Report Title:

**Report on Water Seepage Investigation at Island View**

Report Prepared for:

**MCST 1131**

38 Jalan Mat Jambol

Singapore 119519

Prepared by:

Integraal Building Consultancy and Services Pte Ltd

Date:

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## 1. Preamble

1.1. The Management Corporation Strata Title Plan No. 1131 ("MCST 1131") has commissioned Integraal Building Consultancy and Services Pte Ltd ("Integraal") to conduct an investigation into the water seepages noted within the Island View Condominium ("Island View").

1.2. The following methods were employed as part of the investigative works:

1) ***Preliminaries***

   a. Simultaneously, a review of the seepage cases faced by Island View over the past 3 years were carried out (i.e. between 2021 and 2024) as part of ***Desktop Study.***

   b. Thirteen (13 units) were highlighted as outstanding recurring seepage cases

   The objective of these exercise was to provide an overview of the seepage issue(s) faced by the units, as well as the rectification work(s) that have been carried out. From the frequency of the report(s) made over the years, the efficacy of the works carried out may be established.

2) ***Visual inspection*** was carried out over November/ December 2024 focusing on the units where recurring seepage(s) were noted. The symptoms of seepages observed were documented in photographic form. From the symptoms observed, potential path(s) of seepages were identified. ***Videoscope inspections*** were carried out to weep holes to further understand the construction details of the weep channels observed.

3) ***Drone inspection*** was carried out over the same period to supplement the findings of the visual inspection. The drone inspection focuses particularly on the condition of the exterior façade and roofs of the units where recurring seepage(s) were noted. Overall shots of the Development were also taken to document the condition of the façade and roof elements.

4) ***Infrared thermography*** was carried out to check for thermal anomalies and trapped moisture. This technique is based on the principle that discontinuities such as trapped moisture and cavities below the wall surface finish can affect or change the rate at which heat flow through the structure. This difference between the medium (i.e., paints, moisture, trapped air, plaster, etc.) is visualised as different colours on the thermogram. The survey was carried out via Passive Thermography method using the handheld FLIR T620 infrared camera and drone mounted DJI Matrice 30T infrared camera. The thermograms captured were processed with FLIR TOOLS and DJI Thermal

Analysis Tool 3 respectively. All the thermograms were taken and analysed by Level II Certified Thermographer.

5) ***Microwave moisture tomography*** was carried out to determine the relative moisture profile on the walls for any evidence of water infiltration. The survey is carried out by emitting microwave to the surface of the materials via a microwave sensor head. Since water has a very high dielectric constant, the electric field generated by the microwave will result in the molecules of water trapped inside the materials to vibrate and rearrange. Spots with trapped moisture can thus be detected by the differences in the dielectric constant between the dry spots and those with moisture.

   A 100 mm probe was used in this exercise. After all readings were collected, the measurement points were mapped with software to generate a topographical matrix showing the moisture distribution and location of trapped moisture. The relative moisture readings were taken with MOIST hf sensor.

6) ***Further investigation works*** were carried out to Block B unit #02-20 to establish and verify the path(s) of seepages observed. As part of the investigative works, ***water spray tests*** were carried out between 20 December 2024 and 9 January 2025. Visual inspection and infrared thermograms were taken before, during and after the tests to identify the possible path(s) and source(s) of seepages.

1.3. Recommendations on appropriate courses of actions and/or remedial works that may be undertaken were then given.

1.4. This report shall not be used for litigation purposes without the prior consent from Integraal Building Consultancy and Services Pte Ltd.

## 2. Desktop Study

2.1. Over the years, Island View has experienced multiple cases of seepages across the units. Table 1 below summarises the seepages observed across the units over the past 3 years (i.e. 2021 thru 2024). The source(s) of seepages, number of units facing such seepages, and the rectification approach undertaken are shown. The rectification works were all undertaken by the same MCST-appointed waterproofing contractor.

*Table 1 – Summary of seepage categories and rectification approach*

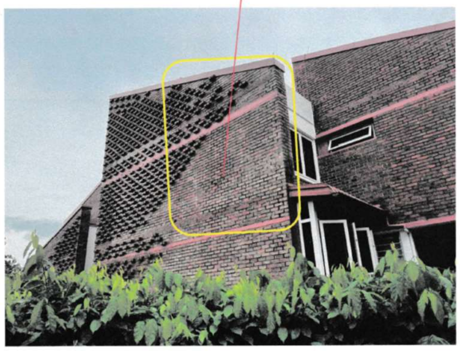
| **Source of seepage** | | **No. of units facing such seepages over 2021- 2024** | **Rectification approach undertaken** |
|---|---|---|---|
| Through gable end masonry | Seepage symptoms noted along top or bottom section of gable end walls | 31 | Patch repairs to crack lines; Waterproofing to exterior masonry walls using a 3 coat |

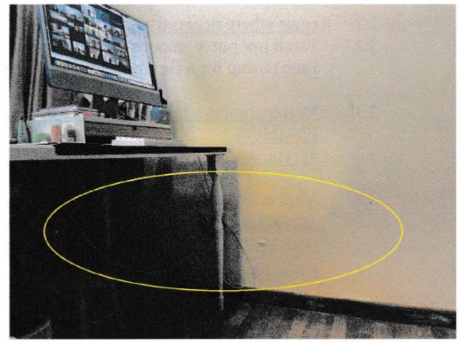
<table>
<tr><th colspan="2">Source of seepage</th><th>No. of units facing such seepages over 2021- 2024</th><th>Rectification approach undertaken</th></tr>
<tr><td>walls</td><td>Seepage symptoms noted along middle section of gable end walls</td><td>8</td><td>system</td></tr>
<tr><td colspan="2">Through plastered walls or masonry walls (non-gable end)</td><td rowspan="2">104</td><td>Patch repairs to crack lines; Waterproofing to exterior masonry walls using a 3 coat system</td></tr>
<tr><td colspan="2">Through window sealant joints</td><td>Sealant works using silicone sealant to be carried out along frame to wall joints</td></tr>
<tr><td colspan="2">Through roof flashing (Aluminum capping)</td><td>59</td><td>Seal all flashing joints using silicone sealant; Waterproofing to flashing using a 5 coat system</td></tr>
<tr><td colspan="2">Through RC airwells (airwells within unit)</td><td>39</td><td>Patch cracks using putty compound for cracks <1mm width; Waterproofing to airwell using a 3 coat system</td></tr>
<tr><td colspan="2">Through RC scupper drain (along the perimeter of flat roofs)</td><td>51</td><td rowspan="2">Waterproofing to flat roofs (and surrounding scupper drain) using a 5 coat system</td></tr>
<tr><td colspan="2">Through RC flat roofs (non scupper drain locations)</td><td>17</td></tr>
<tr><td colspan="2">Through clay roof tiles</td><td>22</td><td>Waterproofing to clay roof tiles using a 5 coat system</td></tr>
<tr><td colspan="2">Through air vent penetration joints</td><td>9</td><td>Waterproofing to air vent penetration joints using a 5 coat system</td></tr>
<tr><td colspan="2">Through rainwater downpipe</td><td>3</td><td>Replace any damaged rainwater downpipe</td></tr>
</table>

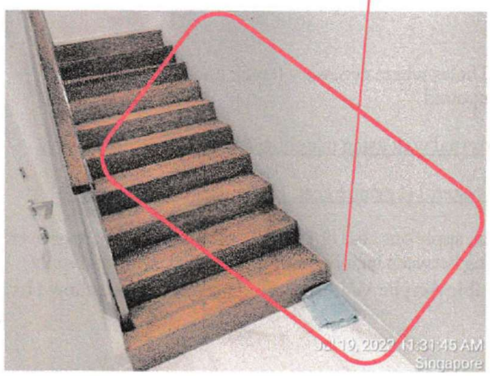
2.2. The repair works indicated above were carried out on an ad-hoc basis over 2021 – 2024. According to the MA, such waterproofing and sealant works had not been carried out in an Estate-wide basis during the recent R&R exercise.

2.3. Typical photos of the past issues observed, along with the rectification approach undertaken by the MCST-appointed waterproofing contractor were shown below:

