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APPENDIX 4 TO PAPER NO. 20-07

Penge and Inkster Houses
Wandsworth

Existing Structure Appraisal

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1.0 Introduction

1.1 Elliott Wood Partnership Ltd have been appointed as part of an architect led design team by Wandsworth Housing Department to advise on the structural implications and options for the proposed regeneration of Penge and Inkster Houses in Wandsworth, south London. The current proposals have been prepared by the architect, Brodie Plant Goddard (BPG) and include options to re-clad the towers, install wintergardens and provide additional accommodation and communal spaces by extending the base of the towers.

1.2 The towers are situated immediately to the north of Clapham Junction train station; Penge House is located on Wye Street, and Inkster House on Ingrave Street. Both towers are residential, and each houses 76 flats. The ground floor of each tower is used for circulation and amenity space; there are 15 storeys of apartments above, and one plant floor to the top of the building, giving a total of 17 storeys.

1.3 An understanding of the form of the existing structures has been obtained from archive drawings, site visits, and through the commissioning of structural investigation surveys.

1.4 The towers were built in 1969 and are of precast panellised construction. Their structural form and their age mean that robustness against disproportionate collapse is a key consideration in the design of any structural alteration works required as part of the proposals.

1.5 This report summarises the findings of the structural investigations, reviews the robustness of the structures against historic and current Building Regulations and discusses the implications that each of the proposals may have on the robustness of the structures.

