

Report of Property Inspection

Engineer's Inspection Report for [REDACTED]
[REDACTED]

Prepared on Instruction from [REDACTED].



[REDACTED] Rev 1.0

09/07/2026

Document Control

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Revision/Issue	Comments	Date	Author	Approved
1.0	FINAL	09-Jul-26	WN	BJM

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Executive Summary

This expert report has been prepared by Structura Engineering Inspections at the request of Mr. [REDACTED] to provide an independent structural engineering opinion regarding the condition of the dwelling located at [REDACTED]. The purpose of this report is to assist in legal proceedings, including potential claims before the Victorian Civil and Administrative Tribunal (VCAT). The scope of the assessment includes structural integrity, weatherproofing performance, and contributing environmental factors.

Structural Defects Assessment

Mr [REDACTED] identified a total of six flagged concerns at the subject property, including:

- Damaged electrical wiring during construction;
- Missing insulation;
- Moisture ingress/leakage;
- Wall out of plumb;
- Cracking to wall surfaces; and
- Moisture-related damage to internal timber beams.

Some of the identified items relate to electrical, construction, or compliance matters and do not, in themselves, constitute structural defects.

Of the six items raised, four were considered to be structural or potentially structurally consequential, namely:

- Moisture ingress/leakage at various locations;
- Wall alignment deviation (out of plumb);
- Cracking to internal wall surfaces; and
- Moisture-related deterioration of internal timber framing members.

The **Structura Engineering Inspections Expert Report** ([REDACTED]) was commissioned to assess the structural condition of the dwelling and directly addressed all structurally relevant matters raised by Mr [REDACTED]. The assessment included a measured floor level survey, evaluation of observed movement against **AS 2870:2011 – Residential slabs and footings**, and classification of cracking in accordance with **AS 2870:2011 Appendix C**. Based on the assessment findings, the observed conditions were characterised primarily as **serviceability-related issues rather than an immediate structural safety risk**.

The Structura report also considered relevant contributing factors, including moisture ingress, drainage conditions, and environmental influences affecting moisture equilibrium around the structure. Appropriate engineering recommendations were provided, including monitoring and rectification measures where required.

Items outside the scope of a structural engineering assessment, including electrical defects and missing insulation, were not assessed as part of the report.

In summary, while Mr [REDACTED] raised a number of concerns regarding the property, the structural matters identified are limited and clearly defined. All structurally relevant issues raised have been appropriately assessed

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and addressed within the **Structura Engineering Inspections Expert Report**, which provides an independent, standards-based engineering opinion suitable for consideration in **VCAT proceedings**.

Structural Defects Site Attendance and Inspections

A physical inspection was conducted on Tuesday 02 June 2026, followed by a supplementary virtual inspection on Thursday, 24 June 2026, to evaluate ongoing issues and review new photographic and video evidence submitted by the client. The assessment was completed per the National Construction Code (Volume 2), and other applicable standards and guidelines.

Key Findings

- **Floor Structure:** Floor level measurements identified maximum slab deviations of approximately 8 mm over a 3 m span, classified as Negligible to Very Slight (Category 0–1) in accordance with AS 2870:2011 Appendix C2. The observed variation is considered within acceptable limits and does not indicate significant differential settlement.
- **Wall Structure:** Minor hairline cracks (approximately 1–2 mm wide) were observed at several internal wall locations and classified as Slight Damage (Category 2). No cracking was observed to external walls, which are considered Negligible Damage (Category 0).
- **Moisture Ingress and Timber Structure:** Active moisture ingress was observed at three locations during rainfall, with moisture staining and mould growth identified on exposed timber framing members. Further investigation is required to identify the source of water ingress and assess the condition of affected timber elements.
- **Wall Alignment:** The eastern concrete wall was observed to be out of plumb by approximately 10–15 mm from the base to ceiling level. No visible cracking, bulging, or signs of structural instability were observed at the time of inspection.

Conclusions & Recommendations

The dwelling exhibits minor structural concerns with clear evidence of defects. The identified issues are primarily associated with minor wall cracking, localised wall alignment variations, and moisture-related deterioration risks, particularly in relation to weatherproofing requirements under **NCC 2022 Volume Two, Part H1**. If left unresolved, these defects may progressively worsen and contribute to further deterioration of affected building elements.

Engage a licensed plumber to undertake leak detection and identify the source of moisture ingress. Following completion of plumbing investigations, a suitably qualified builder should undertake rectification works in accordance with the findings. Should concealed structural deterioration or timber decay be identified, further assessment by a structural engineer is recommended prior to reinstatement works.

This report includes this office's formal declaration in accordance with VCAT Practice Note PNVCAT2, a full summary of qualifications and experience, photographic evidence, and references to supporting documentation. All conclusions are made independently and in accordance with the expert's duties to the Tribunal.

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1. Expert Witness Declaration (PNVCAT2):

1.1. Qualification & Memberships:

- Master of Engineering Structures – The University of Melbourne
- Bachelor of Engineering (Civil & Water Engineering) – National University of Science and Technology, Zimbabwe
- Member of the Zimbabwe Institute of Engineers
- Member of Engineers Australia
- Member of the Association of Consulting Structural Engineers (Victoria)

1.2. Experience:

- Jan 2021 – Present: GUARDIAN Consulting - Senior Structural/Civil Engineer
- Jan-Dec 2020: BSE Consulting - Senior Structural Engineer
- Jan 2019 – Dec 2019: Infradesign Consulting Engineers - Civil/Structural Engineer & Team Leader
- July-Dec 2018: Structerre Consulting Engineers, Australia: Geelong West Office - Junior Structural Engineer
- Jan-June 2018 LGPM Process Innovation, Australia: Scoresby Office – Project Engineer/Estimator
- 2017: MB Prefab Truss and Framing, Australia: Breakwater Plant – Structural Engineer/Detailer

1.3. Professional Registrations:

- Registered Professional Engineer (Victoria), Reg # PE0002781
- VBA-Endorsed Building Engineer (Civil)

2. Declaration:

I am a professional structural engineer registered in Victoria, with nine years of experience in structural and civil design in Australia and three years of international experience.

As a consulting engineer, I have carried out all aspects of residential engineering since 2016. I have experience in the investigation of structural damage and failures and have prepared expert reports in relation to these investigations.

I have read the practice note PNVCAT2 of the Victorian Civil and Administrative Tribunal regarding expert evidence and agree to be bound by it.



Bradley Magocha MIE Aust, MACSEV

MEng (Struct), BEng (Civil)

RPENG (VIC) Senior Engineer

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3. Instructions and Issues in Dispute

We have been asked by Mr. [REDACTED] to provide an expert witness report on existing structural conditions, including assessment of immediate and long-term risks and recommendations for remedial actions.

The following table summarises the defects identified by Mr. [REDACTED]. Each defect has been reviewed and classified as structural or non-structural in nature, based on recognised engineering definitions and applicable standards. The table also identifies whether, and in what manner, the structurally relevant matters raised have been addressed within this report. This table is provided to clearly distinguish between structural issues requiring engineering assessment and non-structural matters falling outside the scope of this structural engineering opinion.

No.	Defect Identified by the owner (Mr. [REDACTED])	Classification	Addressed in our Report?	How Addressed
1	Electrical wires damage	Non-structural	No	Electrical item outside structural scope
2	Missing insulation	Non-structural	No	Compliance item outside structural scope
3	Moisture Leakage	Structural	Partially	Identified as contributing factor for moisture damage to non-treated timber internal elements
4	Wall cracks	Structural	Yes	Measured and classified under AS 2870:2011 – Residential Slabs and Footings, Appendix C, Table C1.
5	Moisture damage to internal timber beam	Structural	Yes	Assessed with reference to AS 1604.1:2012 – Specification for Preservative Treatment, Table 1.1 (Hazard Class Selection) and Appendix D, Table D1 (Hazard Classification for Timber).
6	Wall out of plum	Structural	Yes	Assessed with reference to the VBA Guide to Standards and Tolerances 2015, Section 3, Table 3.04, Item C.