**a. Seepage at bottom of gable end wall**

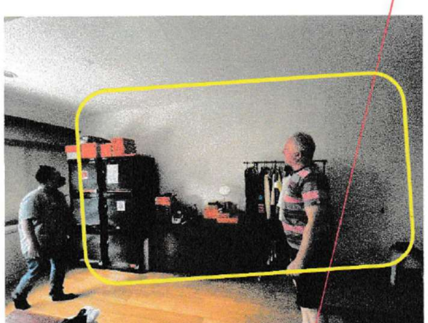


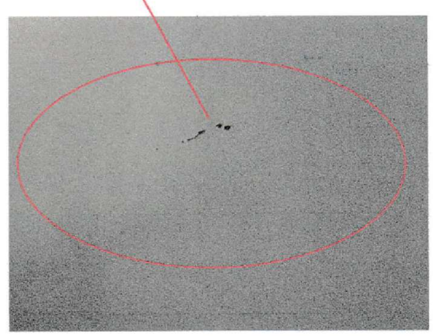



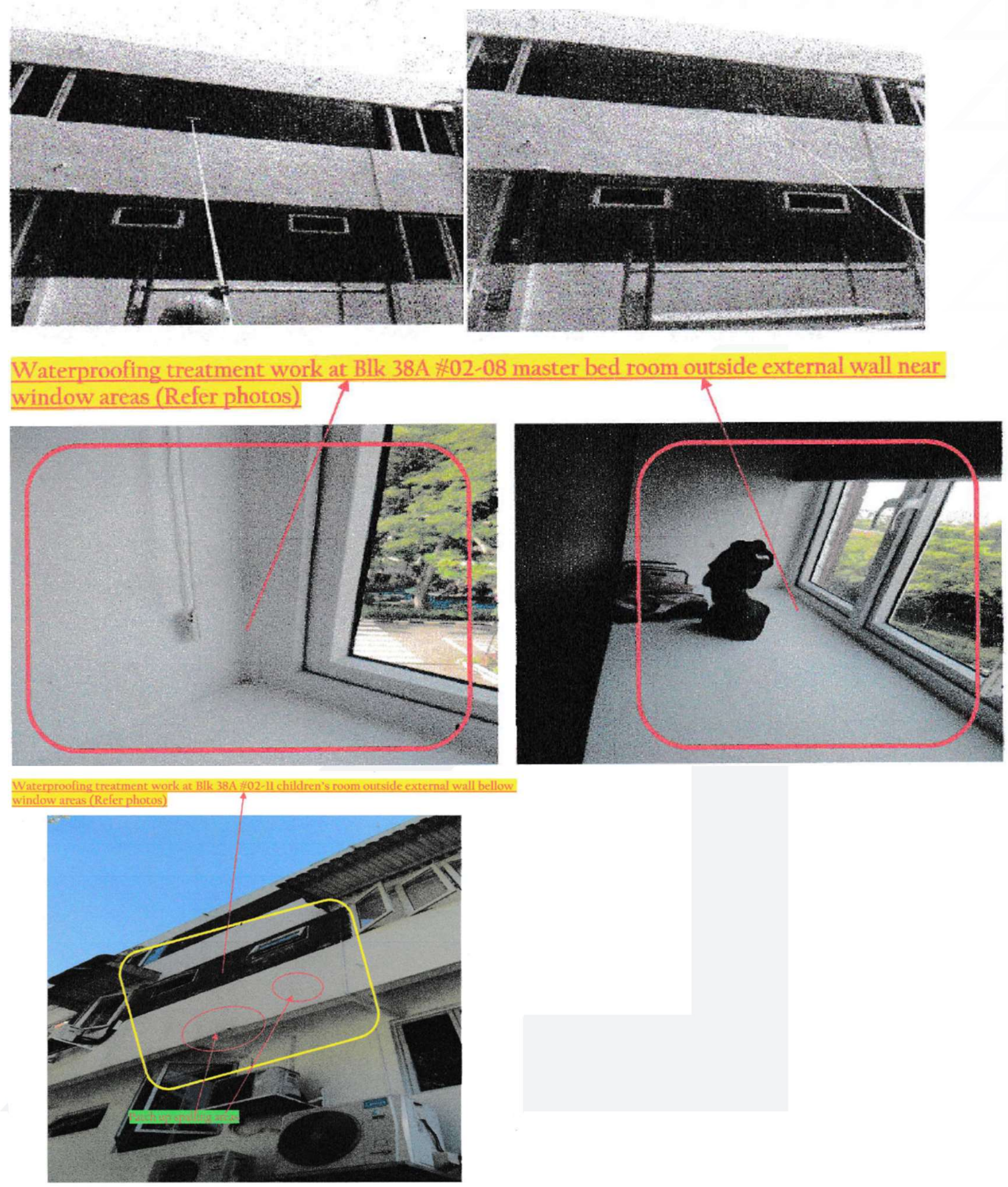


**b. Seepage at middle of gable end wall**

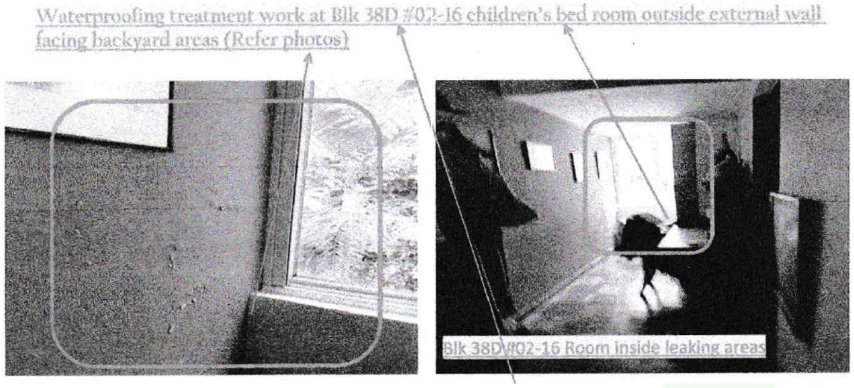


**c. Front and rear external walls (plastered/brick)**



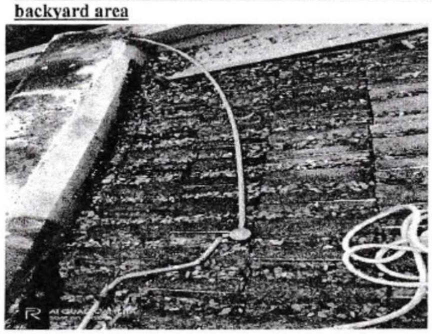
d. **Seepage near window**



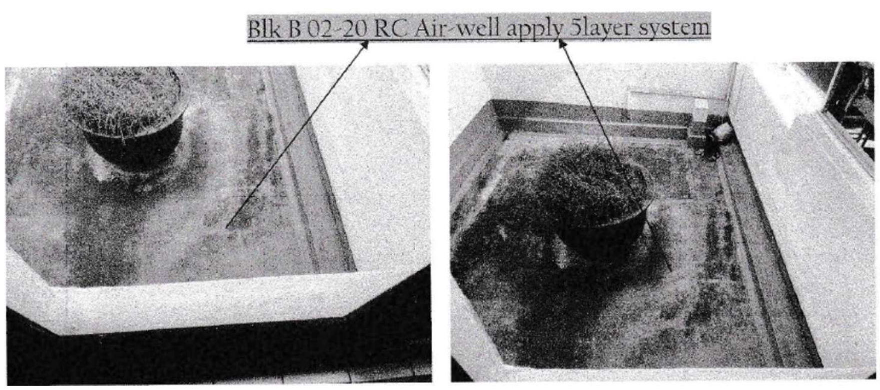

**<u>Waterproofing treatment work at Blk 38B #01-06 Master bedroom outside external wall corner near window areas facing left side</u>**

e. **Roof flashing**

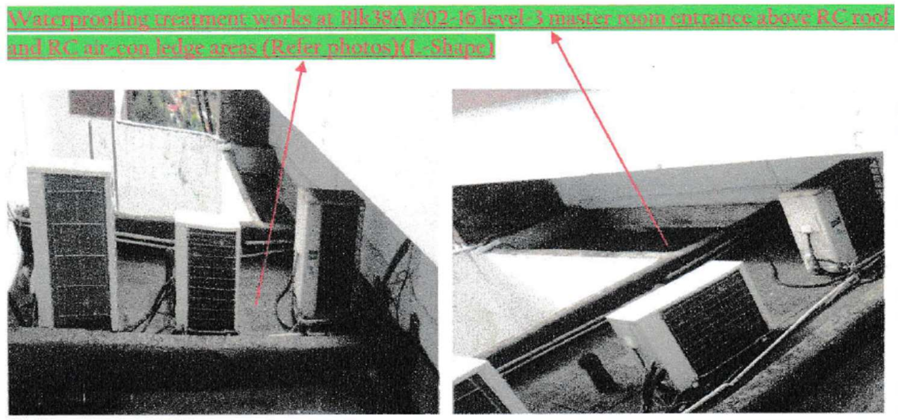
**<u>Waterproofing treatment to Blk 38C #02-03 level 2 Balcony flashing & pitch roof tiles facing left side backyard area</u>**



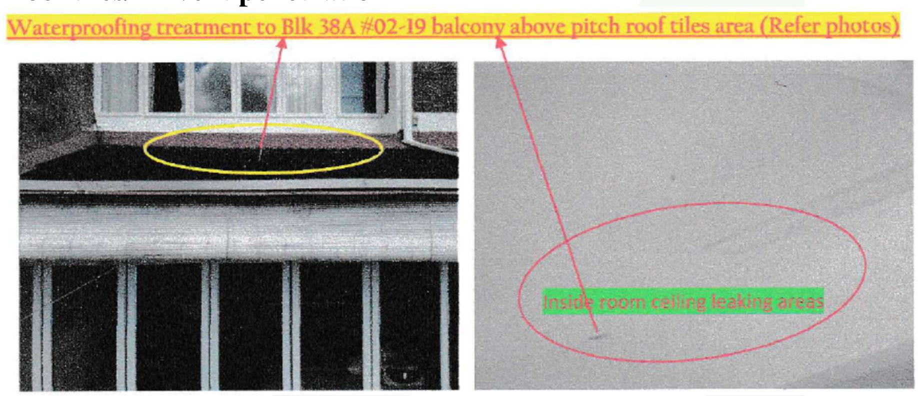
f. **RC airwells**



### g. RC flat roof




### h. Roof tiles/Airvent penetration




### 3. Inspection into units

3.1. From the seepage survey forms returned, a total of 13 units reported recurring seepages despite previous repair works carried out by the MCST-appointed waterproofing contractor.

3.2. A summary of the observations noted from the visual inspection to these 13 units, as well as findings from desktop studies were given in the table below.

For each unit, a summary of the location(s) where the seepages were noted, likely source(s) of seepage, and the rectification works that had been carried out were given. Where the seepage(s) were noted to have recurred, the visual symptoms noted, along with the possible seepage path(s) were given.

3.3. Following the table, typical photos of each source of seepage were given, along with a brief description of the observations made.

| Location | | Desktop Study Findings | | | Visual Survey Findings | |
|---|---|---|---|---|---|---|
| Block # | Unit # | Location(s) where seepage symptoms were observed and possible seepage path(s) | Period(s) where report was made/ repair works carried out | Works(s) carried out previously | Are the seepage symptoms present during visual inspection | Possible seepage path(s) |
| A | #02-04 | Children's bedroom wall near window area facing backyard | Sept 20 and Feb 24 | Waterproofing works to external wall | Yes, paint deterioration and water marks noted along parapet walls around windows | Through frame to wall sealant joints; Through cracks/ deteriorations across exterior plastered walls |
| A | #02-19 | Children's bedroom wall | Mar-23 | Waterproofing works to pitch roof tiles | No access during visual inspection | |
| A | #02-20 | Children's bedroom wall | Mar-23 | Waterproofing works to external wall | No access during visual inspection | |
| B | #01-02 | Children's bedroom wall at Level 3 | May 21 and March 23 | Rainwater downpipe replaced | No symptoms of active seepages noted | Seepage sources have likely been addressed during the previous works |
| B | #02-04 | Balcony above pitched roof tiles | Oct 19 and June 22 | Waterproofing applied to flashing joints and pitched roof tiles | No symptoms of active seepages noted | |
| | | Children's room above pitched roof | Aug 20 and Jun 22 | Waterproofing applied to flashing joints and pitched roof tiles | No symptoms of active seepages noted. | |
| B | #02-12 | RC airwell | Dec19 and Feb 23 | Waterproofing works to airwell | No access during visual inspection | |
| B | #02-16 | RC airwell | Oct 20 and Feb 24 | Waterproofing works to airwell | No access during visual inspection | |

| Location | | Desktop Study Findings | | | Visual Survey Findings | |
|---|---|---|---|---|---|---|
| Block # | Unit # | Location(s) where seepage symptoms were observed and possible seepage path(s) | Period(s) where report was made/ repair works carried out | Works(s) carried out previously | Are the seepage symptoms present during visual inspection | Possible seepage path(s) |
| B | #02-20 | RC airwell | May 19 and Dec 21 | Waterproofing applied to RC airwell with the necessary upturns | Yes, water seepage symptoms noted at living room floor, and at RC airwell.<br><br>Symptoms also noted along walls at children's bedroom (2 nos) | Possible seepage path(s) for living room elaborated later in this report<br><br>Seepages noted around RC airwell likely through deteriorated waterproofing<br><br>Seepages at children's bedroom likely through frame to wall sealant joints; through cracks/ deteriorations across exterior plastered walls |

| Location | | Desktop Study Findings | | | Visual Survey Findings | |
|---|---|---|---|---|---|---|
| Block # | Unit # | Location(s) where seepage symptoms were observed and possible seepage path(s) | Period(s) where report was made/ repair works carried out | Works(s) carried out previously | Are the seepage symptoms present during visual inspection | Possible seepage path(s) |
| C | #02-03 | Roof flashing above balcony | Oct-20 | Waterproofing treatment to flashing | No symptoms of active seepages noted. | Seepage sources have likely been addressed during the previous works |
| C | #02-08 | Roof flashing above balcony | Apr 19 and March 23 | Waterproofing treatment to flashing | No symptoms of active seepages noted. | |
| | | Pitched roofs above master bedroom toilet | Jul-23 | Waterproofing treatment to pitch roof | No symptoms of active seepages noted. | |
| C | #02-16 | - | - | - | Yes, symptoms of seepages noted along plastered walls and gable end walls, and/or around deteriorated window sealant joints | Possible seepage path(s) for gable end walls elaborated later in this report<br><br>Seepages at bedroom likely through frame to wall sealant joints; through cracks/ deteriorations across exterior plastered walls |

| Location | | Desktop Study Findings | | | Visual Survey Findings | |
|---|---|---|---|---|---|---|
| Block # | Unit # | Location(s) where seepage symptoms were observed and possible seepage path(s) | Period(s) where report was made/ repair works carried out | Works(s) carried out previously | Are the seepage symptoms present during visual inspection | Possible seepage path(s) |
| C | #02-11 | Flashing above children bedroom | Apr 19 and June 23 | Waterproofing treatment to flashing | No access during visual inspection | |
| D | #02-15 | Living room exterior walls | Apr 19 and Nov 21 | PU grouting on interior walls and waterproofing treatment on external wall | No symptoms of active seepages noted. | Seepage sources have likely been addressed during the previous works |

3.4. Seepages through the gable-end walls

3.4.1. Within Block B unit 02-20, the parquet flooring immediately adjacent to the gable end walls were noted to be warped and debonded. Additionally, water marks could be observed along the edges of the parquet strips, and along the perimeter of the living room walls. See Plate 1.

The symptoms observed alludes to water retention issues beneath the parquet strips, and along the perimeter walls. Visually, the symptoms observed were noted to be worst adjacent to the gable end wall. The symptoms were noted to be less extensive and less severe further away from the gable end walls. It is therefore hypothesised that the seepage symptoms observed were attributed to seepages through the gable end walls.

Similarly for Block C unit 02-16, the walls immediately adjacent to the gable end walls were noted with symptoms of water retention- these includes paint deterioration and water marks. See Plate 2

While repair works had previously been carried out to the exterior masonry walls, the repair works may not have fully arrested the seepage issue.