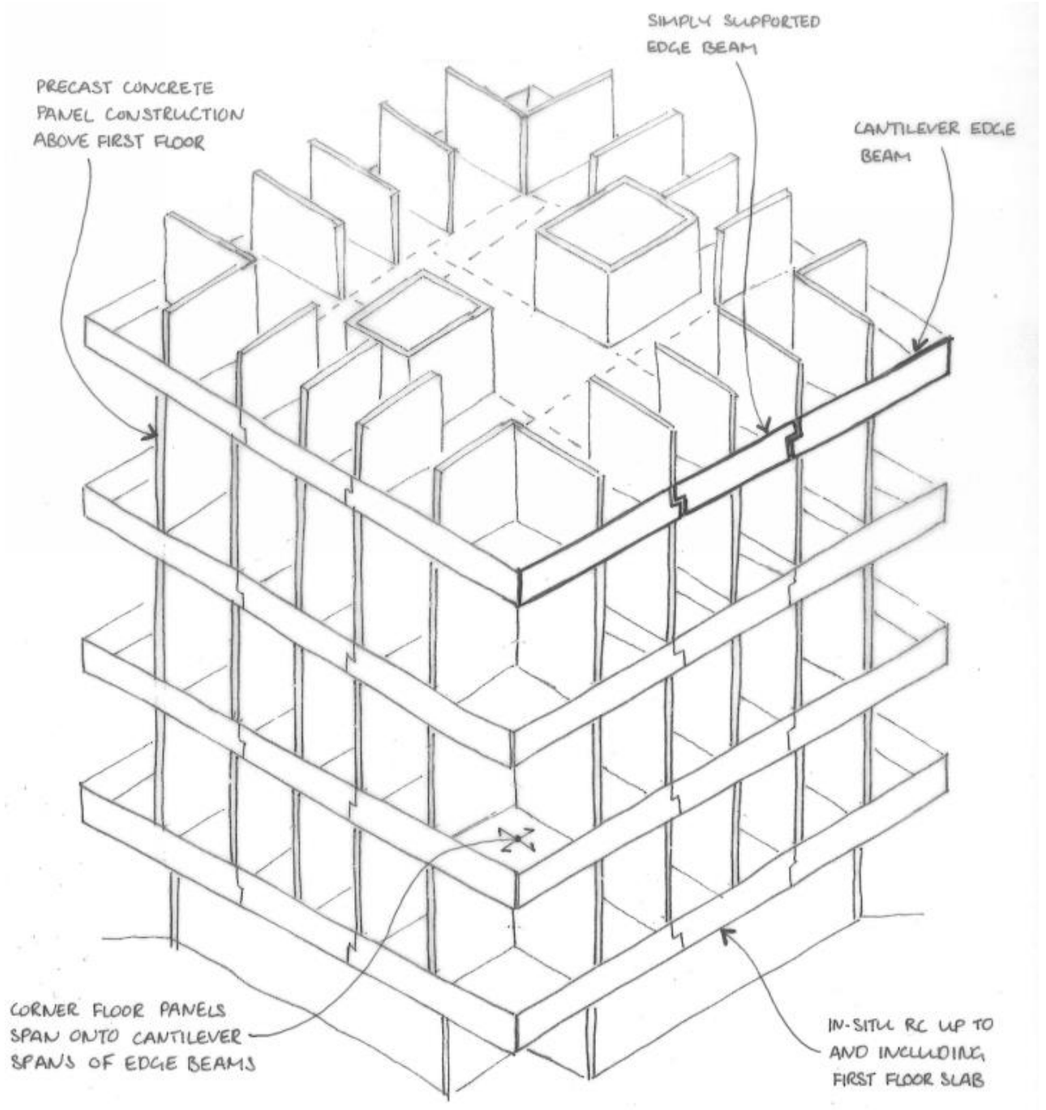

Figure 1.1: Isometric showing the existing structure of the towers

2.0 Existing Structure Summary

2.1 Penge and Inkster houses were constructed in 1969, and occupied in 1970. The architects responsible for the design were Howes, Jackson and Partners, and the engineers J. C. Bianco and Associates, neither of whom are still in business.

2.2 Archive drawings have been obtained from Wandsworth Council, and these showed that the buildings were constructed from in-situ reinforced concrete from ground floor up to and including the first floor slab. Above this level, all structural elements have been formed from pre-cast concrete panels, with the exception of the slabs in the staircase and refuse areas which were formed in-Situ. The project to construct Penge and Inkster Houses is mentioned in The Bartlett Survey of London Vol 50, and was notable for having developed *"an on-site factory used for the casting of the cladding panels and other RC components"*.

2.3 At first floor and above, all of the walls and floors have been formed from precast concrete panels. The panels were cast on site, before being craned into place and grouted together. The archive drawings show that the walls are typically 180mm thick and the floors 125mm thick. The floor panels span onto the wall panels at each connection, and are noted on the drawings as having 25mm bearing.

2.4 The lateral stability of the buildings is provided by the precast concrete wall panels which collectively act as multiple shear walls. These line up down the full height of the building and with the in-situ walls at the base to transfer both vertical and lateral loads down to the foundations.

2.5 The façade is formed from horizontal bands of precast concrete and bands of windows. The precast façade panels are supported on inner precast edge beams which span between the internal wall panels. At the corners of the buildings, the edge beams cantilever and support both the floor slabs and the outer cladding.

2.6 The archive drawings included some details of ties between adjacent floor panels, however no details of vertical ties between wall panels were found within the historic details available.

