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6 March 2012

Orion Limited
P. O. Box 13896
CHRISTCHURCH 8141

ATTENTION: STEPHEN GODFREY

Our Ref: 120228/S1

Dear Sir,

RE: ORION NZ LIMITED
218 MANCHESTER STREET, CHRISTCHURCH
STRUCTURAL CONDITION OF THE CAR PARK BUILDING

SCOPE

This report is an overview of the damage and remedial work required for the carpark building located on the corner of Manchester Street and Gloucester Street in Christchurch that is sited on the property owned by Orion NZ Limited. It addresses structural damage and comments on repair options with main emphasis on the basement area. The emphasis on the basement level is in accordance with our instructions from Orion.

In assessing the building for this report, the following information has been used.

- Original construction plans; Christchurch City Council and I L Holmes dated 1963. Note that only a limited number of plans are available.
- Walk over inspection by Ian Lloyd of Powell Fenwick on 22 February 2012.
- Manchester Street Carpark, Detailed Engineering Evaluation Quantitative Assessment Report, Opus International Ltd, 10 November 2011

BUILDING CONSTRUCTION

The plans are dated 1963 and it presumed the building was constructed about this time. It consists of a part half depth basement with 4 levels of carparking above. The building is split level with each side of the building being half level above the other. The basement area covers approximately two thirds of the plan area with the

remainder of the floor being a double height workshop in the north eastern corner. There is a timber mezzanine floor to a section of the lower level of the building. The timber floor was used as offices for civil defense.

The building construction is prestressed hollow core plank flooring supported on precast post tensioned concrete beams on precast reinforced concrete columns. The post tensioning cables pass through the columns thereby tying the structure together. Lateral restraint appears to be provided in the east-west direction by insitu concrete shear walls and in the north-south direction by frame action.

The basement is approximately a half floor below the ground on one side with insitu concrete retaining walls.

The Opus report states that the building is constructed on a pile foundation.

EARTHQUAKE DAMAGE.

Earthquake damage to the building is noted below. A more detailed list has been prepared for the basement area while only general observations have been noted for the upper carpark area.

Basement.
Refer to the attached marked up plan for location of the damage.
This section also includes damage visible from the basement level but occurring on the floor above.

1. North side ramp from the ground to the upper level has separated from the upper floor. Cracking to the north ramp ground floor midpoint between the supports.
2. Gap formed between the non load bearing concrete masonry walls and the beams above.
3. Shear cracking to the insitu concrete wall adjacent to the entry ramp.
4. Step cracking to the unreinforced masonry wall surrounding the transformers plus 6 mm translation of bricks.
5. Cracking to the ground floor where the centre of the floor has risen.
6. The ramp support beam visible in the generator room has significant cracking to the end supports. The beam has subsequently been propped with SHS steel columns.
7. Step cracking and translation of the masonry wall that forms the side of the ramp to the floor above. This wall is a double skin 90 mm concrete masonry columns with 200 mm masonry bond beams at various levels. There is also damage where the wall intersects the columns.
8. Vertical cracking at the centre of the exterior low level insitu concrete walls, typically midway between columns in numerous locations. (only some locations are indicated on the plan)
9. Spalling of column concrete where it intersects the short walls noted in 9 above.
10. Shear cracking to the concrete wall.
11. Vertical cracking to the concrete walls.

12. Settlement of the floor slab has created a 25-30 mm gap between the beam and the masonry wall below.
13. Minor cracking to the plasterboard walls in the amenities area. Delaminating of the plaster coating to the columns in the toilets.
14. Cracking to the concrete walls in the entry foyer.
15. Step in the floor at the intersection of the centre concrete strip and the main floor. This central strip is the main foundation support for the centre columns and as such is supported on piles. Orion staff have advised that the floor falls in this area is greater than prior to the earthquake. It is not possible to confirm this however the level change indicates that there has been movement in the floor.
16. Extensive diagonal shear cracking to the concrete wall in the north south direction and minor cracking to the walls in the east west direction. The landing to the stairs above has cracking to the underside.
17. The electrical duct at the north end of the workshop now has a 5 mm step indicating either the floor has settled or the duct has risen.

Damage in the ex civil defenses offices.

General cracking to the plasterboard walls and ceiling. Damage to the masonry walls where they intersect the upper beams and columns. Damage to glazing.

Upper level.