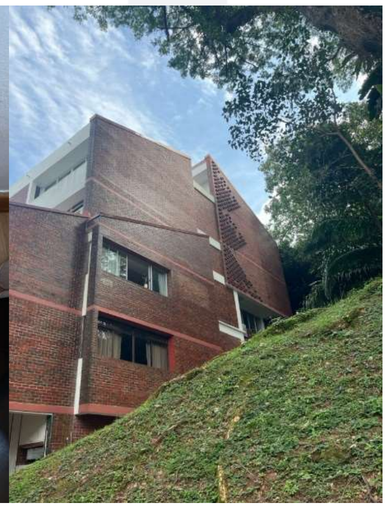



*Plate 1 – Seepage photos in living room of Block B02-20*

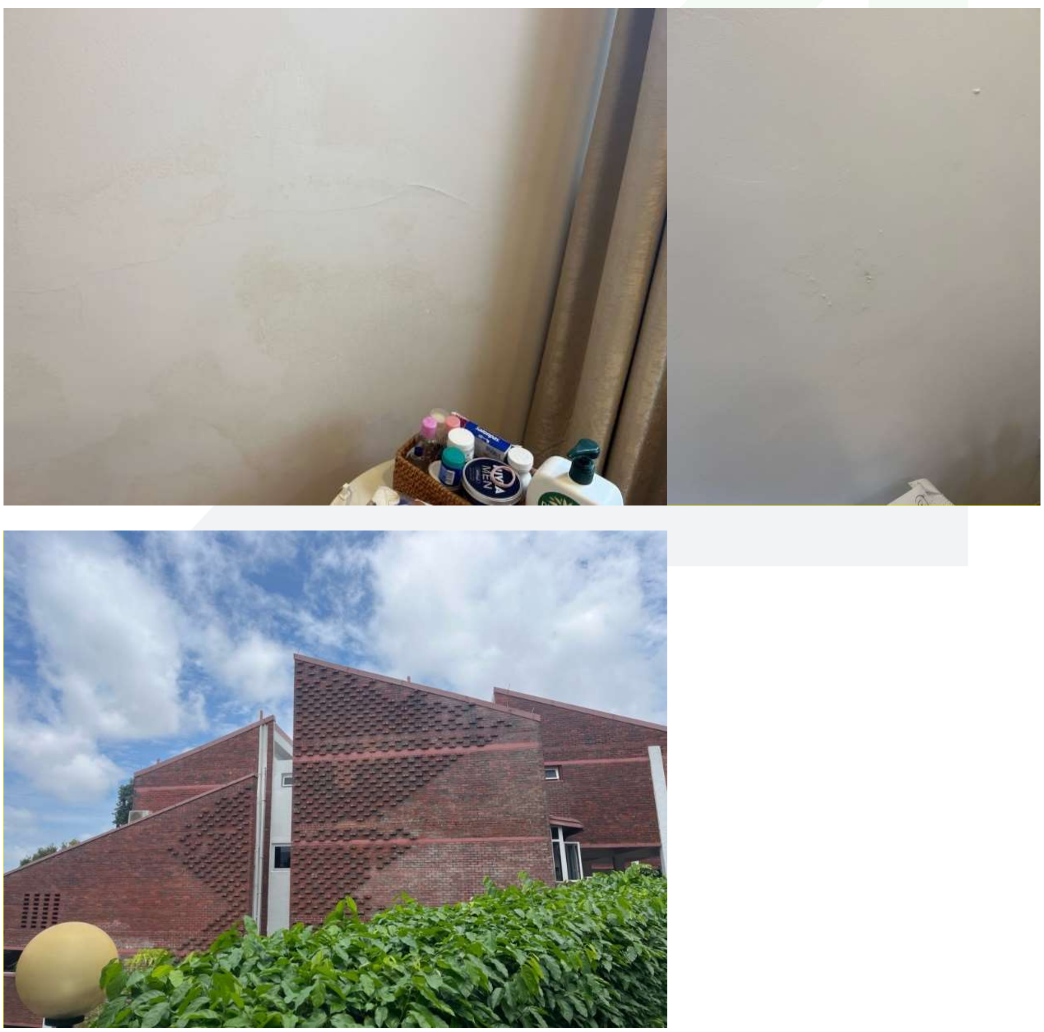


*Plate 2 – Seepage photos in bedroom of Block C02-16*

3.5. Seepages through airwell

3.5.1. Symptoms of water ingress and retention could be observed across plastered surfaces immediately adjacent/ beneath the airwell, likely as a result of seepages through the airwell deteriorated waterproofing. Such symptoms include paint deterioration, water marks and algae formations. The units where these were noted were Block B units 02-16 and 02-20. See Plate 3.

(*Note: Block B units 02-12 and 02-16 also reported seepages through airwell but cannot be accessed during visual inspection).*

3.5.2. Application of new waterproofing membrane is recommended to be carried out as it was proven to be effective in addressing the seepage – of 39 units where such rectification works were carried out, most units (36 units) did not report recurring seepages. The 3 units with recurring seepages could possibly be due to further seepages from the airwell waterproofing membrane. It is noted that the previous waterproofing applied was a liquid-applied system, which is less durable than a torch-on waterproofing membrane.

*Plate 3 – Seepages in airwell*

3.6. Seepages through plastered or fair-faced masonry walls

3.6.1. Water marks and paint deteriorations could be observed across the interior plastered walls for the following units: Block A unit 02-04; Block B unit 02-20; Block C unit 02-16, and Block D unit 02-15. See Plate 4.
(*Note: Block A units 02-20 also reported seepages through plastered/ masonry walls, but cannot be accessed during visual inspection).*

3.6.2. As part of the rectification works carried out by the MCST-appointed Contractor, waterproofing was applied over the plastered / masonry walls to arrest further water seepages. Such rectification works was generally effective – of 107 units where such rectification works were carried out, most units (104 units) did not report recurring seepages.

3.6.3. For the units with reported seepages – seepages have likely occurred through cracks, and/or debonded/ deteriorated plasterworks across the plastered walls. For areas with fair-faced masonry walls, the symptoms observed alludes to seepages through deteriorated/ degraded mortar joints and/ or deteriorated/ degraded brick surfaces. Necessary repairs to the plastered/ masonry wall ought to be carried out as detailed in the subsequent sections.

*Plate 4 – Paint detorioration on interior walls facing front/rear elevations*

3.7. Seepages through window sealant joints

3.7.1. Water marks and paint deteriorations could be observed across the interior walls adjacent to the windows for the following units: Block A unit 02-04; Block B unit 02-20; Block C unit 02-16. The symptoms observed strongly suggests that the window sealant joints (frame-to-wall joints) have deteriorated, thus resulting in water seepages and retention along the sealant joints. See Plate 5 and Plate 6.

3.7.2. As part of the rectification works carried out by the MCST-appointed Contractor, re-sealant works is carried out using silicone sealant along the perimeter window frame-to-wall joints to arrest any seepages along the sealant joints on an ad hoc basis. Such rectification works was generally effective. Units with recurring issues were noted to be with deteriorated sealant joints as described above – re-sealant works ought to be carried out to arrest any seepages.

*Plate 5 – Seepages on wall near to windows at Block B02-20*

*Plate 6 – Seepages near to windows at Block C02-16*

3.8. Seepages through roof tiles/ flashing

3.8.1. While several units did highlight facing recurring seepages through roof tiles and flashing via the water seepage survey forms, visual survey into these units did not find evidence of such active recurring seepages. It is thus likely that the re-waterproofing works to the clay roof tiles/ flashing joints arrested any seepages. The rectification works carried out were thus noted to be effective. See Plate 7.

*Plate 7 – Typical photo of seepage through flashing previously*

3.9. From the visual survey carried out into the units, the key areas of seepages observed across the Development includes:

- Seepage through airwell
- Seepage through plastered RC walls/ masonry walls
- Seepage through gable end walls
- Seepage through roof tiles/air vents

Apart from the seepages through gable end walls, it is noted that **all other sources of seepages were generally resolved after the MCST-appointed waterproofing contractor had carried out rectification works**.

3.10. The visual inspection carried out to the units as discussed in the earlier section was limited to survey carried out from vantage points. In addition to such visual surveys from vantage points, inspections were carried out using drone to the masonry wall façade, flashing, roof tiles and gutters to assess the general condition of these elements. Key findings of the drone inspection were summarised as follows:

3.11. The roof flashings were in generally deteriorated conditions, with deteriorated sealant joints noted across the flashing-to-flashing joints, and along the flashing to roof tiles joints - these sealant works were noted with extensive algae formation/ water marks which alludes to water ingress and retention along such sealant joints. See Plate 8. In the event whereby the defects are left untreated, seepages through the flashing joints could eventually occur.

*Plate 8 – Typical photo of flashing joints deterioration*

3.12. Several of the flashing joints (flashing to flashing/ flashing to roof tiles) were observed to have been waterproofed, likely as part of previous ad-hoc repair exercises. Typical photos were shown below in Plate 9. The repaired areas/ sections were noted to be of generally good condition- there were no evidence of water ingress or retention noted. Further, where such waterproofing works were carried out, there were no evidence or reports of seepages into the units beneath, which suggests that such works were effective.


*Plate 9 – Typical phtotos offlashing area treated previously*

3.13. The roof tiles across the Development were generally observed to be deteriorated conditions, with deteriorated/ worn surface coating, along with algae formations observed. Such worn coating and algae formation alludes to water retention across the deteriorated tiled roofing.

3.14. Infrared thermograms taken of the roof tiles showed signs of water retention particularly along joints between the roof tiles, and along the joints between the roof tiles and vent pipe penetrations.

3.15. Visual photos and infrared thermograms taken of the roof tiles strongly suggest possible weaknesses across the tiled roofs joints, including tile to tile joints, and joints between the roof tiles and services (e.g. vent pipe) penetrations. The clay roof tiles were observed with extensive algae formation and worn coating which suggests water retention within the clay tile material. Left untreated, any further deteriorations could lead to future seepages through such joints, and/or through the tiles with increased deterioration / porosity of the clay tile. See Plate 10.

3.16. Various localised patches of waterproofing were noted to have been carried out across the roof tiles, and along the air vent to roof tiles joints. Such previously applied waterproofing were generally noted to be in excellent conditions - there were no evidence of water ingress or retention noted. Further, where such waterproofing works were carried out, there were no evidence or reports of seepages into the units beneath, which suggests that such works were effective.

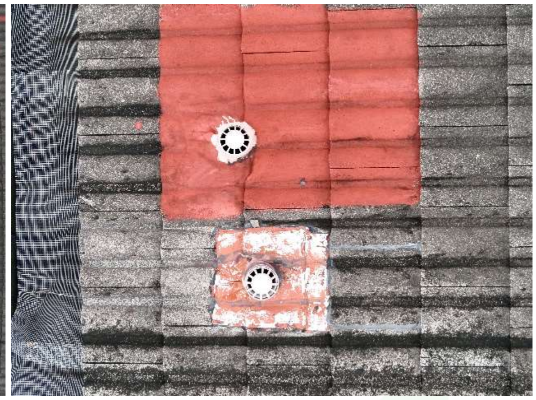
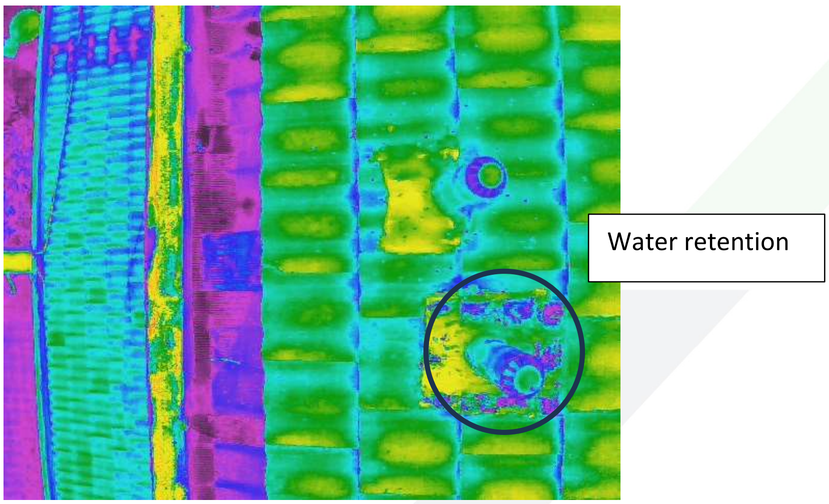





*Plate 10 – Water entrapment in roof tiles/airvents*

3.17. Across the gable end masonry wall façade, weep holes could be observed above the location of the interior floor slab. The weep holes were generally noted to be five (5) courses of bricks above the floor slab level. See Plate 11.


*Plate 11 – Typical weep holes found on gable end walls*

3.18. The gable end masonry wall was noted to be a full course brick wall. The dimension of the wall suggests that the gable end wall is likely a double layer masonry wall with a cavity in between. The cavity was likely constructed to allow any water seeping through the brick wall to discharge out via the weep channels, thus preventing any seepages through to the interior walls.

3.19. A metal plate could be observed immediately above the weep hole channel at random locations. It is unclear what the purpose of this metal plate was. See Plate 12.