This report is limited to the assessment of structural defects and damage. Non-structural issues are outside the scope of this report and have not been assessed.

4. Inspection and Evidence Relied Upon

4.1. Scope of Inspection

This report presents the findings of the inspection undertaken at the existing property at [REDACTED] by the author Structura Engineering Inspections on 02/06/2026, as well as the virtual inspection undertaken on 24/06/2026. The report highlights issues within the structure, categorises these issues based on risk assessment criteria, and provides recommendations on how to resolve/monitor compliance issues or increase building and general safety.

4.2. Inspection Methodology

Structura Engineering Inspections undertook the assessment through a combination of desktop review and a visual, non-invasive site inspection. The inspection included a physical examination of the accessible structural elements, photographic documentation of observed defects, and an engineering assessment of the building's structural condition.

Where relevant, the observed conditions were assessed with reference to applicable Australian Standards and recognised industry guidance. These references were used to support the engineering assessment and classification of observed defects and were considered alongside site observations and professional engineering judgement. The following documents were referenced where applicable:

- **AS 2870:2011 – Residential Slabs and Footings**, Appendix C, Table C1 (Wall Damage Classification).
- **AS 2870:2011 – Residential Slabs and Footings**, Appendix C, Table C2 (Concrete Floor Damage Classification).
- **AS 1604.1:2012 – Specification for Preservative Treatment**, Table 1.1 (Hazard Class Selection) and Appendix D, Table D1 (Hazard Classification for Timber).
- **VBA Guide to Standards and Tolerances (2015)**, Section 3.04, Table 3.04 (Tolerances in Masonry Construction).

The site inspection was conducted on **02 June 2026 at 11:00 AM**, with the client in attendance. Additional photographs and information provided by the client were also reviewed where relevant to assist the engineering assessment.

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5. Inspection Findings

5.1. Floor Structure

5.1.1. Upper Floor Structure

- Floor level discrepancies of approximately **6 mm** over a 3 m span were recorded at the centre of the upper floor.
- Total deviation across the entire upper floor footprint measuring up to 15 mm.

5.1.2. Ground Floor Structure

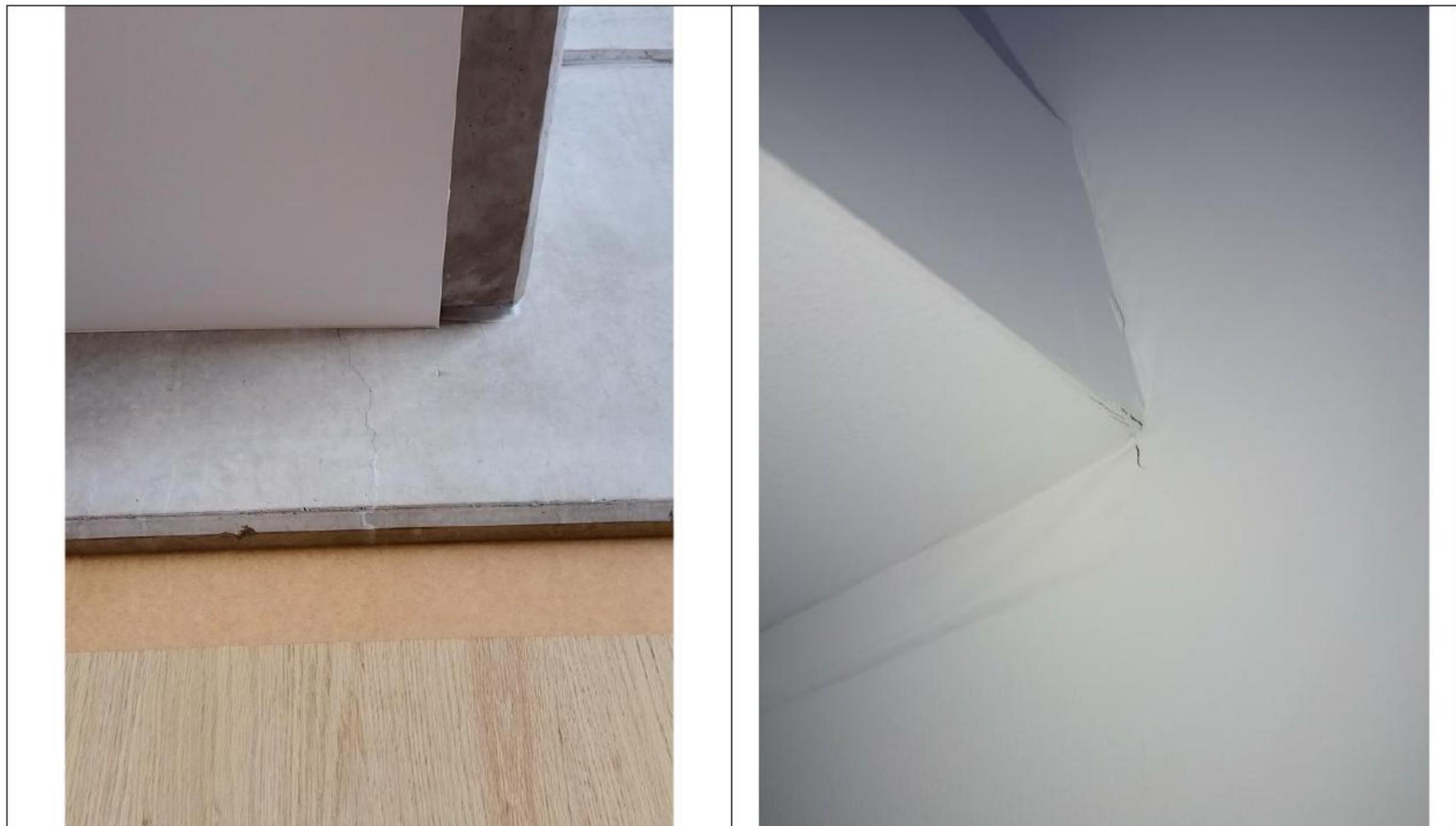
- A level variation of approximately **8 mm** per 3-meter span was recorded within the ground floor.
- Across the entire building footprint, the total floor level deviation measured up to **19 mm**.

Refer to Section 6 for recommendations and Appendix A for the photo log.

5.2. Wall Structure

5.2.1. Internal Wall Structure

A few cracks approximately 1-2 mm were observed on the wall surface at the office areas and the kitchen areas.



Refer to Section 6 for recommendations and Appendix A for the photo log.

5.2.2. External Wall Structure

No crack was observed on the external wall surface of the property at the time of inspection.

Refer to Section 6 for recommendations and Appendix A for the photo log.