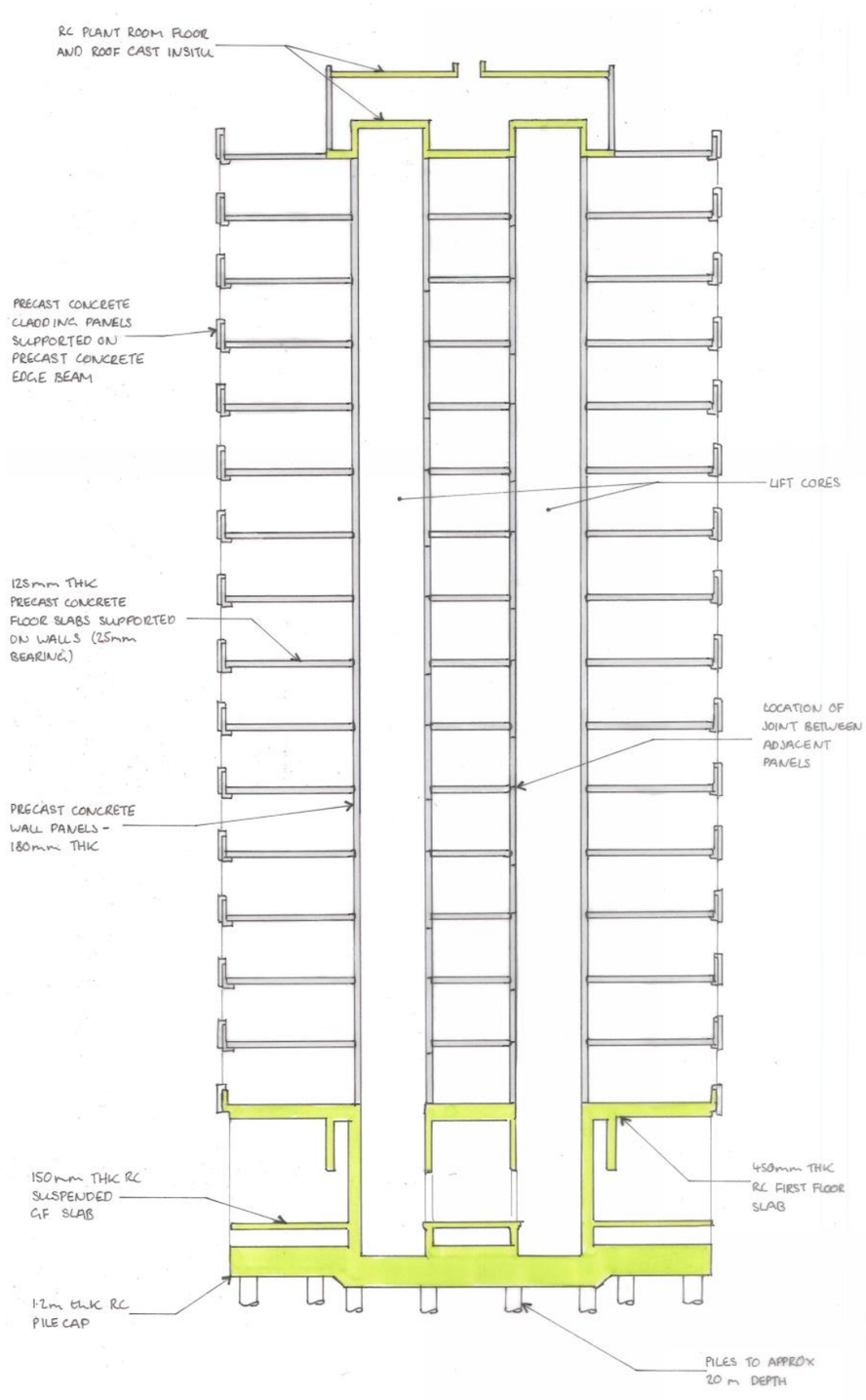

Figure 2.1: Section through tower showing existing structure

3.0 Findings of Structural Investigations

3.1 Because of the absence of vertical tying details in the Wandsworth archive drawings, and doubts over the validity of the horizontal tie details shown, structural investigation surveys were commissioned in order to determine the existing provision against disproportionate collapse and to verify the known details. Compressive strength testing and pull-out testing was also carried out in order to facilitate the design of the proposed overcladding and wintergardens.

3.2 The scope of the investigation works included the testing of concrete core and pull-out tests, as well as the investigation of the connections between:

- floor panels and the edge beams
- wall panels and the edge beams
- adjacent precast floor panels – horizontal ties
- adjacent wall panels – horizontal ties
- stacked wall panels - vertical ties

3.3 These investigations were carried out through a combination of on-site scanning and intrusive methods undertaken by GBG in October 2016.