3.20. It is further noted that a double course of bricks immediately above the weep hole channels were generally bricks that appeared to be newer - These bricks were generally observed to be relatively well-fired and homogeneous in colour. The presence of such newer bricks, at random locations across the gable end façade, strongly suggests that latter-day repair works may have been carried out to the weep channels. Waterproofing membrane was also observed below every weep hole row on the façade. See

*Plate 12 – Close up photo of metal plate within gable end wal*

*Plate 13 – Close up photo of the waterproofing membrane below weep holes*

3.21. From the observations made, a typical construction of the gable end masonry wall is illustrated as follows. As discussed in the preceding sections, the gable end masonry wall is designed to allow water to seep through. However, any water seeping through ought to flow down towards the weep channel and discharge from the weep holes. *The typical location where the waterproofing membrane(see sub paragraph 3.19) and the double course of bricks (see sub paragraph 3.20) may be found is included in the illustration.* See Plate 14

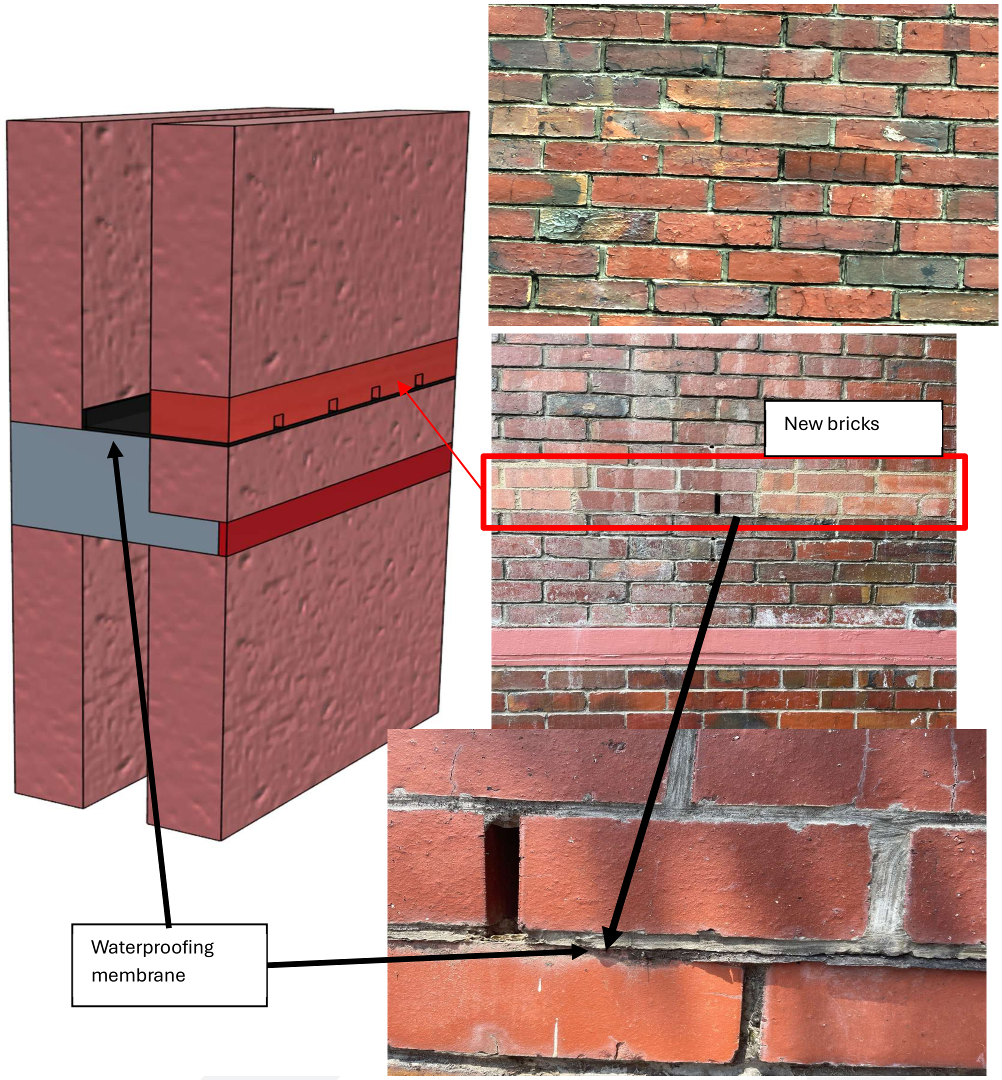



*Plate 14 – Illustration of gable end wall construction details*

3.22. Visual and infrared thermograms taken of the weep channel strongly suggests that the weep channel may not be performing or functioning as intended. Key observations made were summarised as below:

3.23. Efflorescence formation, water marks and degraded surface coating could be observed beneath the weep hole channel, which alludes to water seepages through the deteriorated weep hole channel in a downward manner. Similar symptoms of seepages could also be observed along the floor slab to masonry wall joints. See Plate 15

*Plate 15 – Efflorescence formation below weep holes*

3.24. The gable end masonry wall was noted to be with widespread surface degradations, which includes cracks, deteriorated mortar joints, along with efflorescence formations, algae formation and water marks across the wall. Additionally, the surface coating along the brick surface was observed to be worn, with signs of adhesion failure, discoloration and water marks. See Plate 16

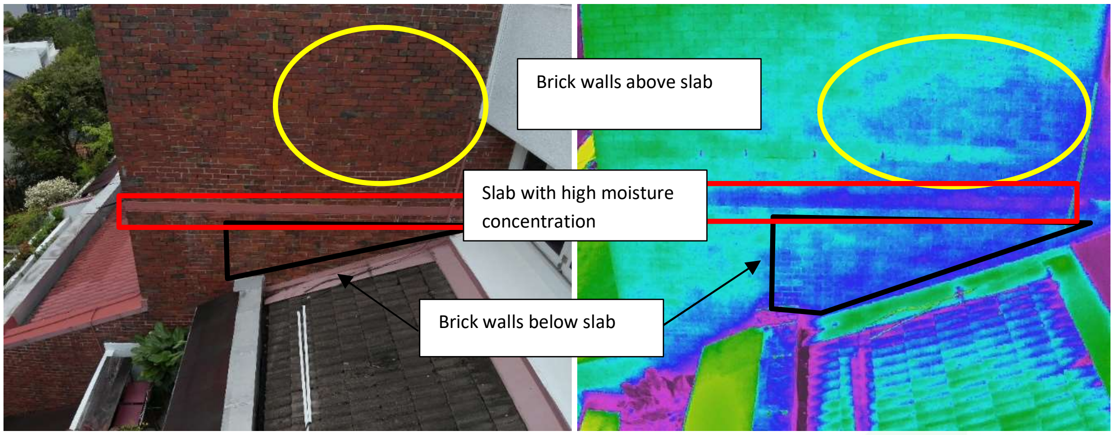
*Plate 16 – Degraded coating on brick surface*

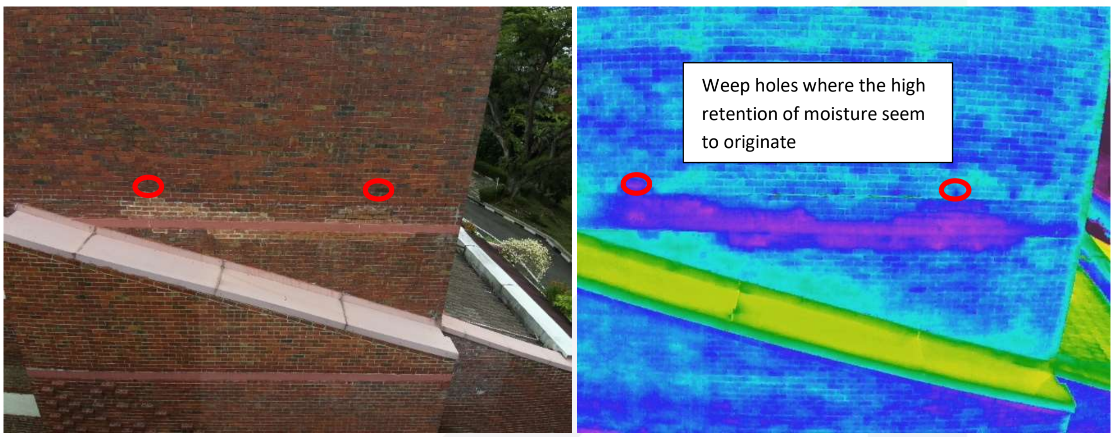
3.25. The symptoms observed herein strongly alludes to water retention within the gable end masonry walls. While an acrylic coating had previously been applied to the wall, likely to arrest such seepages, such a coating was noted to be deteriorated and degraded. Such deterioration/ degradation could possibly have occurred as a result of wear and tear of the coating. Additionally, cracks across the masonry wall, and deteriorated mortar joints, could be observed extensively across the masonry walls.

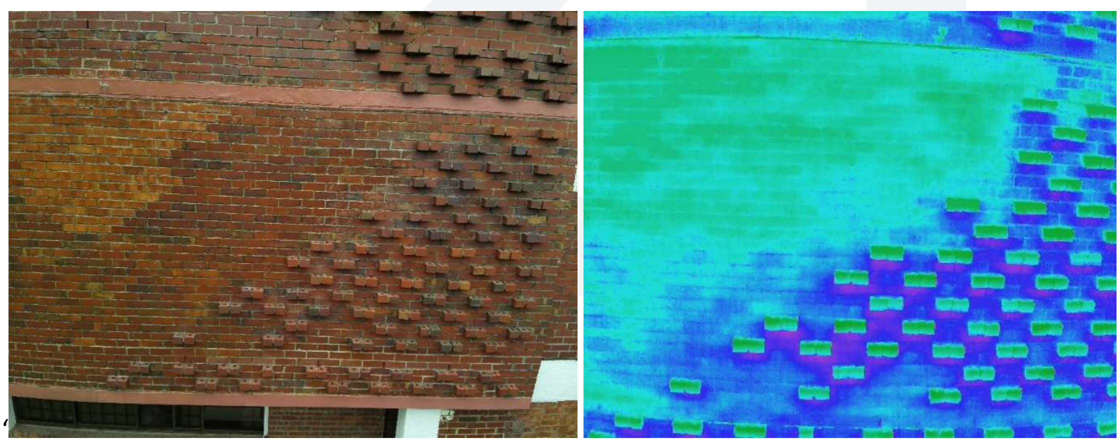
3.26. Such cracks and deteriorated mortar joints, along with the deteriorated surface acrylic coating, would have allowed water to seep through and retain within the cavity. Entrapped water within the cavity wall may trickle down slowly along the inner face of the wall and would over time saturate the capillary pores of the surrounding bricks. Water entrapped within the cavity would also result in the saturation of vapour moisture within the cavity wall. Such saturation of the vapour and/or liquid moisture could potentially result in the failure/ degradation of the surface coating due to adhesion failure between the brick surface and surface coating of the brick wall. Such adhesion failure would lead to further degradation of the surface coating, which leads to a vicious cycle where the coating would experience accelerated degradation with time.

3.27. Besides seeping through the masonry walls, other sources of moisture into the cavity wall could include seepages through the flashing to flashing or flashing to wall joints as highlighted above in sub paragraph 3.11-3.12.

3.28. Infrared thermograms across the façade supports the hypothesis that water is seeping through and retaining within the cavity wall- thermograms taken showed that there are concentrations of moisture entrapped within the floor slab between levels. The brick walls above and below the slab were also noted with symptoms of water retention as indicated in the thermograms. See Plate 17 for thermograms illustration, with those in blue shade indicating presence of moisture retention.


Brick walls above slab
Slab with high moisture concentration
Brick walls below slab


Weep holes where the high retention of moisture seem to originate



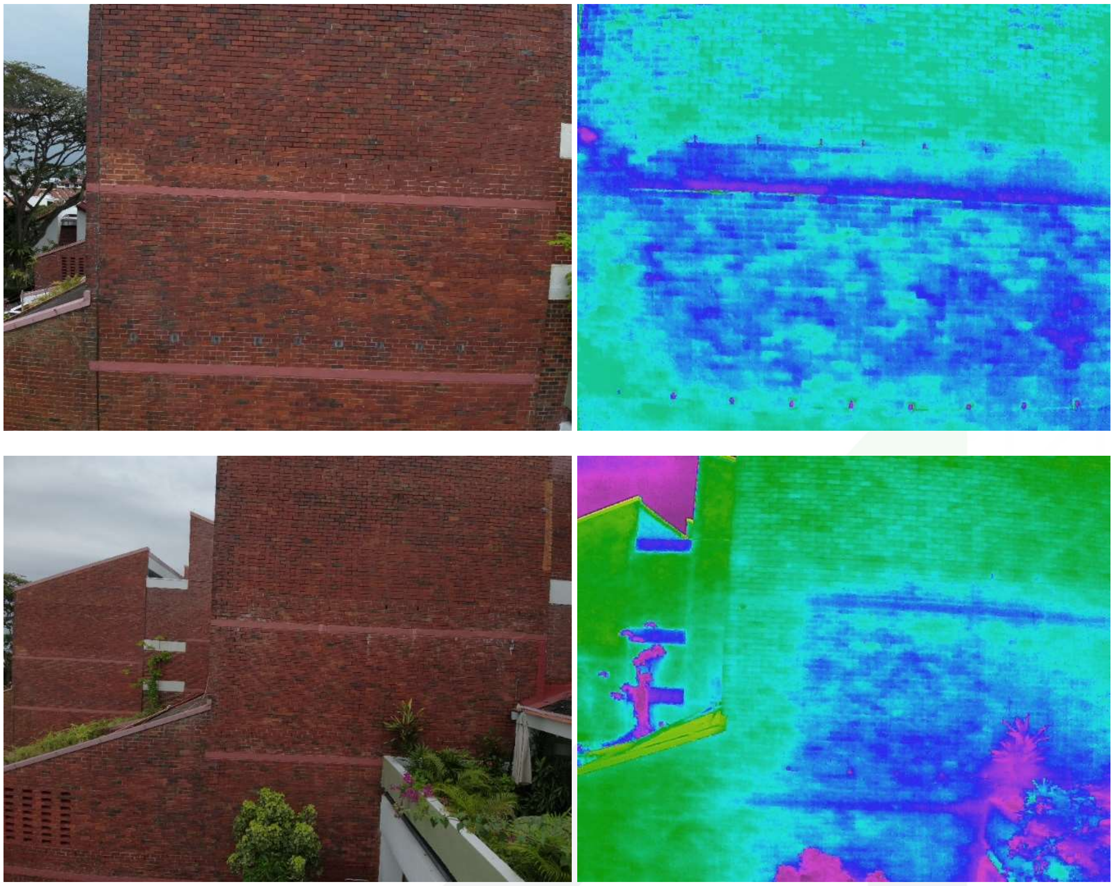


*Plate 17 – Cold spots (shaded in blue) are signs of moisture retention within the brick facade*

3.29. In summary, it is noted that the seepages through the gable end masonry walls were still active despite the works carried out by the waterproofing contractor. Findings from our visual assessment and thermograms taken have also shown that water is still able to seep through the gable end masonry walls. Water, instead of discharging out through the weep hole channels, was observed to be trapped within the base of the cavity wall, resulting in seepages around the weep channel. A detailed study of this channel was thus carried out to further understand why water is unable to discharge out per designed.