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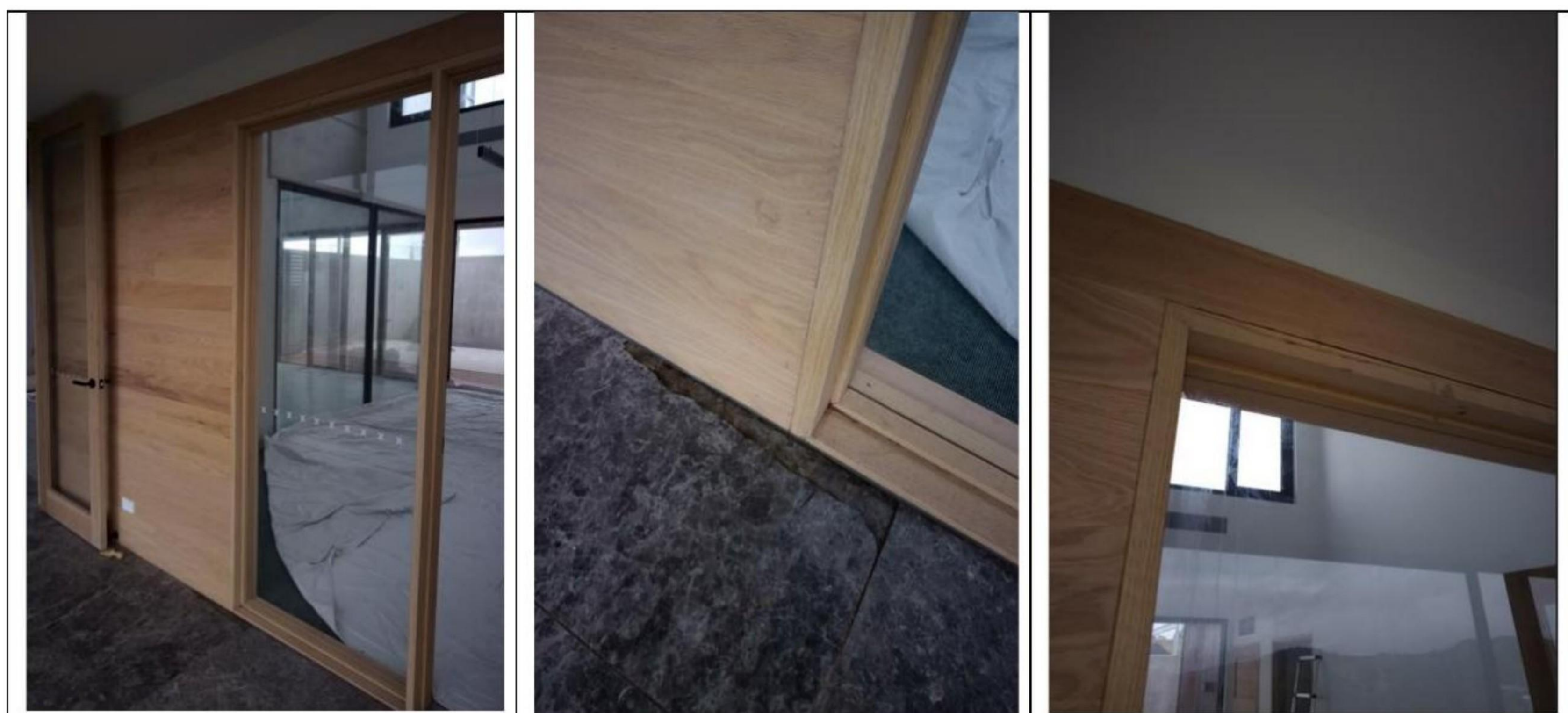
5.3. Moisture ingress/leakage

Moisture ingress was observed at three locations within the property. Evidence of moisture leakage was identified at the front of the office area, within the office, and at the side entrance.

- Inside of the home-office area:

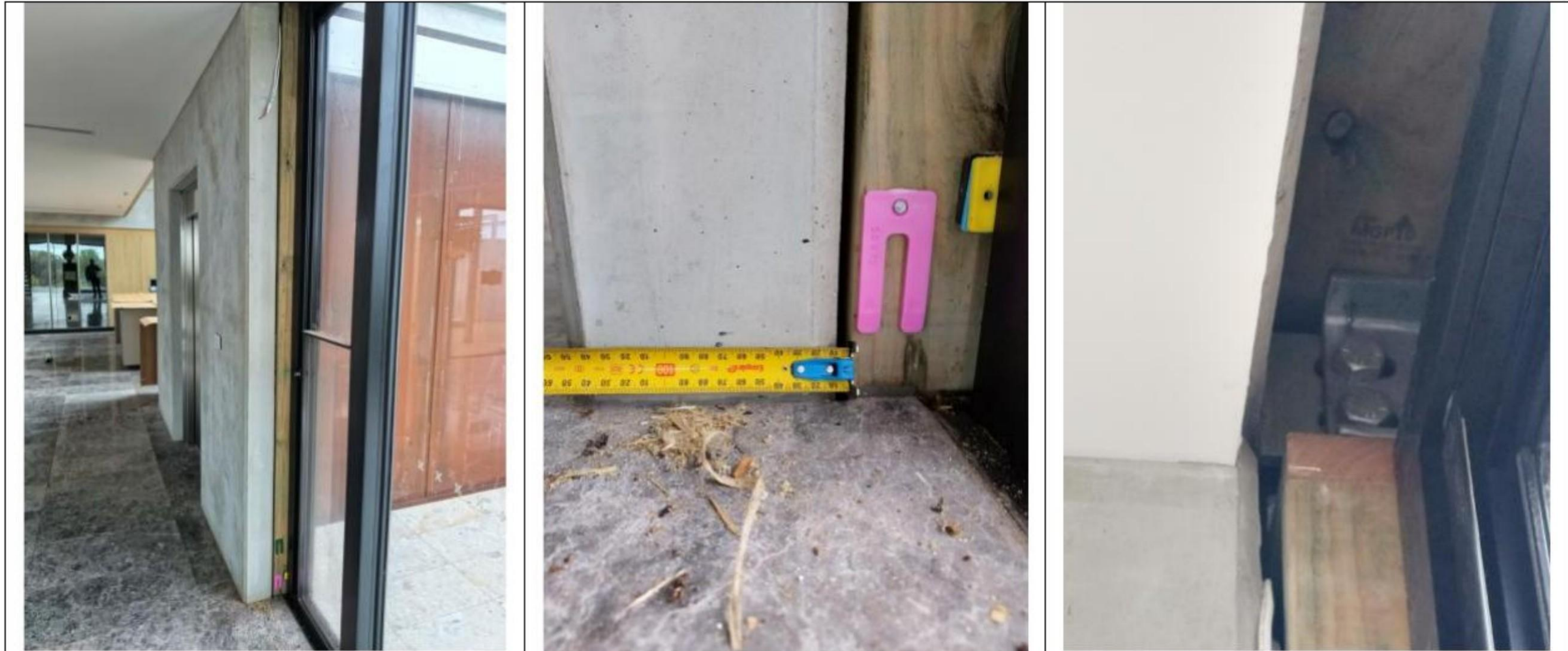


- Outside of the home-office area:



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- Side entrance of the property:



Refer to section 6 for recommendations and Appendix A for photo log.

5.4. Moisture Damage to Timber Structure

The timber framing at the entrance to the office area had been partially removed to facilitate inspection. Evidence of mould growth was observed on the exposed timber members. At the time of inspection, it could not be confirmed whether the timber had been treated for resistance to moisture exposure.



5.5. Wall Out of Plumb

The concrete wall located on the West side of the property show sign of leaning and out of plumbs approximately 10mm from the bottom to top.



Refer to Section 6 for recommendations and Appendix A for the photo log.

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6. Discussion & Recommendations

Responses to the brief provided by the client have been listed below:

The consultant has reviewed the property in accordance with AS 1604.1:2012 Specification for preservative treatment, AS 2870:2011 Residential Slabs and Footings, the VBA Guide to Standards and Tolerances (2015), and the National Construction Code (NCC) 2022, Volume Two.