3.4 During the investigations, the following general observations were made:

- Where investigated, the integrity of the panels and the quality of the grouting was seen to be in typically good condition
- Internally, where exposed, the concrete of both the precast concrete panels and the in-situ concrete in the joints between them were of a good quality; the in-situ concrete was well compacted and seemed to form a good bond with the precast panels.
- Where exposed, reinforcement within the precast panels and the fixings between them were in good condition with little or no evidence of corrosion.
- Where tested using phenolphthalein indicator (c.1-2mm maximum depth), little or no carbonation within the precast concrete panels was observed.
- Externally, where surveyed visually, the concrete cladding panels were in good condition with no evidence of cracking or spalling.

Edge beams

3.5 The investigations of the edge beam verified that the connections had in general been constructed in accordance with the archive drawings.

3.6 At the corners of the building, the edge beam cantilevers in order to support the floor panels. In these locations, 3 no. pockets have been formed in the edge beam, and U bars cast into the floor panels. These connections have been grouted on site. At all other locations along the elevations, the edge beam panels appear to be tied neither to the floor panels, nor to each other.

3.7 At the supporting wall locations, the edge beams have been connected to the walls with tie-back angles and grouted in tie bars. These tie bar details seem to vary considerably from wall to wall and the embedment depth of the tie bars was not always found from the investigations. It is therefore difficult to assess the adequacy of these connections. The facade panels have been fixed back to the edge beams using cladding sockets and dowel bars – these details were not investigated.

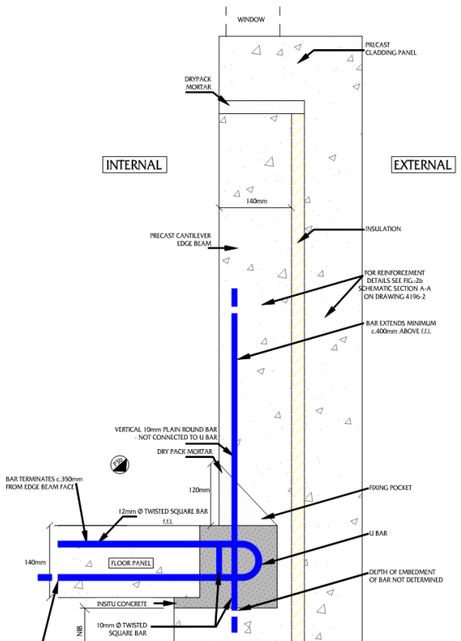

Fig 3.1: connection of floor panel to cantilever edge beam (from GBG report)

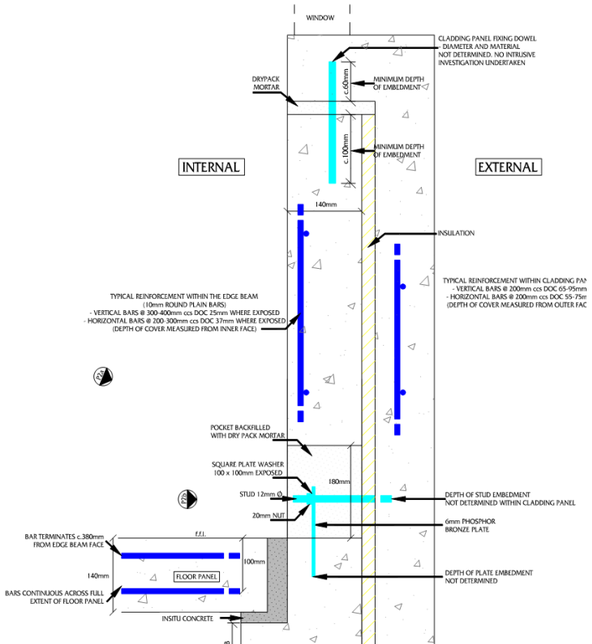

Fig 3.2: connection of façade panel to edge beam (from GBG report)