3.30. Apart from the gable end masonry walls, most of the rectification works carried out by the waterproofing Contractor had resolved the seepage issues noted within the Development. The works carried out that were noted to be effective are as follows in summary:

| **Source of seepage** | **Rectification approach undertaken** |
|---|---|
| Through plastered RC walls or masonry walls (non-gable end) | Patch repairs to crack lines;<br>Waterproofing to exterior masonry walls using a 3 coat system |

| Source of seepage | Rectification approach undertaken |
|---|---|
| Through window sealant joints | Sealant works using silicone sealant to be carried out along frame to wall joints |
| Through roof flashing (Aluminum capping) | Seal all flashing joints using silicone sealant; Waterproofing to flashing using a 5 coat system |
| Through RC airwells (airwells within unit) | Patch cracks using putty compound for cracks <1mm width; Waterproofing to airwell using a 3 coat system |
| Through clay roof tiles | Waterproofing to clay roof tiles using a 5 coat system |
| Through air vent penetration joints | Waterproofing to air vent penetration joints using a 5 coat system |

**4. Close up study of the gable end masonry walls**

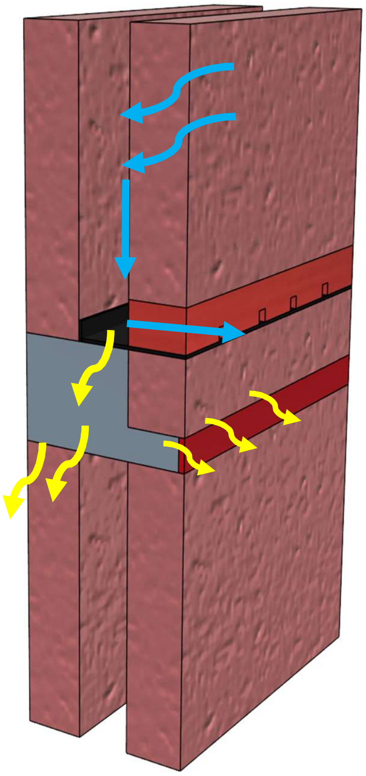
4.1. A videoscope inspection was carried out to the weep holes to further understand why the weep channels were not working as intended. Several key observations were made.

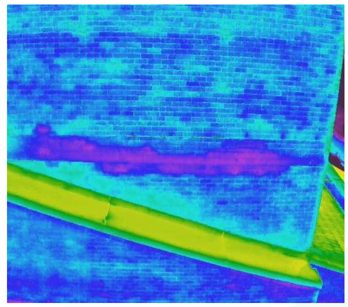
4.2. It is noted that the weep holes were not level with the weep channel within the cavity wall. Instead, the weep channel was located at a level beneath the weep holes. As a direct consequence, it would not be possible for water to discharge out from the weep holes via the weep channel. Additionally, the weep channel was graded in a manner that allowed water to stagnate along the inner-face of the cavity wall.

4.3. From videoscope images, waterproofing works had been carried out to the weep channels. This could be possibly carried out latter-day, particularly in view of the newly installed double courses of bricks observed around the weep hole channel level. Nonetheless, despite the repair works/ waterproofing works carried out, the seepages along the weep channel persisted.


**5. Hypothesis of the seepage pathway**

5.1. From our visual, thermographic and videoscope findings, the possible water seepage path through a typical cavity wall is illustrated as below.






5.2. Water could seep in through the exterior face of the cavity wall via cracks, debonded/ degraded/ deteriorated mortar joints and/or through the deteriorated acrylic coating applied onto the masonry wall. Other potential sources of water also includes the roofs' flashing joints.

5.3. Any water that have seeped through into the cavity wall would be channeled towards the weep channel. As a direct consequence of the grading of the channel, any seeped water would retain along the inner-face of the cavity wall.

5.4. Visual observation and infrared thermograms taken across the exterior walls suggests that the entrapped water could seep through the weep channel into the interior walls, or through the slab into the unit beneath, or through to the exterior wall beneath the weep channel.

5.5. A water spray test was carried out to confirm the hypothesis.

## 6. Water spray test

6.1. Of the 9 units inspected, Block B unit 02-20 was selected for further testing. The impetus for the selection of this unit was:

6.1.1. Referencing to the findings from visual inspection into this unit (see sub-paragraph 3.4.1), there were evidence of entrapped moisture along the living room skirting, parquet flooring and plastered walls. The symptoms were notably worst adjacent to the gable end wall and became less extensive and less severe further away from the gable end walls. It is therefore hypothesised that the seepage symptoms observed were attributed to seepages through the gable end walls. The symptoms within this unit were also observed to be worst amongst all 9 units inspected. See Plate 18.

6.1.2. The gable end wall for this unit was also easily accessible for water spray test given the proximity to the ground.

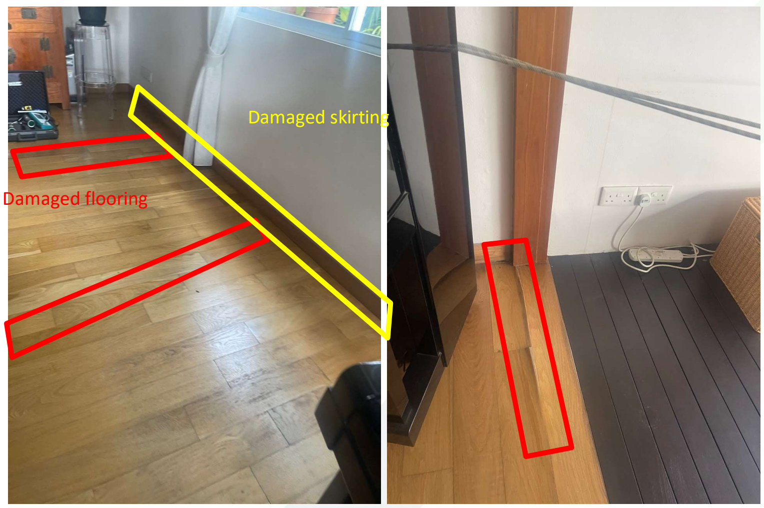



*Plate 18 – Areas with damaged flooring and skirting at living room*

*Plate 19 – Gable end wall to be tested*

6.1.3. A section of the façade wall outside unit 02-20 was observed with weep holes, while the remainder was observed without. The section without weep holes were noted immediately beneath the window whereas the section with weep holes was found to the right of the windows. See Plate 20 For the section without weep holes, latter-day installed weep pipes could be observed. The entire stretch of the masonry walls were further observed to have been treated with an acrylic waterproofing coating.

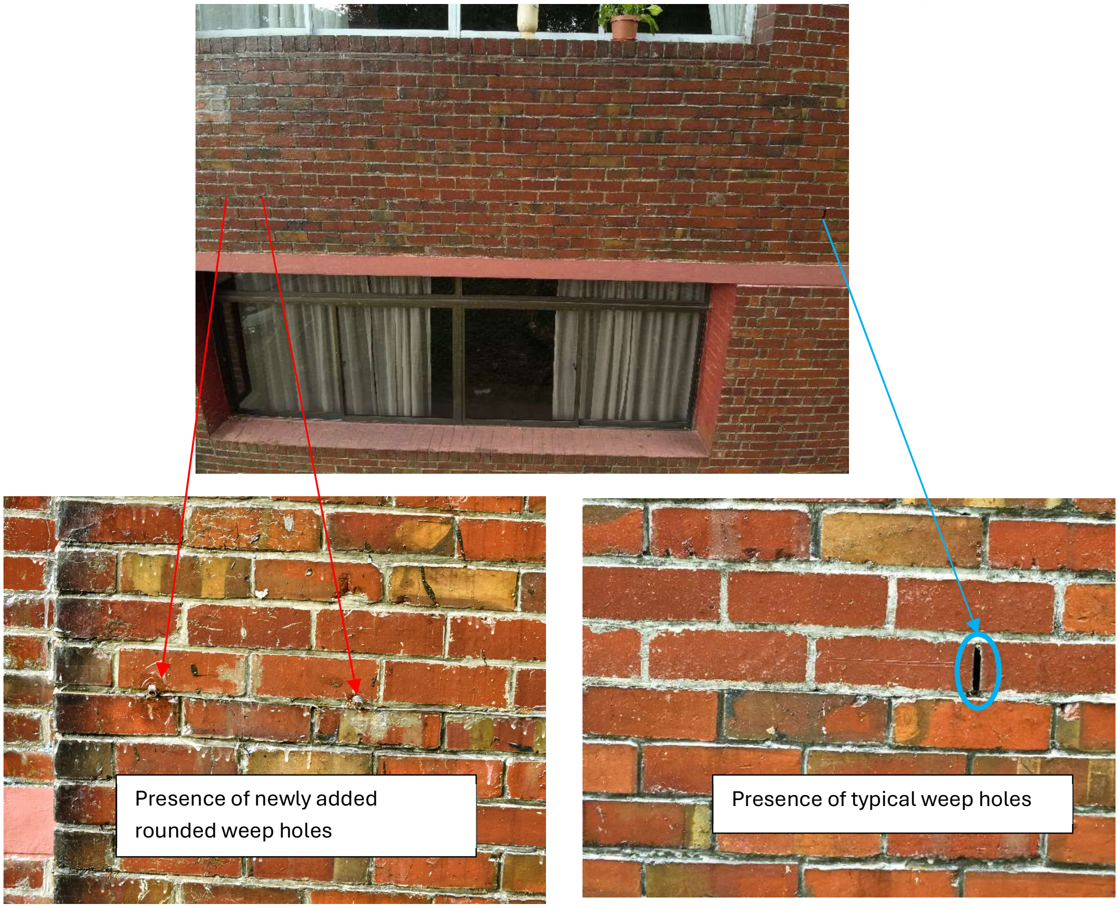



*Plate 20 – Illustration of new and original weep holes locations at B02-20 gable end wall*

6.2. Infrared thermograms were taken of the façade and interior walls before water spray tests as baseline measurements.

6.2.1. Across the section of the masonry wall without weep holes, there were no evidence of moisture retention as observed from the thermograms. Cold bands could be observed along the slab level- such cold bands were likely observed due to differences in material, rather than the presence of moisture entrapment given its' consistency across the entire slab. See Plate 21

6.2.2. For the section of the masonry walls with weep holes, evidence of moisture retention across the wall could be observed as evidenced by the cold spots noted. See Plate 22.

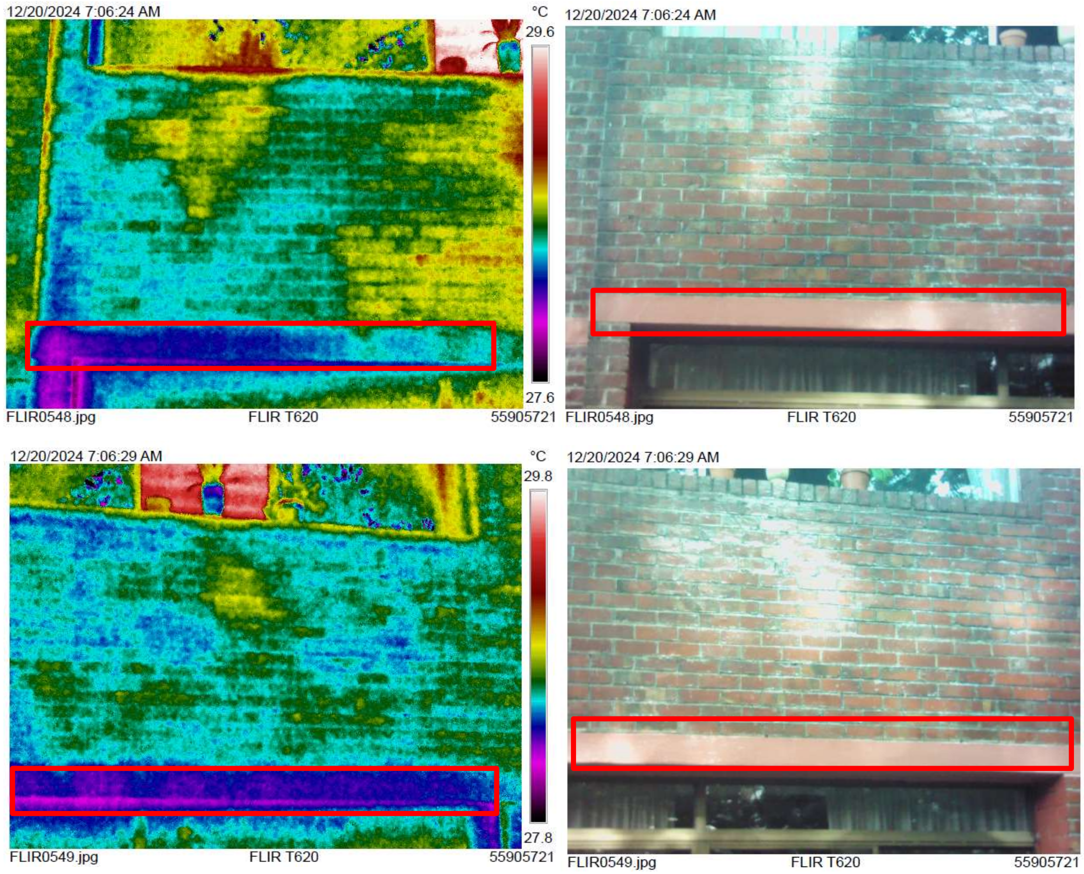



*Plate 21 – Thermograms showing moisture retention within the external gable end wall (before spray test)*