The observed conditions are considered serviceability-related and do not present an immediate structural danger.

However, maintenance and remediation are required to prevent future deterioration.

1. Overall Structural Assessment

Based on the risk criteria and the evaluation tools provided in the Australian Standards and NCC 2022, the structure shows slight structural distortion with a few compliance issue that need to be rectify.

While the building remains structurally stable, existing defects has affected the following performance requirements under the NCC 2022 Volume Two, Part H1:

- H1D1 Structural robustness: Localised slab movement and wall cracking indicate reduced uniformity of support.
- H1D2 Weatherproofing and surface water management: Inadequate site drainage and tree influence have affected moisture equilibrium around footings.

2. Floor Structure:

In accordance with AS 2870—Residential slabs and footings (2011), Section 2 – table C2: Classification of damage with reference to concrete floors (Appendix D).

Measured site data indicated deviations of **maximum 8 mm per 3 meters**, classifying the slab distortion as **Negligible to Very Slight (Category 0-1)** under AS 2870 Appendix C2.

This variation within acceptable tolerance and does not represent significant differential settlement.

Recommended Action:

No urgent action is currently required, as the observed defects are considered Negligible to Very Slight.

3. Wall Structure:

- Internal Wall Structure

Hairline cracks (1–2 mm wide) were observed on the internal wall surface at a few different locations mentioned above.

In accordance with AS 2870:2011, the observed wall damage is classified as **Slight (Category 2)** for the external elements.

Recommended Action:

Routine monitoring and cosmetic repairs are sufficient unless the existing cracks widen or new cracks develop. Cosmetic repairs should be undertaken only after the leakage has been rectified to minimise the likelihood of the defects reappearing.

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- External Wall Structure:

No cracks were observed at the time of the inspection.

In accordance with AS 2870:2011, the observed wall damage is classified as **Negligible (Category 0)** for the external elements.

Recommended Action:

No urgent action is required as the observed wall damage is Negligible.

4. Moisture Ingress, Moisture Damage to Internal Timber Structures.

The active moisture ingress was observed at three separate locations throughout the building during rainfall. The pattern of moisture staining and leakage indicates that the source is likely associated with the roof structure above. In addition, mould growth was observed on one of the exposed timber framing members, indicating prolonged exposure to moisture.

At the time of inspection, it could not be confirmed whether the affected timber members had been preservative-treated. Reference to **AS 1604.1:2012 – Specification for Preservative Treatment** may assist in identifying the required hazard class (e.g. H1, H2 or H3) for the timber and determining whether the installed material is suitable for its service environment.

Recommended Action:

- Engage a suitably qualified roofing contractor to inspect the roof structure, identify the source of the moisture ingress, and undertake the necessary rectification works to eliminate the leak in accordance with the relevant Australian Standards and the manufacturer's installation requirements.
- Once the leak has been rectified and the affected area has dried, inspect the damaged timber members to determine the timber type and whether preservative treatment has been applied.
- If the affected timber is untreated and has sustained moisture-related deterioration, replace the damaged timber members on a like-for-like basis to restore the structural integrity and intended load-carrying capacity of the affected framing.
- If the timber is preservative-treated (e.g. H2 or higher), assess whether the mould is limited to surface growth or whether prolonged moisture exposure has resulted in fungal decay or loss of structural integrity. Replace any timber members that are found to have significant decay or compromised structural capacity.

5. Wall out of Plumb

The concrete wall located on the eastern side of the property was observed to be out of plumb by approximately 10–15 mm, measured from the base of the wall to the ceiling level at the ground floor. The original structural documentation was not available at the time of inspection to confirm whether the wall is reinforced concrete or unreinforced masonry.

If the wall is reinforced concrete, the acceptable alignment and performance should be assessed against the original structural design documentation and engineering specifications. If the wall is unreinforced masonry, the measured out-of-plumb condition has been compared with the construction tolerances provided in the VBA Guide to Standards and Tolerances (2015), Section 3.04 – Tolerances in Masonry Construction, Item C, as

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reference guidance only. This guide specifies a maximum horizontal deviation of 10 mm over a 3 m height for structural masonry walls during construction.

No cracking or bulging were observed on the wall surface at the time of inspection.

Recommended Action:

Continue to monitor the wall for 12 months to identify any increase in out-of-plumb, cracking, or other signs of movement. If further movement is observed, engage a structural engineer to investigate the underlying cause and determine whether foundation stabilisation, additional structural restraint, or masonry rectification works are required.

6. Limitation

This investigation was limited to a visual non-invasive inspection only. No destructive, invasive or intrusive investigations were undertaken unless otherwise stated. Concealed structural elements, finishes and services were not inspected and may contain defects not apparent at the time of inspection.

Important Note: All necessary and appropriate safety precautions must also be achieved to ensure health and safety requirements have not been compromised.

It should be noted that the findings of this report are based on the information referenced and available during this investigation and may differ if further previously undisclosed material evident.

If you have any further queries, or wish to discuss these matters further, please do not hesitate to contact this office.

Summary of Recommendations

Based on the inspections, Structura Engineering Inspections recommends the following actions:

- **Floor Structure**
No structural rectification is required at this stage. Continue normal occupancy and monitor the floor for any increase in differential movement or distortion.
- **Internal Wall Structure**
Continue routine monitoring of the observed hairline cracking. Cosmetic repairs may be undertaken as required. Seek further structural assessment if cracks widen, develop into step-cracking, or additional movement is observed.
- **External Wall Structure**
No structural rectification is required. Continue normal maintenance and monitor for any future cracking or signs of movement.
- **Moisture Ingress and Timber Framing**

Engage a suitably qualified roofing contractor to identify and rectify the source of the roof leakage.

Following rectification and drying of the affected areas, inspect the damaged timber members to determine the timber type, preservative treatment, and extent of any moisture-related deterioration.

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Replace any untreated timber members that have sustained moisture-related damage on a like-for-like basis to restore their structural integrity.

Where preservative-treated timber is present, assess whether deterioration is limited to surface mould or has progressed to fungal decay, and replace any timber members with compromised structural capacity.

- **Wall Out of Plumb**

Continue to monitor the wall for any increase in out-of-plumb, cracking, bulging, or other signs of movement.

If further movement is observed, engage a structural engineer to investigate the cause and determine whether foundation stabilisation, additional structural restraint, or masonry rectification works are required.

These recommendations are provided independently, in accordance with the author's duty under VCAT Practice Note PNVCAT2 (Victorian Civil and Administrative Tribunal, 2022), and reflect observed conditions as of July 2025.