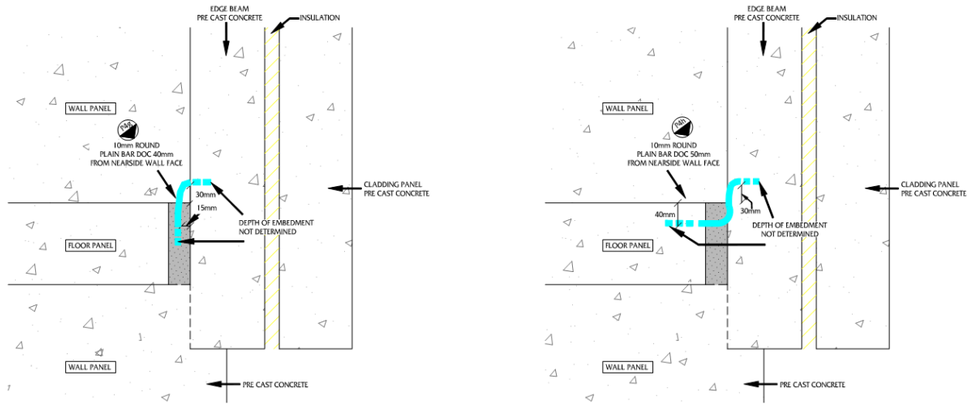

Fig 3.3: connection details of edge beams to wall supports (from GBG report)

Floor panels

3.8 Connections between adjacent floor panels were found to have been generally formed by staggered u-bars projecting from the precast panels with a lacer bar running through the centre of them. This joint was then grouted up on site. This detail is constant with the archived drawings and seems to occur in most locations where floor panels span onto wall panels

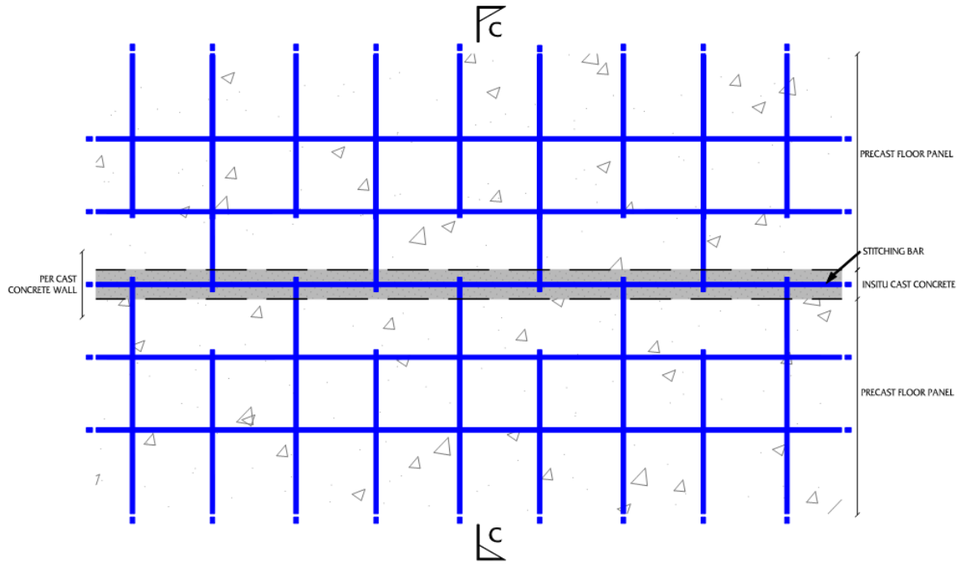

Fig 3.3: plan of connection between adjacent floor panels (from GBG report)