- The ramp from Gloucester Street has detached from the floor at the upper end creating a 3-4 mm gap.
- Diagonal shear and horizontal bending cracking to the columns becoming less frequent on the upper floors.
- Cracking to the underside of the interconnecting ramps.
- The stair walls in the east west direction have diagonal cracking originating from the door heads.
- North south walls at the stairs and lift have shear cracking.
- Horizontal cracking at the prestress duct locations in the columns.
- Diagonal and vertical cracking to the main support walls in the east west direction becoming less frequent on the upper levels.
- Some of the non structural masonry surrounding the stairs on the upper level has fallen away from the support structure.
- Extensive damage to a column on the east end of the building where the link beam has pulled against the column causing vertical cracking.

Generally the building has suffered minimal damage to the main structural elements. This damage is limited to shear and some bending cracking to the shear walls and shear cracking in the columns. It is unlikely that the damage would have significantly reduced the lateral performance of the building.

BUILDING PERFORMANCE

Generally the building has performed very well in the recent earthquake events.

The main damage of structural significance is:

- Where the ramps intersect the floor, there has been partial or full separation and spalling where the building has been tied to the ground.

- The ground floor has settled relative to the supporting frame leaving a gap above many of the non load bearing walls and a step at location 15 and 17. This is due to settlement of the soil immediately under the slab while the structure is supported on piles. It is possible that there was filling under the slab during construction and it is this material that has consolidated.

- Cracking to the east-west shear walls. These walls have performed well with some diagonal shear cracks as expected.

- The extensive cracking to the walls in the north south direction is an indication that these walls attracted load that they were not designed for. Generally the walls in this direction are short and therefore have little resistance to horizontal loads. However they were stiffer that the beam column frames and attracted load they could not resist and hence the significant shear cracking. The reinforcing exposed by the intrusive survey undertaken by Opus would imply that these walls were not designed to resist seismic loads.

- Diagonal cracking in the columns. This is indicative of the frames being loaded as designed.

BUILDING CAPACITY

The Opus report has determined that the seismic capacity of the building is equal to 16% of New Building Standard (%NBS). This assessment compares the seismic capacity of the building to that of a similar building constructed to the currently codes using current building techniques and materials. Their report states the limiting factor in relation to the strength is the interconnecting ramps. The next limiting element is the frames which can sustain 34% NBS.

We have undertaken an approximate calculation on the building to verify these conclusions and we believe that the capacity may be less than the 34% calculated by Opus.

We have undertaken a brief overview of the Opus report and the assumptions used. Only a summary of the calculations is given in the report and a more in depth assessment and review would be needed for comment however there are aspects of design we believe could be non conservative and could lead to a lower percentage NBS for the building than implied by the report.

This is in relation the Opus assessment where the ramps are used as connections enabling the building to be treated as a single entity as compared to two separate buildings. Treating it as two separate buildings may reduce the %NBS. If the ramps were to fail in an earthquake, then the building would act as two separate buildings. As two separate buildings, the loads on some of the members, notably the higher ground floor columns may increase considerably. We estimate that this could be at a similar load capacity to the capacity of the ramp, ie under 20% NBS. It appears from the report that they have assigned a hierarchy of members %NBS using the same design model and not taken into account the change in model when the ramps fail. Opus may have accounted for this however their report is unclear on what calculations have been undertaken.

The current legal requirement is for buildings to attain a minimum of 33% of current code capacity if undamaged. If the structure is damaged, the requirement is to increase the building strength to 66% of current code for seismic loading. In this instance, there is structural damage and hence the building requires upgrading. There is considerable debate surrounding the requirement to upgrade the building and the legality of this requirement so legal advice should be sort.

Building falling below 33% NBS are defined as Earthquake Prone Building under the Building Act and hence may be deemed a "dangerous building" by the Christchurch City Council as permitted by the Canterbury Earthquake (Building Act) Order 2011.

REPAIR OPTIONS FOR BASEMENT

Structural repairs to basement

There are minimal repairs required to the basement to reinstate the structure back to the condition was prior to the earthquakes. These include;

- Epoxy injection of the cracking of the walls where cracking is less than 0.5 mm. This includes the main longitudinal shear walls.
- Epoxy injection of the vertical cracking in the short retaining walls between the columns. This is mainly for protection of the reinforcing.
- Replacement of the extensively damage concrete wall adjacent to the stairs in the western end of the building with a new concrete wall (item 14 and 16)
- Epoxy injection of the column cracking.
- Repair the ramp where it has separated from the floor by breaking back the slab and lapping in new reinforcing. It would be advisable to design in a slip joint in this location so damage is limited in future events however this would be considered an improvement.