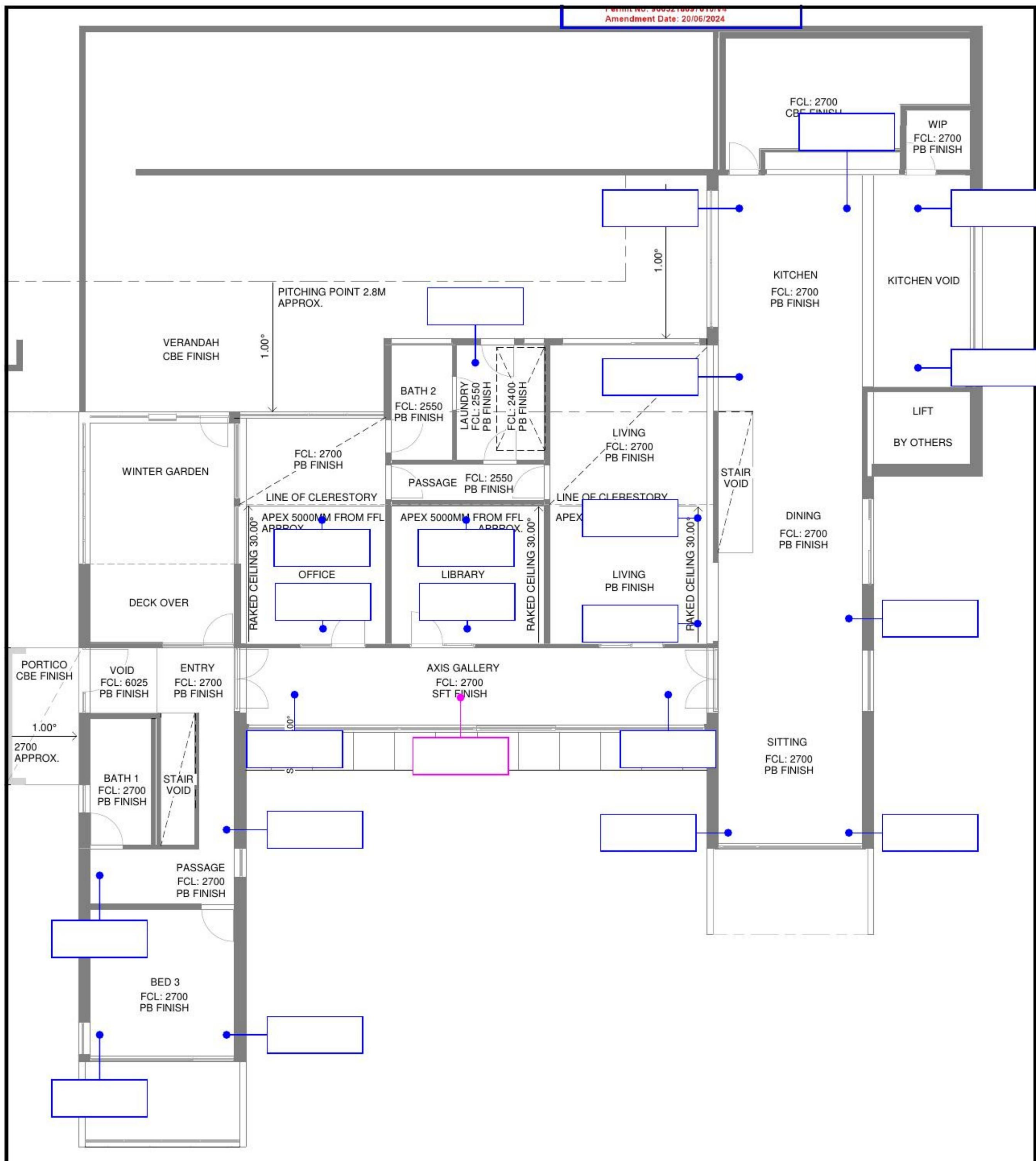
7. References

- Australian Building Codes Board, 2022. *National Construction Code Volume 2 – Housing Provisions*. 2022 ed. Canberra: Australian Building Codes Board.
- CSIRO, 2011. *Foundation Maintenance and Footing Performance: A Homeowner's Guide*, s.l.: CSIRO.
- Parliament of Victoria, 2023. *Water Act 1989 (Vic)*. Authorised Reprint – Current Consolidated Version ed. Melbourne: Victorian Government Printer.
- Standards Australia, 2011. *Australian Standard 2870: Residential slabs and footings*. Sydney: SAI Global.
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- Victorian Building Authority, 2015. *Guide to Standards and Tolerances*. 2015 ed. Melbourne: Victorian Building Authority.
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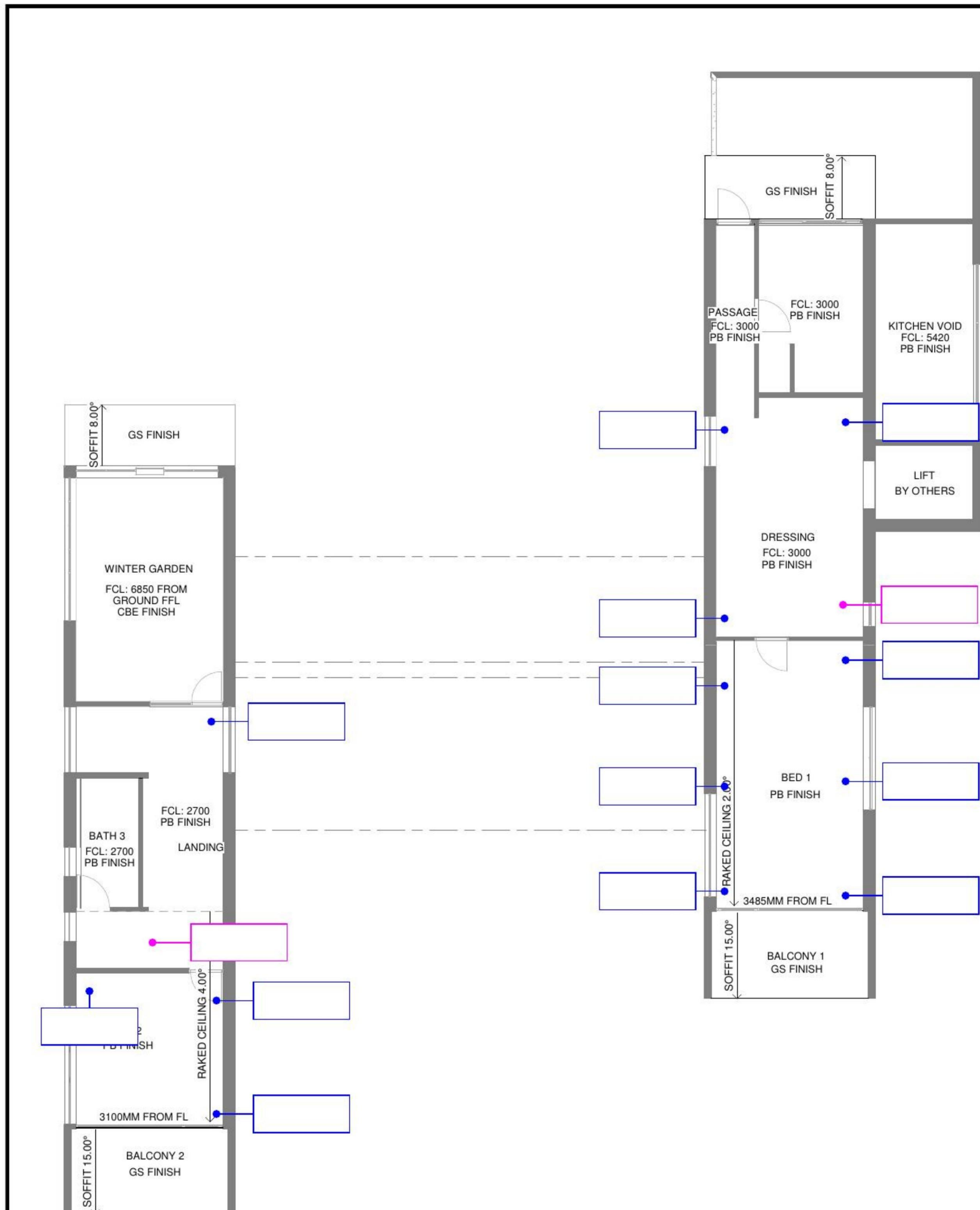
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8. Appendix A: Floor Level Survey of the Building

- First Floor:



- Second floor:



9. Appendix B: Classification of damage due to foundation movements concerning walls. (AS2870-2011 Appendix C, Table C1).