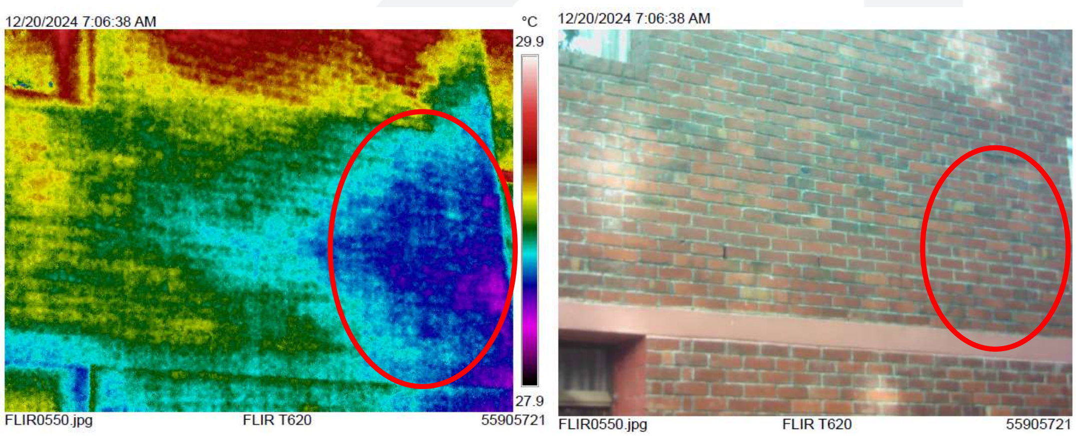



*Plate 22 – Thermogram showing moisture retention on wall at where original weep holes are at*

6.2.3. Thermograms on the internal living room showed moisture retention along the bottom of the wall and skirting, indicating likelihood of seepage from the external gable end wall. See Plate 23 for moisture retention areas on thermograms

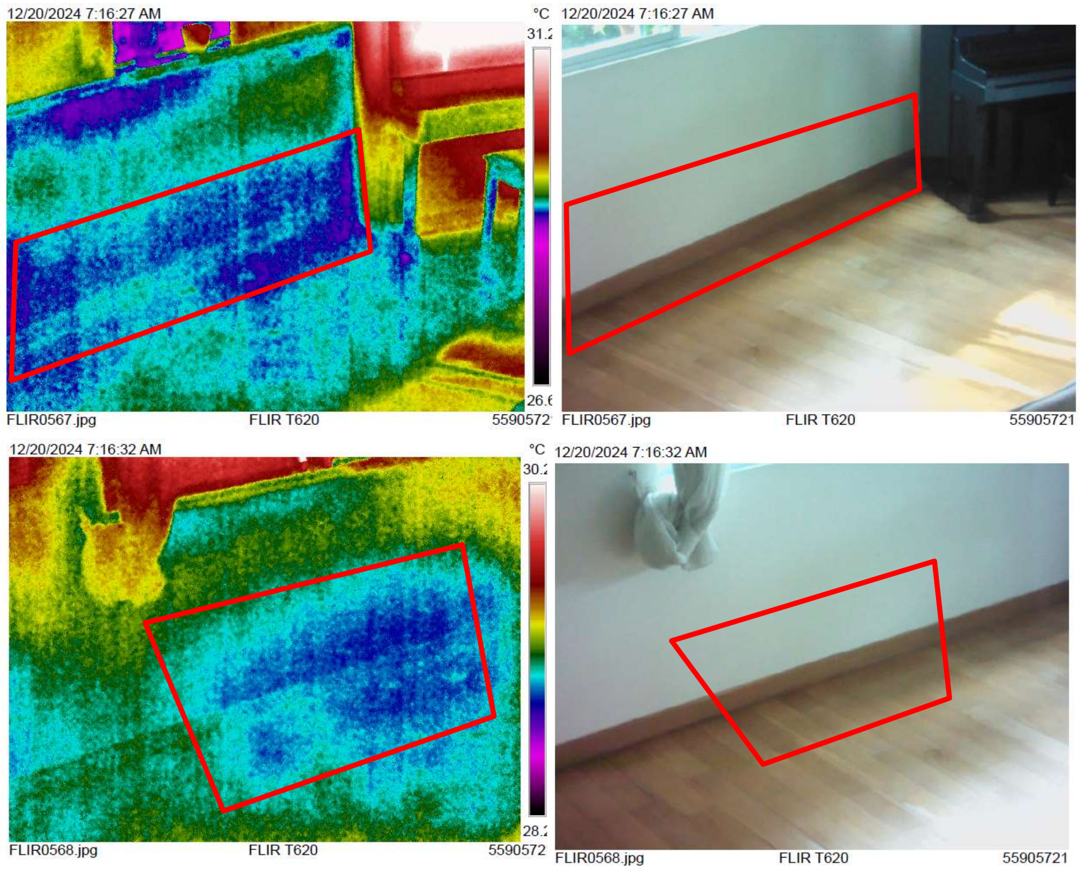



*Plate 23 – Thermograms of living room (before spray test)*

6.3. Water spray test was performed on the weep holes along the right side of wall to simulate water ingress into the cavity wall. See Plate 24. Thermograms were taken after 20 mins of the spray test which showed a slight increase in the cold spots observed across the masonry wall. Such a slight increase alludes to increase in moisture across the affected walls, which is to be expected given that the water spray test introduces significant water to the masonry walls. See Plate 25. There was however no significant increase in the moisture affected areas within the interior living room wall and floors. See Plate 26.

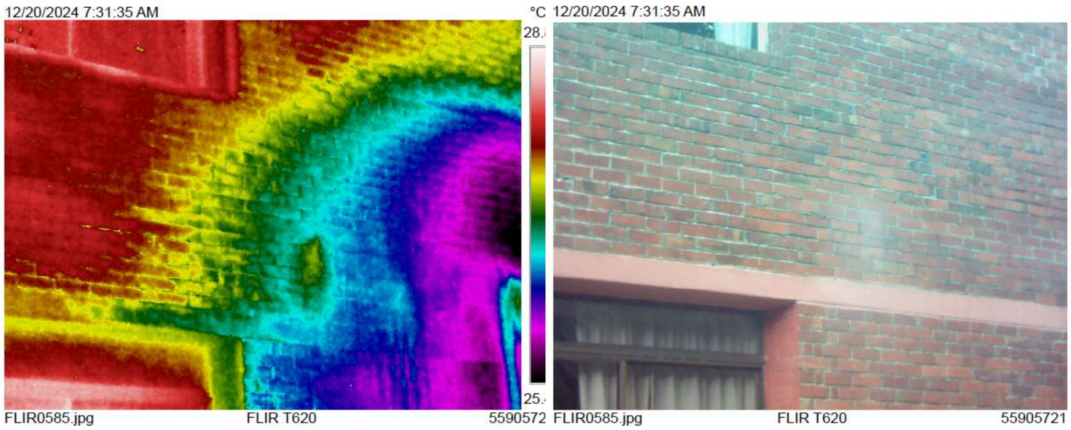



*Plate 24 – Thermogram of façade wall during spray test*

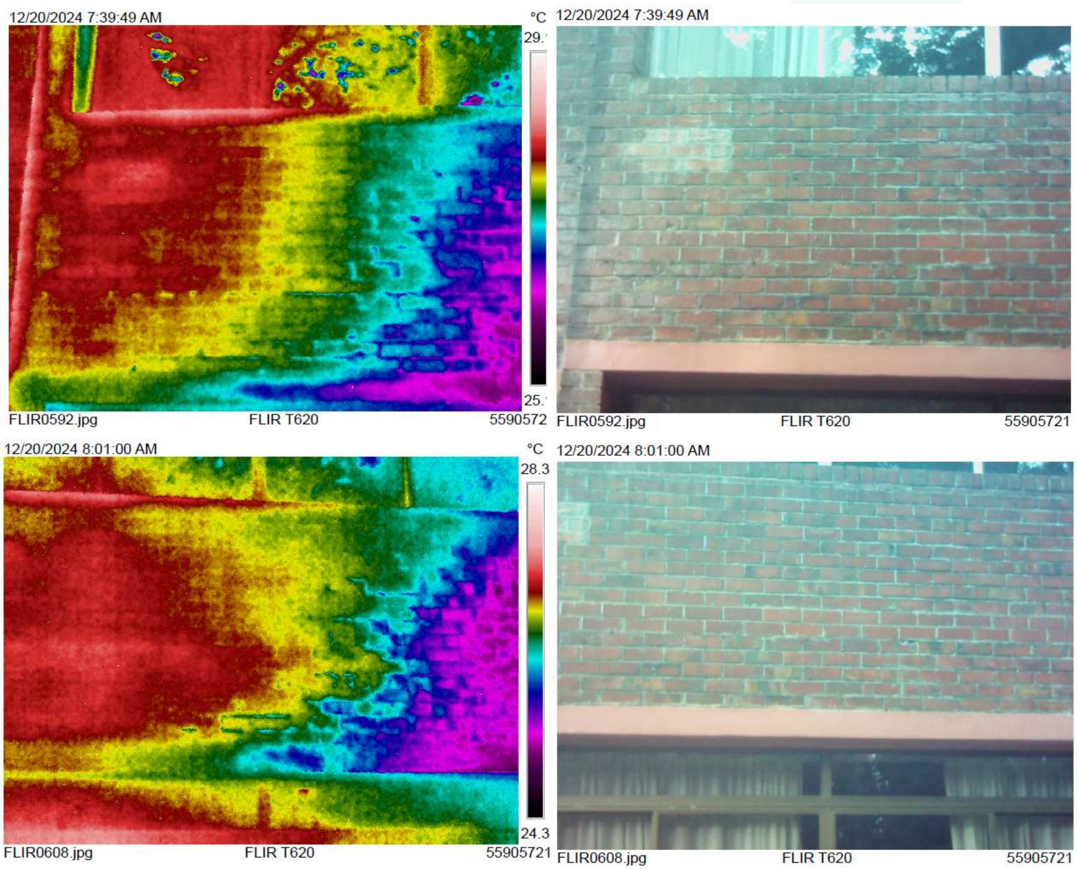



*Plate 25 – Thermograms of façade after spray test*

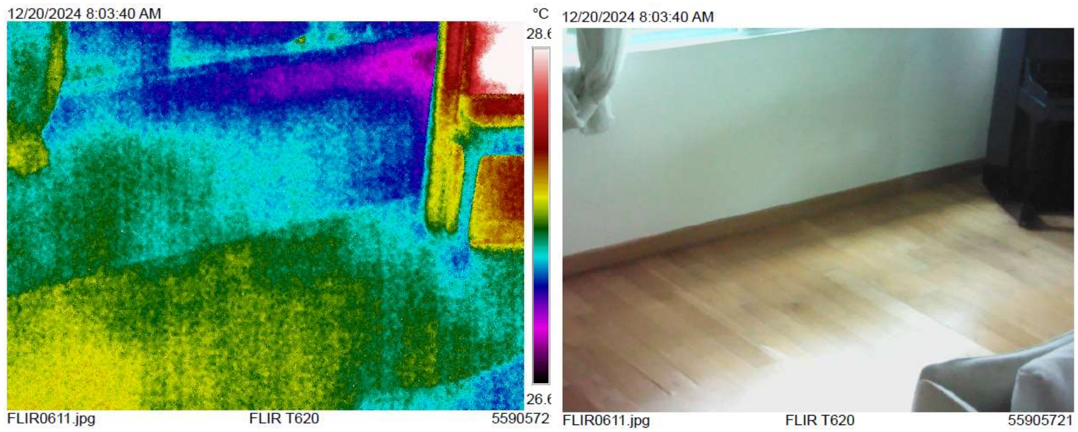



*Plate 26 – Thermogram of façade after spray test*

6.3.1. Testing results for the water spray test were inconclusive as there was no significant increase in moisture levels detected within the unit after the water spray test.

6.4. In light of the above, a second spray test and tactile survey was arranged on 9 Jan 2025. A breakout inspection was also carried out to the weep channel to confirm the construction details of the weep channel. This breakout inspection was carried out to the left end of the gable end wall as shown in Plate 27. Latter-day installed weep pipes could be observed for this section.


*Plate 27 – Breakout inspection location*

6.4.1. Similar to what was observed during the videoscope inspection, a cavity wall could be observed within the gable end wall. Notably, a cementitious layer had been applied across the walls of the weep channel. This cementitious layer appeared to be a latter-day addition. It is highly likely that the area of replaced bricks above the breakout area was previously opened to facilitate the application of this cementitious layer. See Plate 28 for photos within the breakout area. An illustration is shown in Plate 29 showing the extent of cementitious top up within the cavity.