Non structural repairs to basement.

- Injection grout the damaged concrete wall at location 3. As this would not have been a designed shear wall, full replacement would not be required to reinstate the building.

- Replace the brick walls surrounding the transformer room. This could be constructed of concrete masonry or timber depending on operational requirements. If this wall cannot be removed for operational reasons, then an external strengthening systems may be required. This could consist of a spray on concrete or perhaps a carbon fibre wrap to stabilize the brick. Alternatively, timber and plywood walls could be constructed each side to support the brickwork.

- Epoxy injection of the cracking to the floor in the transformer room. Ideally, the floor should be replaced however this may not be practical considering the rooms use.

- Re leveling the main floor would require removal of the existing slab and constructing a new one to eliminate the step at location 15. Alternatively a floor topping system such as Sika Monotop could be used to feather the floor to eliminate the steps.

- Additional strengthening plates to the ends of the beam in the generator room to provide lateral support. If the temporary steel posts are to be removed, additional steel beams could be added adjacent to the existing beam. Reinstating the ramp back to the condition prior to the earthquakes would require demolition of most of the ramp and beam and a new ramp constructed.

- The gap between the masonry walls (item 7 and 12) to be filled with a compressible material for example polystyrene as previously. The lateral restraint of these walls will need to be checked.

- Replace the damaged masonry units at location 7, 12 and in the ex civil defense areas. Allowance should be made for separation of these walls from the main structure.

- Epoxy injection of the cracking above 0.2 mm wide in the concrete walls.

- Replacement of the floor slab in the workshop to eliminate the step at the electrical duct or feather the surface with Sika Monotop or equal.

REPAIR OPTIONS FOR THE UPPER LEVEL.

Some of the cracking in the upper level walls is in excess dimensions recommended in the Guidance on Detailed Engineering Evaluation of Earthquake affected non Residential Buildings. The recommendation is for further testing of the reinforcing to determine if strain hardening has occurred. If the results indicate extensive strain hardening wall replacement is required rather than epoxy injection.

For wall with cracking less than 0.5mm, the cracks should be epoxy injected. We recommend Sikadur 52 for this however there are other products which would also be suitable.

Shear cracking to the columns will require epoxy injection.

The non structural masonry damaged on the upper floor will require replacement.

A number of the columns have significant shear cracks. This could have strained the reinforcing so it is advisable that remedial work be undertaken on these columns. Options for this are the addition of additional members or some form of wrapping around the columns to reinstate the required strength. These could be steel or some a composite material such as carbon fibre.

The vertical cracking to the column on the east wall will require a similar strengthening to those noted above.

UPGRADE THE BUILDING FOR SEISMIC LOAD.

Currently we believe the building has a capacity of below 33 % NBS. Strengthening the building to 66% NBS by enhancing the existing structural elements will present some difficulties and therefore the addition of further structure will be required. The strengthening could consist of new concrete walls or a structural steel frame to resist the seismic loads.

The locations for the strengthening elements in the north south direction may inhibit the usable area of the building as there may not be adequate space between the central columns to adequately provide sufficient strength. The pile foundations may also limit the capacity of these walls thereby requiring additional elements.

Any additional structure will continue to the basement and hence may impede on the useable floor area. The reduction in useable space is difficult to quantify until a more detailed design is undertaken.