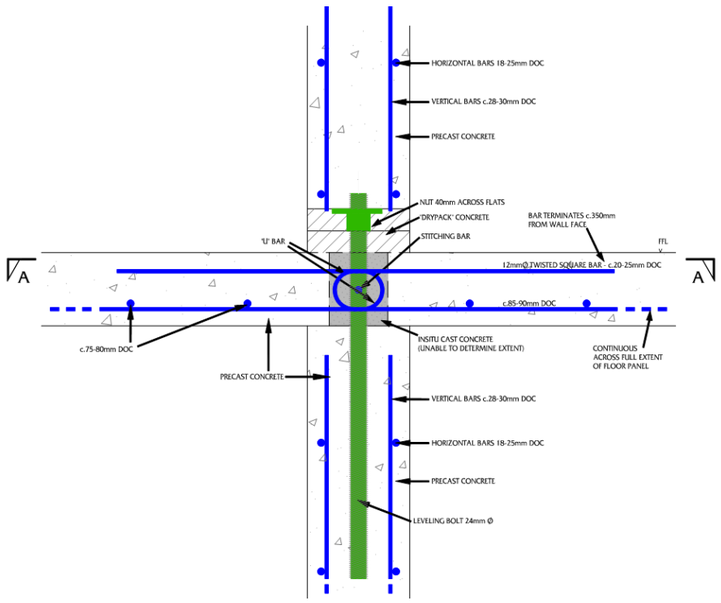

Fig 3.4: section of connection between adjacent floor panels (from GBG report)

3.9 In other areas mostly around the central lift core, where floor panels abut but do not have walls below them, the joint detail is different. In these locations there does not appear to be reinforcement tying the floor panels together.

Wall panels

3.10 The investigations did not find any vertical ties between stacked wall panels, which is consistent with the lack of vertical ties shown on the archive drawings. The investigations did not find any horizontal ties between adjacent wall panels either, except in the few locations where small in-situ wall panels are adjacent to precast wall panels. In these locations it seems that the panels have been connected with reinforcement.

Concrete testing

3.11 Pull out tests were carried out by installing resin anchors into the edge beam, and applying a specified load of 15kN. This testing was carried out to facilitate the design of the connections required into the edge beams to support the proposed overcladding. A 15kN proof load was applied, rather than testing the anchors to failure, as this may have caused damage to the structure of the beams. 2 no. M10 and 2 no. M12 anchors where tested in each building; there were no signs of failure during any of the tests.

3.12 3 no. 70mm diameter concrete cores were obtained from the edge beams of each building, and these were tested in order to determine their compressive strength. An average strength of 39.8N/mm^2 was calculated across 6 samples, with a minimum measured strength of 26.6N/mm^2, and a maximum of 63.9N/mm^2.

3.13 The concrete core samples were also tested for the presence of chlorides and high alumina cement. Both substances were widely used in concrete buildings throughout the 1970s and are now known to cause long-term issues with concrete strength and durability. The tests concluded that high alumina cement was not present in the samples. However, the level of chlorides in two out of five samples tested was found to be above the levels recommended in modern standards. Further testing may be required to determine the extent of chlorides present.

4.0 Disproportionate Collapse

4.1 Penge and Inkster Houses were constructed in 1969, less than a year after the collapse of Ronan Point in May 1968. Following this incident, regulations were introduced to prevent progressive collapse, with the first guidance documents issued in November 1968, and the 5th amendment made to the Building Regulations in 1970.

4.2 Because the buildings were constructed so soon after the collapse of Ronan Point, and because of the lack of vertical tying details available in the archive information, it was not clear what provision against disproportionate collapse had originally been implemented. Neither Wandsworth Council nor Wandsworth Building Control have any records of strengthening or remedial works being carried out since the buildings were constructed and no visible signs of strengthening were found.

Disproportionate collapse requirements in place during the design of the buildings

4.3 On the 15th November 1968, the Ministry of Housing and Local Government published a document titled; 'Flats Constructed with Pre-cast Concrete Panels. Appraisal and Strengthening of Existing High Blocks: Deign of New Blocks'[1]. This document details the measures to be implemented in the design of new building and the design of retrofitted ties between structural elements within precast apartment blocks of over 6 storeys. The requirements listed include:

- Accidental loads are assumed to be 34.5kN/m^2
- The two allowable methods of dealing with disproportionate collapse include:
  1: By providing alternative paths of support to carry the load, assuming the removal of a critical section of the load-bearing walls
  2: By providing a form of construction of such stiffness and continuity so as to ensure the stability of the building against forces liable to damage the supporting members
- If Method 1 is implemented, steel connections are required:
  a) Between floor/roof panels and the supporting external wall panels
  b) Between adjacent floor panels over internal walls panels
  c) Between adjacent external load bearing wall panels - horizontal joints at the top of panels.
- A tensile resistance of 44kN/m should be provided continuously along the joints between adjacent floor panels, and floor to supporting external wall panels. Spacing of ties should be less than 600mm.
- The steel connection can be formed by either :
  - Welding together projecting reinforcement
  - Lapping projecting loop bars and providing lacer bars

4.4 It should be noted that in the 1968 design guidance there was no requirement for vertical ties, except for at the perimeter of the building.

4.5 The archive drawings and intrusive investigations show that Method 1 was implemented for the construction of Penge and Inkster Houses, with the ties between floor panels generally formed by the installation of U-bars and lacer bars, rather than through the welding of reinforcement.

4.6 Table A details the provision of the required ties within Penge and Inkster Houses in accordance with the 1968 guidance.

Requirement	Provision in Penge and Inkster	Comments/actions
a) Between floor panels and the supporting external wall panels	- There are no external wall panels, but in this case, the edge beams fulfil the same function (ie support the floor loads) at the corners of the building. - U-bars cast into the floor panels have been grouted into pockets within the edge beams.	- The edge beam only supports the floor panels in the cantilever sections- ties have only been provided in these areas. - This detail appears to be in accordance with the tying detail in the guidance note
b) Between adjacent floor panels over internal walls panels	- Staggered U-bars have been cast into floor panels. Lacer bars have been installed to tie adjacent panels	- This detail appears to be in accordance with the tying detail in the guidance note
c) Between adjacent external wall panels- horizontal joints at the top of panels.	- Not clear if there are direct ties.	- Detail is likely to be insufficient

Table A: requirements and provision of structural ties

Current Robustness Requirements

4.7 Under current Building Regulations, the buildings fall into Class 3; they are residential buildings exceeding 15 storeys. This would require that there are both horizontal and vertical ties between elements throughout the building, and that a systematic risk assessment is carried out. This is more onerous than the 1968 guidance under which the building frames were originally constructed.

4.8 Tying requirements for precast panel buildings of this class can be found within BS EN 1992-1-1. The locations and required values are as follows:

- Peripheral horizontal ties - should be provided within 1.2m from the perimeter of the building.
- Internal horizontal ties - should be provided at right angles throughout the floor plate
- Vertical ties – should be provided in walls, continuously up the height of the building

4.9 Peripheral internal ties are provided in Penge and Inkster houses by the reinforcement within the floor slab panels. The connections between the adjacent floor panels will ensure that this tie is continuous.

4.10 Internal horizontal ties are again provided by the reinforcement within the floor slab panels, and the horizontal ties between adjacent slab panels.

4.11 As previously stated, the investigations did not find any vertical ties, and therefore it is unlikely that the current Building Regulations requirement against disproportionate collapse is met.

4.12 Requirements for disproportionate collapse under the current regulations can also be met by justifying a structure through;

- Notional removal: each of the structural elements is removed in turn, and the remainder of the structure is shown to be supported by alternative load paths
- Key elements: the structural elements are designed to be robust enough to withstand a specified blast load

4.13 An initial assessment of Penge and Inkster has shown that the buildings cannot be justified in accordance with the current building regulations through either of these methods whilst there are no vertical ties in place.

5.0 Proposed Regeneration Options

5.1 The regeneration options currently being considered include:

A. The overcladding of the existing façade;
B. The addition of wintergardens to provide private amenity space to the residents;
C. The construction of a new structure to extend the base of the towers and to provide additional apartments and public amenity space to the residents;

5.2 For all of the options, it has been assumed that there will be no alterations made to the main vertical stability elements of the existing structure; and that no new openings will be made through internal walls, or risers through floors.