AS 2870—2011

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APPENDIX C

CLASSIFICATION OF DAMAGE DUE TO FOUNDATION MOVEMENTS

(Normative)

Classification of damage with reference to wall is given in Table C1. Classification of damage with reference to concrete floors is given in Table C2.

TABLE C1

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 1)	Damage category
Hairline cracks	<0.1 mm	0 Negligible
Fine cracks that do not need repair	<1 mm	1 Very slight
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2 Slight
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weather tightness often impaired	5 mm to 15 mm (or a number of cracks 3 mm or more in one group)	3 Moderate
Extensive repair work involving breaking out and replacing sections of walls, especially over doors and windows. Window frames and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15 mm to 25 mm but also depends on number of cracks	4 Severe

NOTES:

- Where the cracking occurs in easily repaired plasterboard or similar clad-framed partitions, the crack width limits may be increased by 50% for each damage category.
- Crack width is the main factor by which damage to walls is categorized. The width may be supplemented by other factors, including serviceability, in assessing category of damage.
- In assessing the degree of damage, account shall be taken of the location in the building or structure where it occurs, and also of the function of the building or structure.

10. Appendix C: Classification of damage due to foundation movements concerning concrete floor.
(AS2870-2011 Appendix C, Table C2).

TABLE C2
CLASSIFICATION OF DAMAGE WITH REFERENCE TO CONCRETE FLOORS

Description of typical damage	Approx. crack width limit in floor	Change in offset from a 3 m straightedge centred over defect (see Note 1)	Damage category
Hairline cracks, insignificant movement of slab from level	<0.3 mm	<8 mm	0 Negligible
Fine but noticeable cracks. Slab reasonably level	<1.0 mm	<10 mm	1 Very slight
Distinct cracks. Slab noticeably curved or changed in level	<2.0 mm	<15 mm	2 Slight
Wide cracks. Obvious curvature or change in level	2 mm to 4 mm	15 mm to 25 mm	3 Moderate
Gaps in slab. Disturbing curvature or change in level	4 mm to 10 mm	>25 mm	4 Severe

NOTES:

- 1 The straightedge is centred over the defect, usually, and supported at its ends by equal height spacers. The change in offset is then measured relative to this straightedge, which is not necessarily horizontal.
- 2 Local deviation of slope, from the horizontal or vertical, of more than 1:100 will normally be clearly visible. Overall deviations in excess of 1:150 is undesirable.
- 3 Account should be taken of the past history of damage in order to assess whether it is stable or likely to increase.

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2.07 Finished floor levels

Finished floor levels (FFL) or reduced levels (RL) are defective where they do not comply with specified planning and/or building permit requirements.

In other cases, FFL or RL are defective where:

- a) they depart from the documented RL or FFL by more than 40 mm; or
- b) floors are documented to be on the same plane but are constructed on different planes; or
- c) the building work is an extension or addition and new floor levels do not match the existing building floor levels. Also refer to Item I of this Guide.

2.08 Levelness of concrete floors

Except where documented otherwise, new floors are defective if within the first 24 months of handover they differ in level by more than 10 mm in any room or area, or more than 4 mm in any 2 m length. The overall deviation of floor level to the entire building footprint shall not exceed 20 mm. Refer to Item I of this Guide where the new floor is to abut an existing floor.

2.09 Dimensions of building elements

Deviations from the documented height or cross-sectional dimension of building elements such as beams and posts are defective if they exceed $L/200$ where L is the documented dimension or 5 mm, whichever is the greater.

12. Appendix E: Hazard Class Selection for Timber (AS1604.1-2012 Section 1, Table 1.1).

AS 1604.1—2012

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The specific requirements for preservative penetration and retention, appropriate to each of the hazard classifications, are set out in Sections 2 to 7 inclusive.

TABLE 1.1
HAZARD CLASS SELECTION

Hazard class	Exposure	Specific service conditions	Biological hazard	Typical uses
H1	Inside, above ground	Completely protected from the weather and well ventilated, and protected from termites	Lyctid borers	Susceptible framing, flooring, furniture, interior joinery
H2	Inside, above ground	Protected from wetting. Nil leaching	Borers and termites	Framing, flooring, and similar, used in dry situations
H3	Outside, above ground	Subject to periodic moderate wetting and leaching	Moderate decay, borers and termites	Weatherboard, fascia, pergolas (above ground), window joinery, framing and decking
H4	Outside, in-ground	Subject to severe wetting and leaching	Severe decay, borers and termites	Fence posts, garden wall less than 1 m high, greenhouses, pergolas (in ground) and landscaping timbers
H5	Outside, in ground contact with or in fresh water	Subject to extreme wetting and leaching and/or where the critical use requires a higher degree of protection	Very severe decay, borers and termites	Retaining walls, piling, house stumps, building poles, cooling tower fill
H6	Marine waters	Subject to prolonged immersion in sea water	Marine wood borers and decay	Boat hulls, marine piles, jetty cross-bracing, landing steps, and similar

NOTES:

- 1 Typical uses given in this Table are not exhaustive. Reference should be made to Table D1 in Appendix D.
- 2 The attention of specifiers and users of treated timber in a marine situation is especially drawn to the Notes of Clause 7.1.
- 3 Specifiers should nominate the minimum hazard class level appropriate to the specific exposure and service conditions.

APPENDIX D
GUIDE TO HAZARD CLASSIFICATIONS FOR VARIOUS END USE
APPLICATIONS

(Informative)

TABLE D1
HAZARD CLASSIFICATION

Timber product application		Hazard class
Battens	Interior	H1, H2, H2 F
	Exterior—Structural	H3
	Exterior—Non-structural	H3, H3 A
Beams laminated interior		H1, H2
Beams laminated exterior, and interior high risk		H3
Boat building—Decks and superstructure		H4
Boat hull		H6
Cattle grid		H5
Cladding		H3, H3 A
Compost bin		H3, H4
Containers—Plants		H4
Cooling tower	Structure	H5
	Fill	H5
Crib walling and structural retaining wall		H5
Decking	Bridge	H5
	Wharf	H5
	Jetty	H4
	Patio (see Note)	H3
Drain linings		H5
Droppers—Fence		H3, H3 A
Fascia board		H3, H3 A
Fence	Palings	H3, H3 A
	Fence rails	H3
Flooring—Interior		H1, H2
Framing—Interior	Components of engineering products	H1, H2, H2 F
	Lintels	
	Noggins	
	Roof trusses/beams	
	Studs	
	Subfloor	
	Top and bottom plates	
Furniture—Garden (see Note)		H3, H3 A

13. Appendix F: Tolerances in Masonry Construction (VBA Guide to Standards and Tolerances – 2015, Section 3.04, Table 3.04).