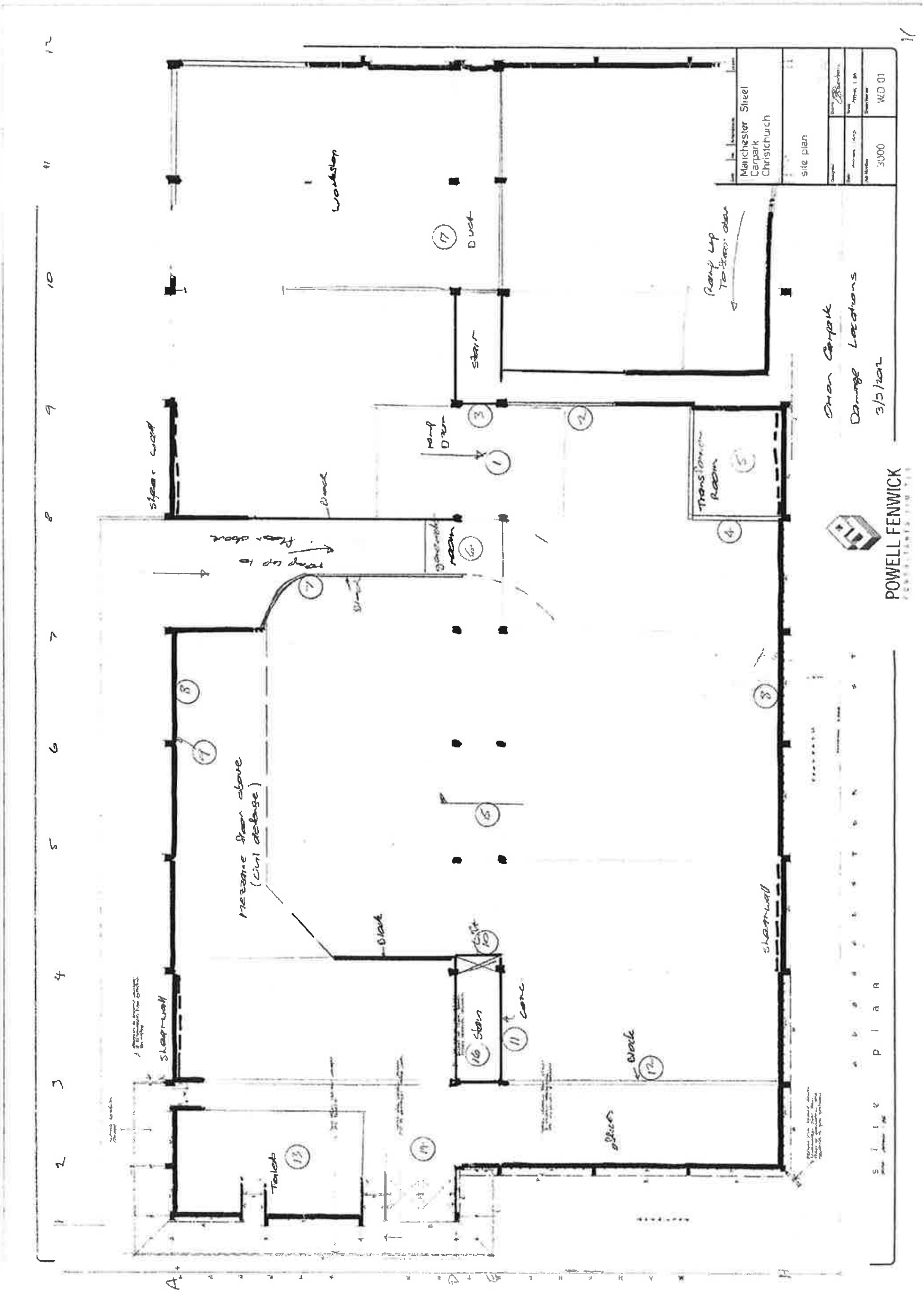
In the east west direction the addition of new structure is relatively easy and it will not impede the use of the building.

As the building is an open structure, the costs of this strengthening is limited to the addition of new members with no consequential damage to non structural elements and hence is easier to achieve than in other types of building.

If you wish to discuss any of the above or if you require further information, please do not hesitate to contact the undersigned.