*Plate 28 – Photos of the caivty wall within breakout location*


*Plate 29 – Cementitious top up layer*

6.4.2. Another notable observation was that the original weep holes across the cavity walls beneath the window had been sealed off. In its' place, new weep pipes had been installed one (1) course of bricks above the typical weep holes.

6.4.3. The close up and breakout inspection revealed that the weep channel has likely been re-levelled. Given that the new weep pipes were higher than the typical weep holes, a re-levelling work had likely been carried out to ensure increased gradient to discharge any surface runoff within the weep channel. See Plate 30. Such works were likely carried out together with the application of cementitious layer to the cavity walls. The cementitious layer noted could possibly be a waterproofing layer.

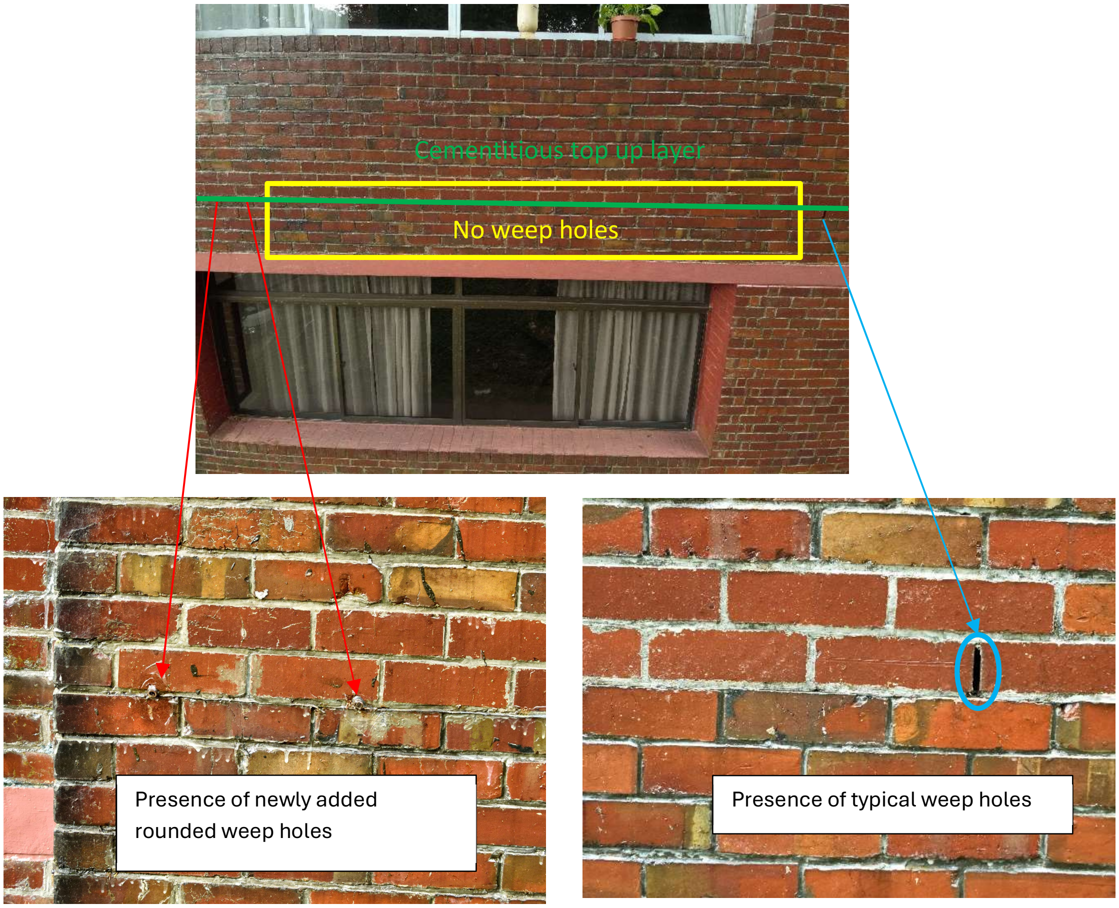



*Plate 30 – Illustration of position of weep holes and top up layer found in cavity wall*

6.5. Water spray test was next carried out to the cavity wall to simulate water ingress into the cavity. During the course of water spray test, it was observed that water was able to discharge through the latter-day added weep pipes, and through the weak/ deteriorated mortar joints across the brick walls. See Plate 31. No water was noted to be discharging from the original weep holes.

6.6. Observation from the water spray test appeared to confirm the hypothesis given under sub paragraph 6.4.3 where the weep channel was likely re-levelled. Instead of providing a smooth gradient, it is likely that a layer of cement equivalent to the thickness of a brick row were added. With the addition of this cementitious layer, the original weep holes had likely been sealed off. New weep pipes had been added to facilitate draining of water through the weep channel.

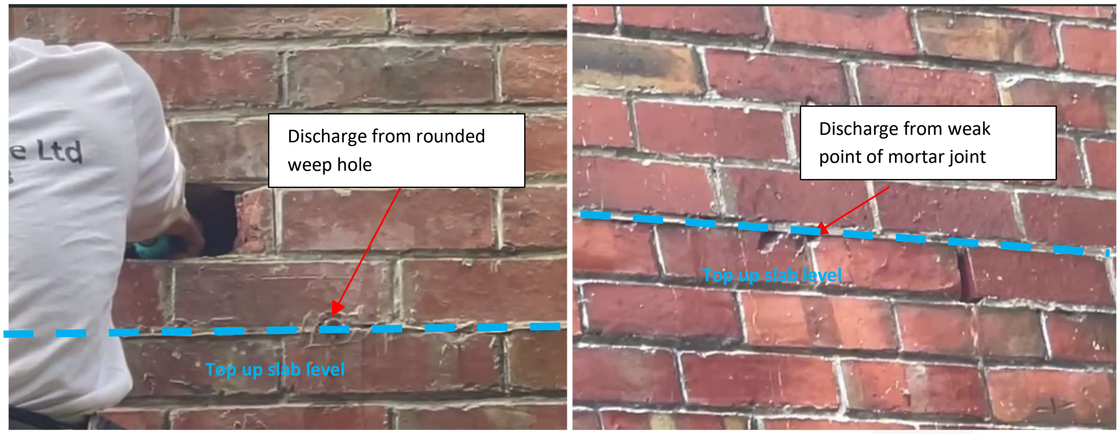



*Plate 31 – Location of discharge water on façade during water spray test*

6.7. Within one hour of spraying, infrared thermograms showed an increase in moisture distribution along the base of the wall and along the skirting. See Plate 32 and Plate 33 for thermograms showing the difference in moisture distribution before and after spray test.

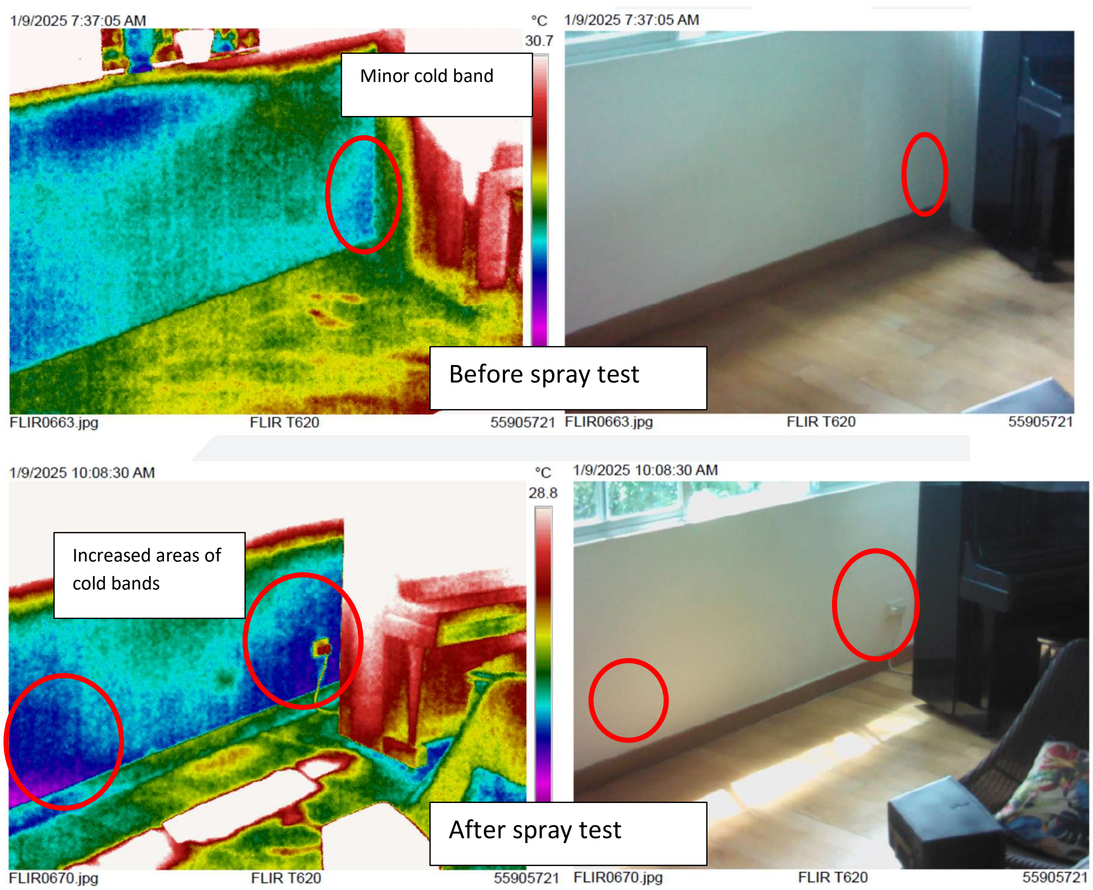



*Plate 32 – Before and after thermograms in linving room*

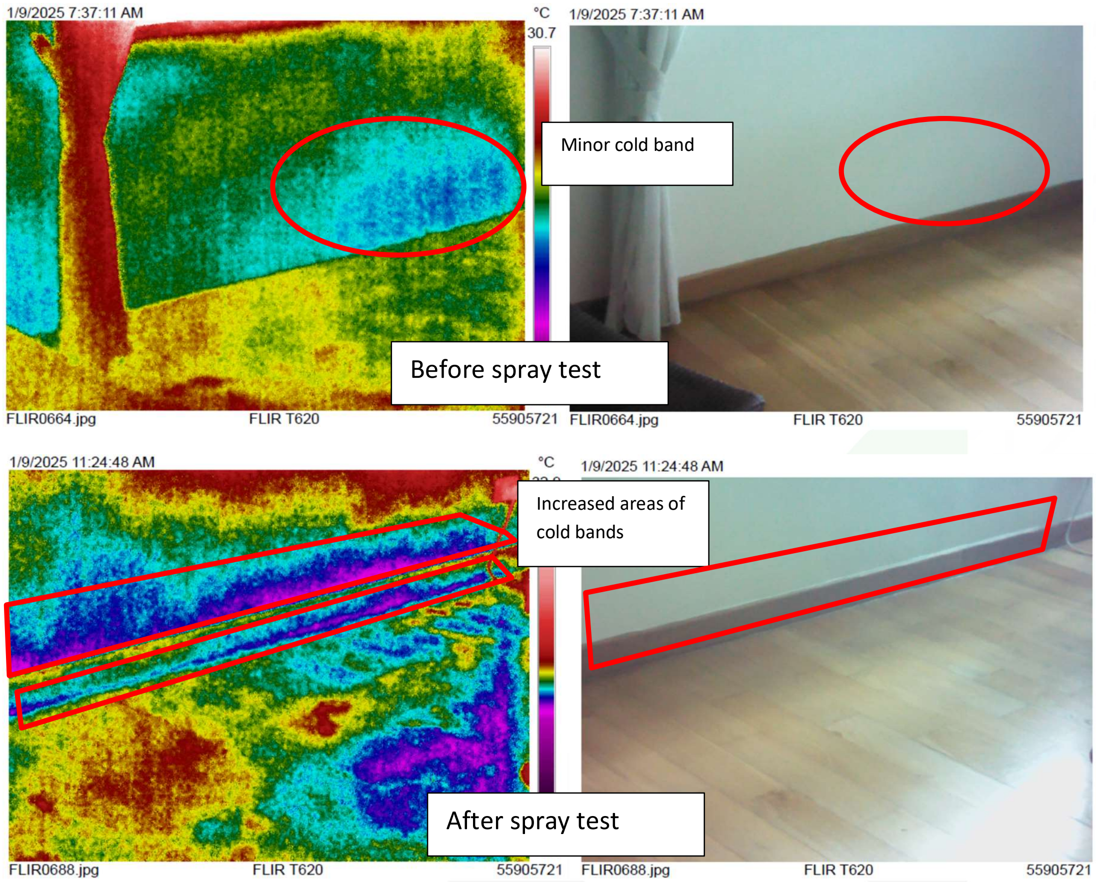



*Plate 33 – Before and after thermograms in linving room*

6.8. Results from microwave moisture tomography also showed a slight increase in moisture distribution along the living room wall. See Plate 34 for comparison of before and after microwave moisture results.

