab.

Photo 3.11: Spalling of concrete at bottom of 5th floor balcony slab and roof beam facing inner green between sub entry to flats 37-38 and 44-43

Photo 3.12: Crack in top corner of beam facing green adjacent stairwell to flats 247-248. Visible from landing window.

Photo 3.13: Crack in top corner of beam facing green adjacent stairwell to flats 208-209. Visible from landing window.

Photo 3.14: Spalling of concrete on beam surface exposing reinforcement, facing green adjacent stairwell to flats 216 and 217. Visible from landing window.

Photo 3.15: Crack in base of column on 4th floor walkway in front of sub entry to flats 252-257

Photo 3.16: Crack at the top of column in front of sub entry to flats 249-251 on 4th floor walkway

Photo 3.17: Crack and spalling of concrete at base of column in front of sub entry to flats 249-251 on 4th floor walkway.

Photo 3.18: crack at top corner of beam LHS of entry to flats 165-170 at on 4th floor walkway.

Photo 3.19: Column fractured at bottom on 4th floor walkway, adjacent entry to flats 165-170

Photo 3.20: Severely spalled concrete exposing reinforcement at beam and column joint on 4th floor walkway adjacent entry to flats 171-176

Photo 3.21: Severely spalled concrete with surface painted. Adjacent to entry to flats 177-182 at 4th floor walkway. Same beam in photo 22.

Photo 3.22: Spalling of concrete at top corner of beam. Same beam in photo 21

Photo 3.23: Spalling on 5th floor slab edge visible from 4th floor walkway between entry to 177-182 and 183-188

Photo 3.24: Cracked asphalt termination on wall at 4th floor walkway.

Photo 3.25: Severely cracked asphalt on 4th floor walkway

Photo 3.26: Spalled concrete in bottom corner of top lintol in recessed bay facing inner green above flat 127

Photo 3.27: Multiple cracks on face of concrete slab at 1st floor, LHS of Entrance C on Bullen Street

Photo 3.28: Cracks in recessed bay on 4th and 5th floor slab/beam faces adjacent downpipe between Flat 77 and Entrance B on Bullen Street

Photo 3.29: Cracked and spalled concrete on face of 1st floor slab at corner of Bullen Street and Shuttleworth Road junction.

Photo 3.30: Entrance side wall to flat [redacted] facing inner green showing hole in brickwork resulting from pipe removal.

Photo 3.31: Peeling of paint underside of roof slab in living room of flat [redacted]

Photo 3.32: spalled concrete underside of balcony lintol in flat [redacted]

Photo 3.33: crack in repair work to concrete beam in the past

Photo 3.34: Fine crack in beam

Photo 3.35: Holes in brick work on Shuttleworth Road elevation to flats 63-65

Photo 3.36: Dislodged bricks around boiler exhaust on Shuttleworth Road elevation to flats 63-65

Photo 3.37: Spalling of concrete and diagonal top crack in beam LHS of Entrance B on Bullen Street

Photo 3.38: Concrete spalling at bottom RHS corner of lintol over storage window

Photo 3.39: Crack at top corner of column on 4th floor walkway adjacent to entrance to flats 264-269