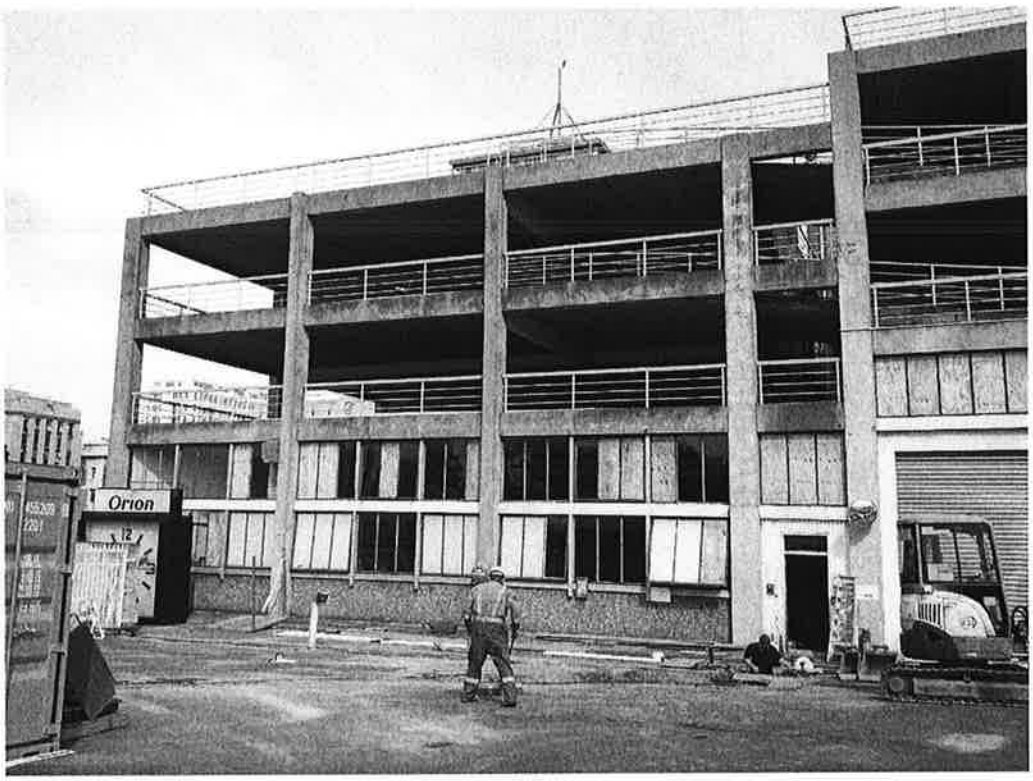
Yours faithfully,
POWELL FENWICK CONSULTANTS LIMITED

Ian Lloyd

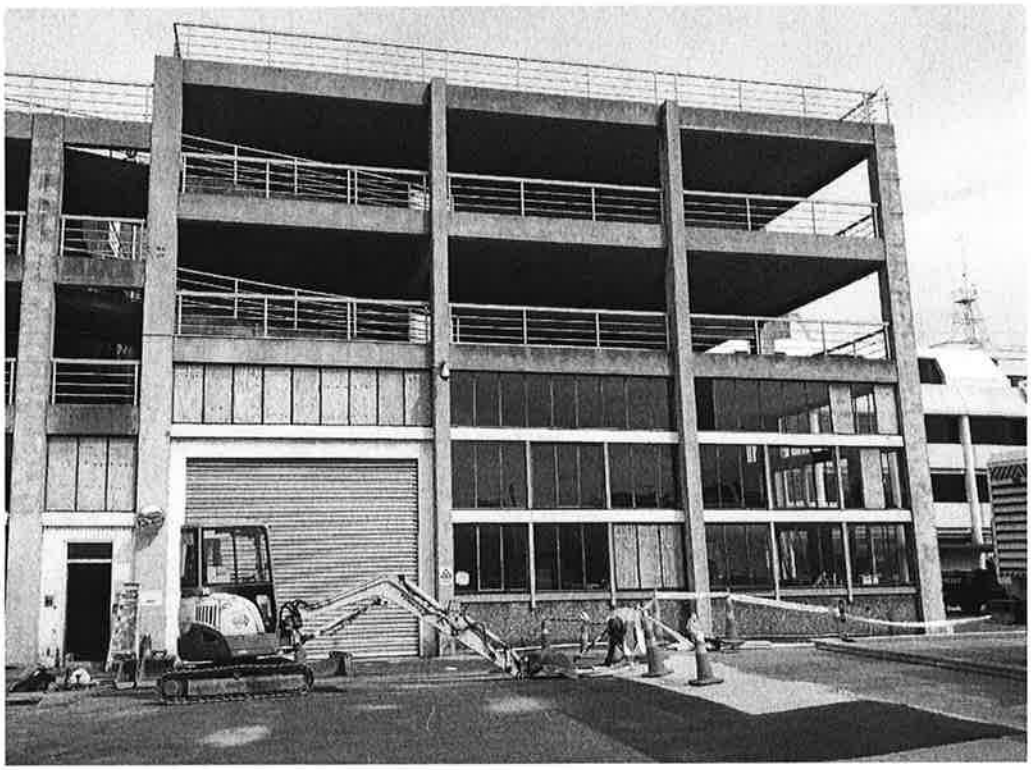


Plan of damage locations

South elevation



East Elevation 1



East Elevation 2