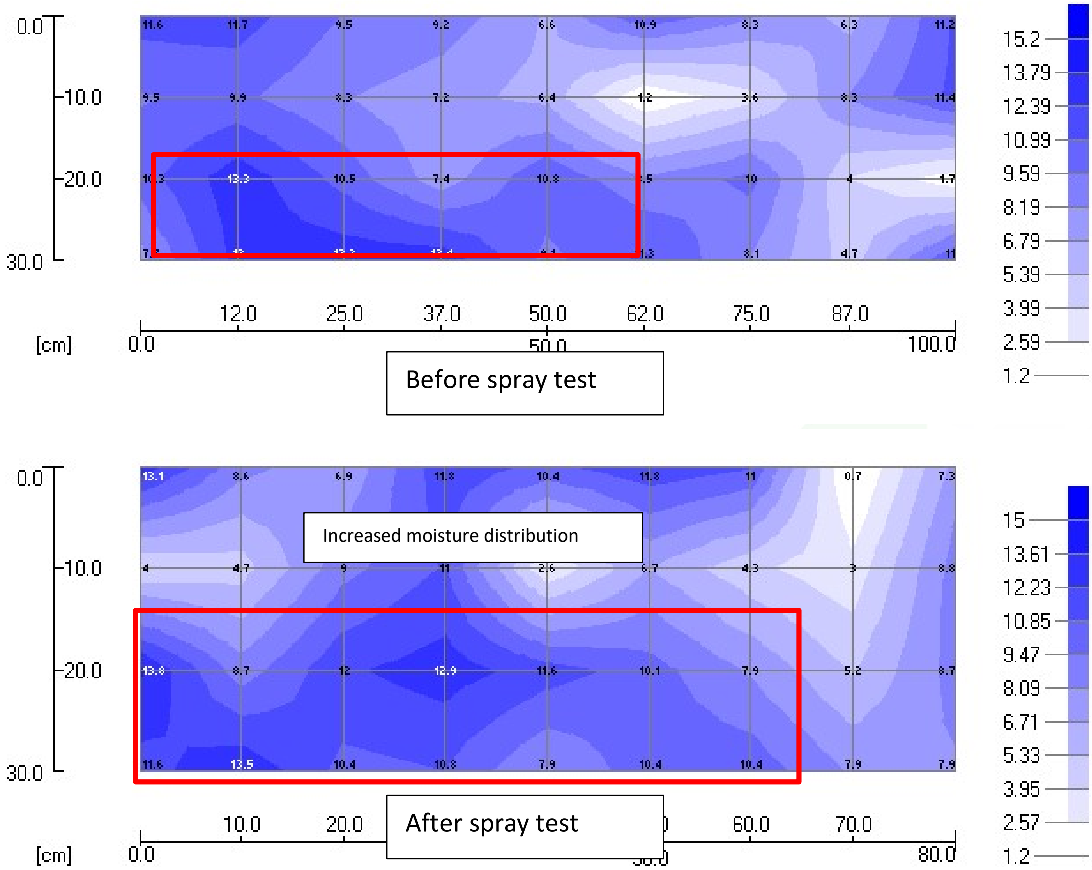



*Plate 34 – Before and after microave tomograph on wall*

6.9. **The results of the second water spray test conclusively proved our hypothesis presented under sub section 5 of this report.** During heavy rains, water is able to seep through the deteriorated brick walls/ flashing joints into the cavity wall. Any water that have seeped through into the cavity wall would be channeled towards the weep channel.

6.10. As a result of wear and tear/ deterioration of the weep channel waterproofing and likely poor levelling (inefficient discharge), water could seep through any weaknesses across the weep channel into the interior walls, or through the slab into the unit beneath, or through to the exterior wall beneath the weep channel.

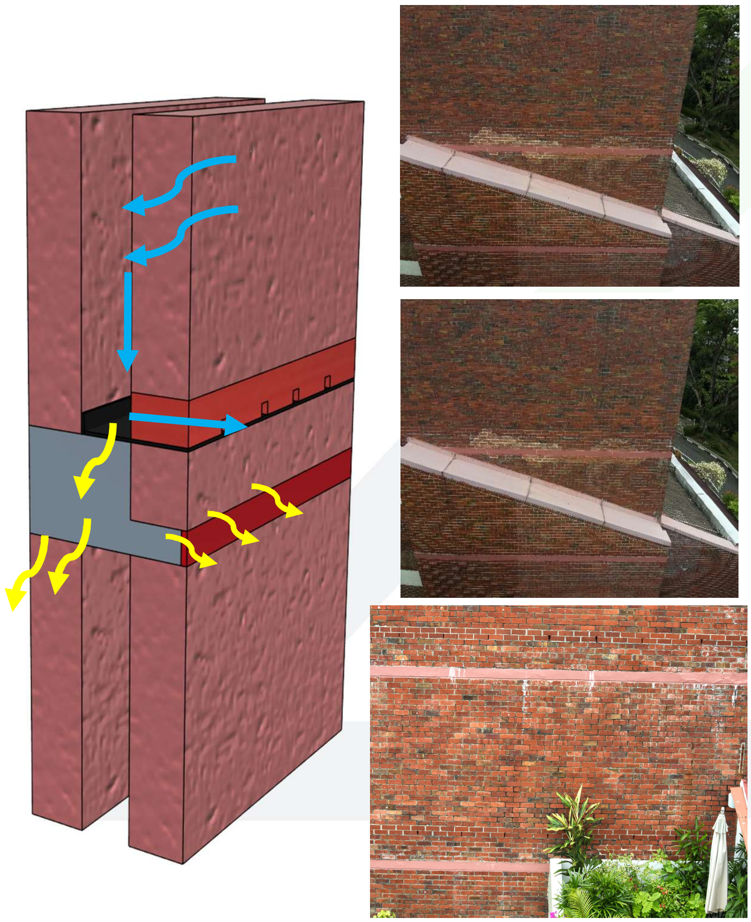


*Plate 35 – Illustration of seepage path*

7. **Conclusion**

7.1. Across the Development's gable end walls, two (2) courses of bricks above the weep channel were typically newer, well fired bricks that had been removed for repair works to the weep channels to be carried out. The extensiveness of these double course new brick layers, along with the extensive deteriorations observed beneath the weep channel strongly suggests that numerous ad hoc repair / re-waterproofing exercises had been carried out to the weep channel/ cavity wall over the years.

7.2. In fact, throughout the inspection and testing carried out, we have noted different types and approaches of repairs to the cavity wall. In some instances, the weep channel was re-levelled with new weep holes created as shown in the tactile inspection of Block B 02-20.

7.3. Nonetheless, despite these repair/ re-waterproofing works, the weep channel/ cavity wall remained particularly susceptible to recurring seepages.

7.4. Any creation of access into the weep channel for re-waterproofing/ repair works is a tedious and labour-intensive process, requiring removal of at least 2 courses of bricks above the weep channel to expose the channel for access. Even with the removal of these 2 courses of bricks, the access opening created provides limited space and manoeuvrability for the necessary works to be carried out. A typical re-waterproofing works will require proper surface preparation works including relevelling, crack repair, removal of any loose or debonded layers and etc. The limited access increases the difficulty of such works and give rise to potential workmanship issues, which would reduce the lifespan and efficacy of the waterproofing works.

7.5. Notwithstanding the observation made in 7.4, a typical liquid applied waterproofing has a lifespan of ~5 years. As such, a typical warranty for such works is 5 years or lesser. Such waterproofing works are subjected to wear and tear, and would fail over time, and the tedious process of re-waterproofing would have to be carried out repeatedly.

7.6. Given the above factors, it is recommended for the cavity wall to be sealed watertight instead of allowing water to seep through. Such works will entail application of a water-repellent coating over the existing brick walls. See the recommendation section below for more details.

7.7. In the case of other elements across the Development, as referred to the past records provided by MCST it is noted that the repair works that had been undertaken to date by the MCST-appointed contractor had been effective. It is recommended for a holistic rewaterproofing/ resealant works to be carried out across the Development to ensure water-tightness of the different elements. See the recommendation section below for more details.

## 8. Recommendations for Repair

8.1. There are a few available products in the market to ensure water-tightness of a fair-faced masonry wall. These includes an acrylic waterproofing coating similar to what is applied currently to the Development on an ad hoc basis. The second type is a silane-based nanomolecular emulsion product. It is recommended for the latter type to be used for the holistic waterproofing of the fair faced masonry wall.

8.2. A comparison of the performance of the two products is given below:

| | **Acrylic-based coating (currently used)** | **Nanomolecular emulsion product** |
|---|---|---|
| **Material** | Acrylic based | Silane based |
| **How it works** | Forms a coating over the masonry wall thus prevent water from seeping through | Penetrates into the brick capillary pores forming a micro crystalline layer within the pores, thus increasing the water repellancy of the brick layer and preventing water from seeping through |
| **Penetration into brick substrate** | NIL | Penetrates to at least 5 - 10mm deep depending on product used |
| **Breathability of the substrate following coating** | NIL | Substrate remains breathable |
| **Resistance to ultraviolet radiation** | Typically low as such a coating would degrade with UV | Typically high |
| **Efficacy** | 2-3 years (based on historic records and current observations) | Able to obtain 5 years warranty against water ingress |

8.3. It is imperative that any waterproofing treatment to the masonry wall does not reduce its' breathability as this would allow any entrapped vapour moisture to escape. Applying a non-breathable system to the masonry wall surface prevents such entrapped moisture from escaping, which may result in degradation of the coating and adhesion failure between the coating and brick substrate, similar to what is observed on site (as discussed under sub paragraph 3.25 – 3.26.

8.4. Generally, the scope of such waterproofing works to the brick wall would include:

8.4.1. Sealing of any weep holes using cementitious mortar;
8.4.2. Removal of any deteriorated pointing mortar joints and repointing with a suitable cementitious mortar;
8.4.3. Cleaning of the brick substrate by jet washing;
8.4.4. Removal of any deteriorated/ degraded/ cracked brick surface or surface coating using wire brush;
8.4.5. Waterproofing the exterior face of the cavity wall using a nano-based water repellent coating

(*Note: As an acrylic coating had previously been applied to the masonry walls, the efficacy of the penetration of the nanomolecular water repellent coating may be compromised for locations where the acrylic coating remains well bonded/adhered to the substrate. However, such a nanomolecular coating can be easily reapplied should the acrylic coating wears off)*

8.5. There are two (2) types of such nanomolecular water repellent coating available in the market – Nano Star NSC Nano Waterproofer and Warrior W4 Water Repellant. The technical data of these 2 products are appended herein for information. Both products operate in a similar manner whereby the nanomolecular coating penetrates into the brick capillary pores forming a micro crystalline layer within the pores, thus increasing the water repellancy of the brick layer and preventing water from seeping through. It is recommended for both coatings to be applied for an evaluation of the efficacy of the coating to be carried out.

8.6. The mockup of the 2 different material will be on 2 locations for evaluation. Put Bernard and Andrew unit wall. Integraal will do testing on the 2 units thereafter for further evaluation. The cost of this mock up is $4000 on each material. ***Additional non-destructive testing (infrared thermography and microwave moisture tomography) will be carried out to compare the moisture differences before and after the mockup as well.***

8.7. Apart from the brick walls, the entire Development should also be made water-tight holistically. Any such works will include:
8.7.1. Sealant/ waterproofing works to **ALL** flashing-to-flashing/ wall joints with proper upturns/ terminations;
8.7.2. Application of waterproofing to **ALL** clay roof tiles, with proper upturns/ terminations along the air vent penetrations/ flashing to tile joints;
8.7.3. Waterproofing of **ALL** RC flat roof and scupper using a torch on membrane system;
8.7.4. Waterproofing of **units'** airwell using torch on membrane system;
8.7.5. Repainting of **ALL** plastered walls with an elastomeric paint system (ss500).

8.8. The estimated costing for such a holistic repair is given below:

| Description | Costing (S$) |
|---|---|
| Application of liquid applied waterproofing to the flashing-to-flashing/ wall joints; | $120,000 |
| Application of liquid applied waterproofing to the clay roof tiles, with proper terminations along the air vent penetrations/ flashing to tile joints | |
| Waterproofing of the RC flat roof and scupper using a torch on waterproofing system | $40,000 |
| Waterproofing of the airwell (to be carried out by individual SPs) using a torch on waterproofing system | $1,000 per unit |
| Resealant works to façade perimeter window frame to wall joints using silicone sealant | $40,000 |
| Repainting of the plastered walls with an elastomeric paint system. | $220,000 |
| Waterproofing works to the brick wall (per sub paragraph 8.4) | $300,000 |
| Estimated Total (excluding works to individual SP's unit) | $720,000 |

| **Prepared by:** | **Approved by:** |
|---|---|
| Mr Lionel Foo<br>*B. Eng. (Civil & Structural Eng)*<br>*IES Certified Façade Inspector*<br>*IRT Certified Level 2*<br>Consultant | Mr Eddie Loke Jun Wei<br>*MSc. Building, B.Eng Env*<br>*Chartered Building Surveyor, MRICS*<br>*IRT Certified Level 2*<br>Senior Consultant |
| **Signature**:<br>**Date:** 25 Jan 2025 | **Signature**:<br>**Date**: 25 Jan 2025 |