Overcladding

5.3 This would involve the addition of a new layer of cladding to the outside of the existing facade. This would be supported on rails, with brackets punched through the existing concrete cladding, and fixed back to the precast edge beam behind.

5.4 The increase in loading on the existing structure has been analysed, assuming an additional cladding load of 1kN/m^2. It is thought that the edge beams have sufficient capacity to allow for the increase in loading; however the critical components are likely to be the connections of the edge beam back to the rest of the structure. The percentage increase in load on the worst case wall at ground floor level and on the foundations is less than 10%. The layout of the existing buildings with a large number of concrete walls aligning through to foundation level means that a level of redundancy is likely to be present in the structure and that load increases of this order could be accommodated.

5.5 This option would have little effect on the overall robustness of the existing building. However, guidance is required from building control on whether these works would trigger the need to reassess the buildings against the current disproportionate collapse requirements. This needs to be confirmed by Wandsworth Building Control.

Wintergardens

5.6 New private amenity space would be provided for each of the residential units by providing glazed balconies around the perimeters of the buildings. These would be supported off of a new steel frame, and tied back to the existing building at each floor level in order to provide lateral stability to the new structure.

5.7 As the wintergardens would be supported from a separate structural frame, there would be no increase in vertical loads on the existing structure. However, openings would be required through the existing façade in order to access the wintergardens, and this will require that sections of the precast concrete edge beam are removed.

5.8 Removing sections of the edge beams could reduce the robustness of the structure in these areas and the alterations required for the wintergardens would therefore be carefully designed to restore robustness where parts of the existing structure are to be removed.

5.9 As part of this design, additional ties between the remaining edge beams and the floor slabs may be required and/or the wintergarden frames may need to be integral with the existing structure to provide alternative load paths for robustness.

5.10 The wintergarden structures and alterations to the existing structure will be developed further during the detailed design stage with these principles in mind.

5.11 It is assumed that these works which require a portion of remodelling to the frame may trigger the need to reassess the buildings against the current disproportionate collapse requirements. This would potentially require retrofitting the structures with additional ties in order to meet these requirements. This needs to be confirmed by Wandsworth Building Control.

Ground floor extension

5.12 A new single storey extension would be built around the base of the towers and used to house new flats, amenities spaces and plant rooms.

5.13 The extension would be supported on an independent frame, and this option would therefore have no effect on the structure or robustness of the existing buildings. It is therefore assumed that this work would not trigger the need for a reassessment of robustness relative to the current building regulations.

6.0 Conclusions and Recommendations

6.1 It is concluded that based on the site investigations completed, in general the existing structures of both Penge and Inkster Houses are in good condition, and appear to have been constructed in accordance with the drawings found in the Wandsworth Council archive and the design guidance available at the time.

6.2 Under current Building Regulations, the buildings are categorised as Class 3 structures as they are residential buildings exceeding 15 storeys. This generally requires that there are both horizontal and vertical ties between elements throughout the building, and that a systematic risk assessment be carried out. This requirement is more onerous than the 1968 guidance under which the building frames were originally constructed.

6.3 The structural investigations carried out in October 2016 did not find any vertical ties between stacked precast wall panels. However the Investigations have provided sufficient information to verify that the horizontal ties are in accordance with the building regulations at the time the buildings were constructed and are likely to have sufficient capacity to comply with the current building regulations. It is therefore concluded that although the buildings may have met the robustness requirements in place at the time of their construction, it is unlikely that they would meet current building regulations due to the lack of vertical ties.

6.4 The investigations have shown that the buildings should be capable of carrying the additional loads from the lightweight overcladding and wintergardens proposals. However, Wandsworth Building Control will need to confirm whether or not the current building regulations with regards to disproportionate collapse will need to be applied. If they do need to be applied, the buildings will not meet the current robustness requirements and it is therefore highly likely that additional strengthening/trying works will be required to the wall and floor panel junctions.

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