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CHAPTER

TABLE 3.04 TOLERANCES IN MASONRY CONSTRUCTION

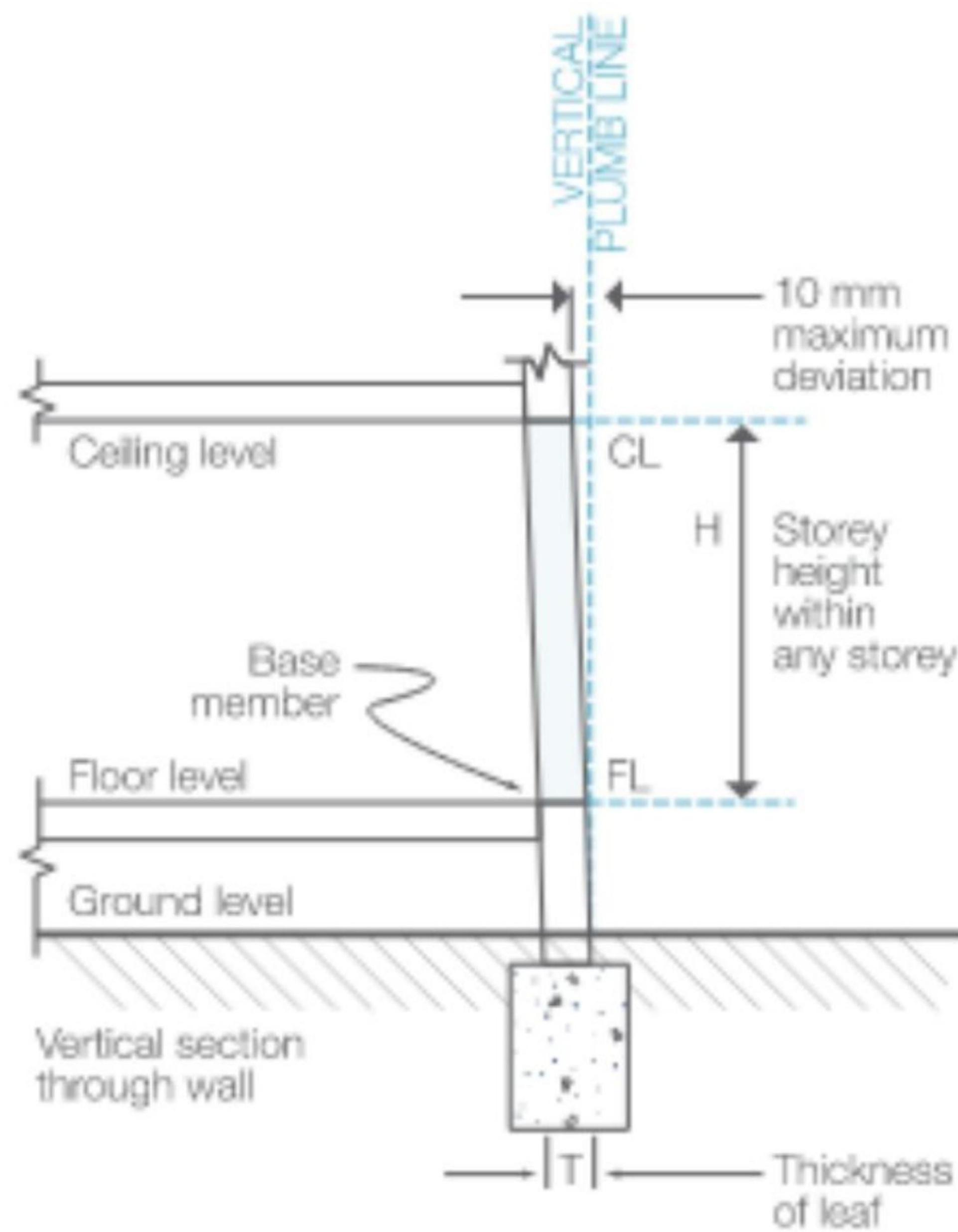
Item	Column 1 (Structural tolerance)	Column 2 (Non-structural tolerance)	Reference
A Horizontal position of any masonry element documented or shown in plan at its base or at each storey level	15 mm	15 mm	Diagram 3.04(A) Do not exceed set out tolerances in clause 2.03
B Relative displacement between loadbearing walls in adjacent stories intended to be in vertical alignment	10 mm	10 mm	Diagram 3.04(B)
C Maximum deviation from plumb within a storey from a vertical line through the base of the member	The lesser of 10 mm per 3 m of height or 0.05 times the thickness of the leaf	10 mm	Diagram 3.04(C)
D Maximum deviation from plumb in total height of the building (from the base)	25 mm	25 mm	Diagram 3.04(D)
E Maximum horizontal or vertical deviation of a surface from a plane surface (bow) in any 2 m length	5 mm	3 mm	Diagram E(ii) and E(v) From page 13
F Deviation (step) of any exposed masonry surface from any adjacent exposed masonry surface. The bow provision of Item E above also applies	Not applicable	2 mm	Diagram 3.04(D)
G Deviation of bed joint from horizontal, or from the level documented or shown in elevation	10 mm in any 10 m length, 15 mm in total	10 mm in any 10 m length, 15 mm in total	Diagram 3.04(G)
H Deviation from documented thickness of bed joint	3 mm	3 mm	Diagram 3.04(H)
I Minimum perpend thickness	5 mm	5 mm	Diagram 3.04(I, J)
J Deviation from documented thickness of perpend	10 mm maximum	5 mm	Diagram 3.04(I, J)
K Maximum difference in perpend thickness in any wall	No limit	8 mm	Diagram 3.04(I, J)
L Deviation from documented width of cavity minimum width as required by the Building Code of Australia	15 mm	15 mm	Diagram 3.04(L)

Taken from AS 3700 – Masonry structures, Table 12.1: Tolerances in masonry construction. Reproduced with permission from SAI Global Ltd under Licence 1407-c122.

Notes to Table 3.04

- Items H, I, J and K are not applicable to thin-bed mortar joints.
- Items I and J tolerances are not applicable when perpend joints are not filled with mortar as is the case with some horizontally cored masonry that is not required to resist horizontal bending.
- Items E, F and I only apply to the true, fair or finish face of single skin masonry.
- For structural tolerances in masonry refer to the Building Code of Australia.
- The tolerances within the table apply to each separate masonry panel face.
- The nominal size of mortar joints is to be 10 mm unless specified otherwise.

MASONRY



Formula:

Maximum deviation from plumb within any storey

Structural lesser of $\pm \left(\frac{10H}{3} \right)$ or $\pm 0.05T$

H measured in m

T measured in mm

For example if a storey height,
H= 4000 mm and leaf thickness,
T= 190 mm. Tolerance is the lesser of
 $10 \times 4.0 \div 3 = 13.3$ mm or $0.05 \times 190 = 9.5$ mm
ie. 9.5 mm

C

14. Appendix G: Foundation Maintenance and Footing Performance: A Homeowner's Guide

Foundation Maintenance and Footing Performance: A Homeowner's Guide



PUBLISHING
BTF 18-2011
replaces
Information
Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870-2011, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume, particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.

In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites, which may experience only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes
H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes
E	Extremely reactive sites, which may experience extreme ground movement from moisture changes

Notes

1. Where controlled fill has been used, the site may be classified A to E according to the type of fill used.
2. Filled sites. Class P is used for sites which include soft fills, such as clay or silt or loose sands; landslide; mine subsidence; collapsing soils; soil subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise.
3. Where deep-seated moisture changes exist on sites at depths of 3 m or greater, further classification is needed for Classes M to E (M-D, H1-D, H2-D and E-D).

Tree root growth

Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation

Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpend).

Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay

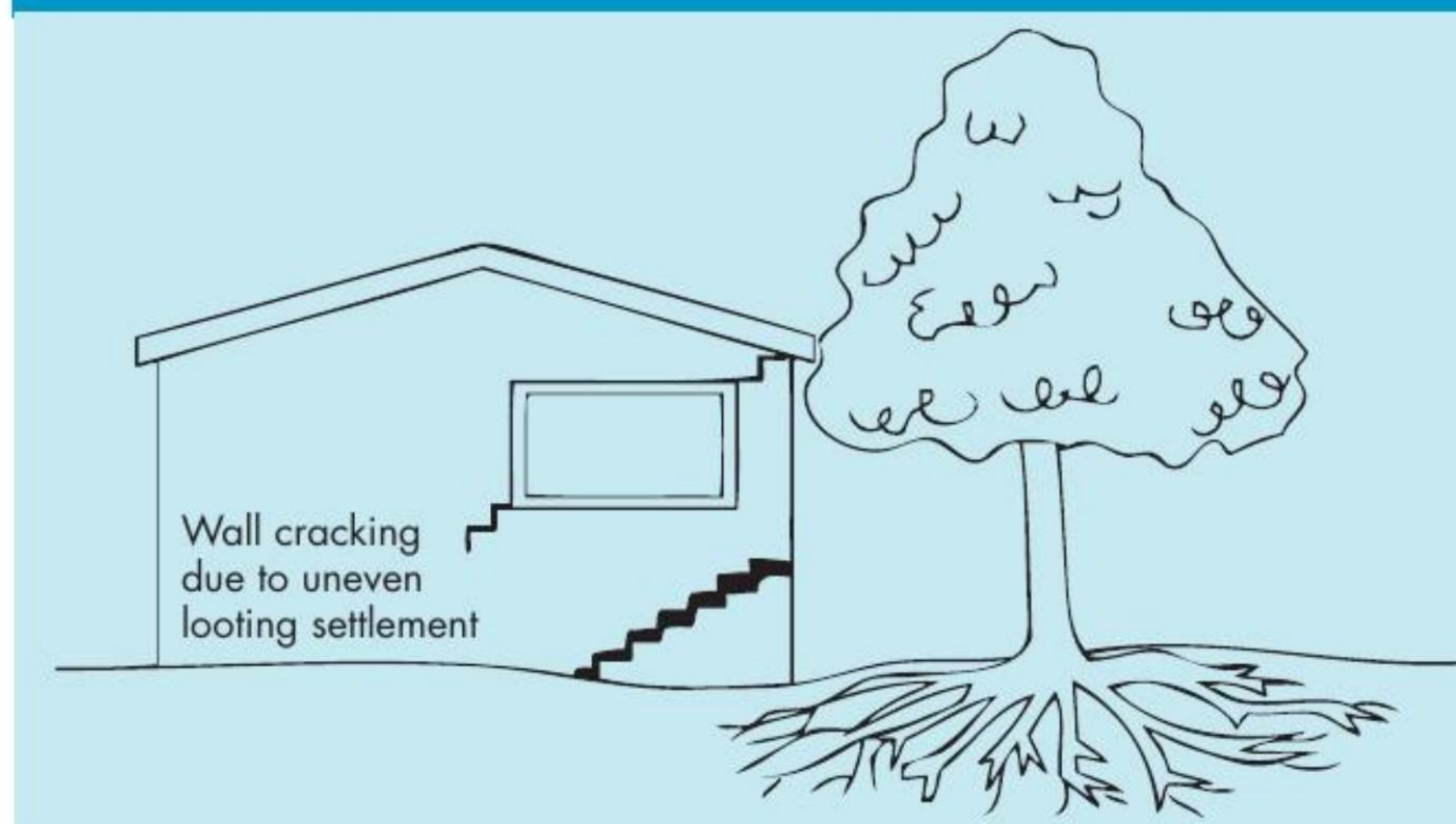
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the

Trees can cause shrinkage and damage



external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots

In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself

Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures

Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures

Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation causes a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures

Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem. Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.

- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870-2011.

AS 2870-2011 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing

Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage

In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

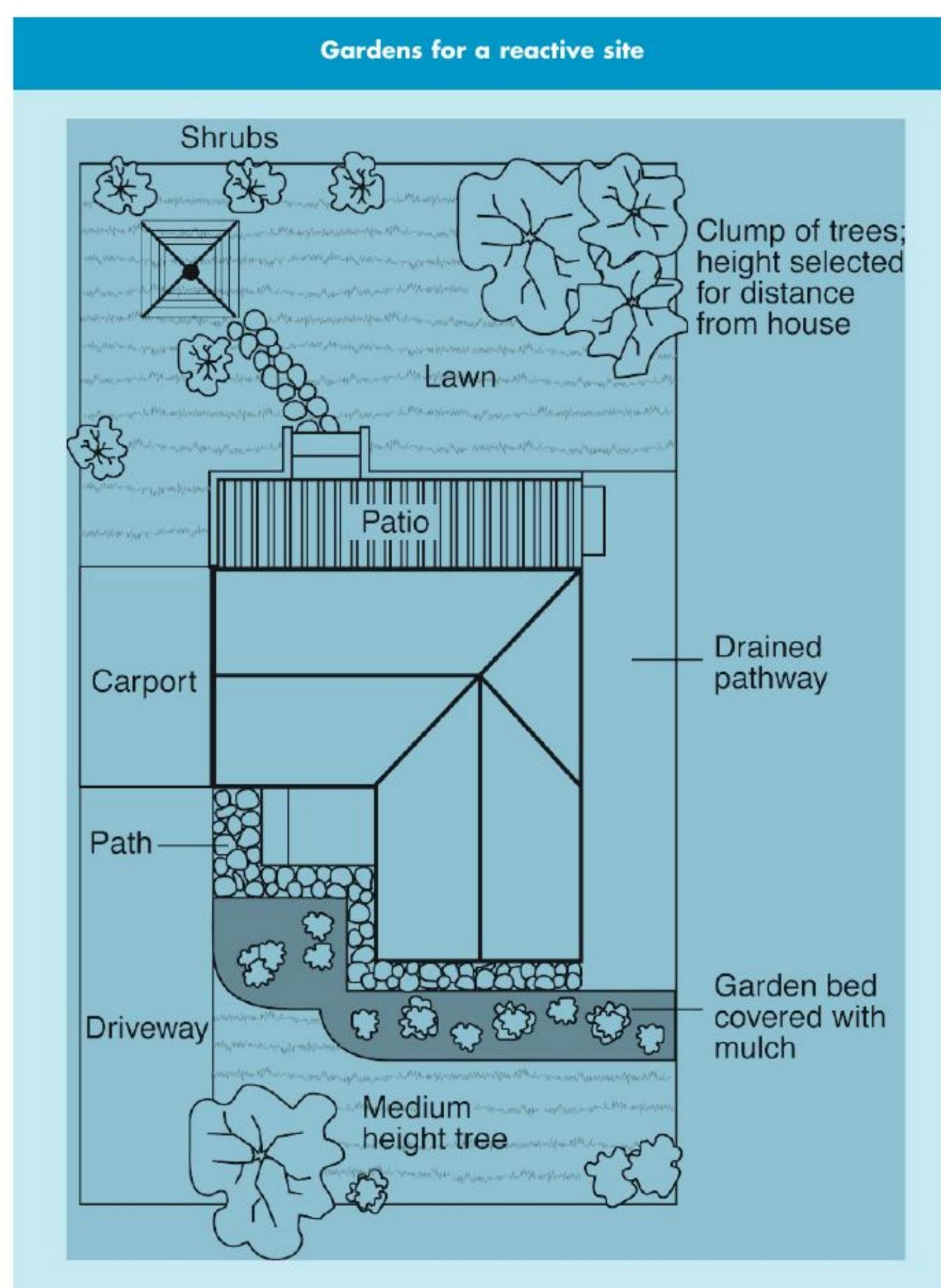
Protection of the building perimeter

It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving should

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly.	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired.	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted.	15–25 mm but also depends on number of cracks	4



extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

The information in this and other issues in the series was derived from various sources and was believed to be correct when published.

The information is advisory. It is provided in good faith and not claimed to be an exhaustive treatment of the relevant subject.

Further professional advice needs to be obtained before taking any action based on the information provided.

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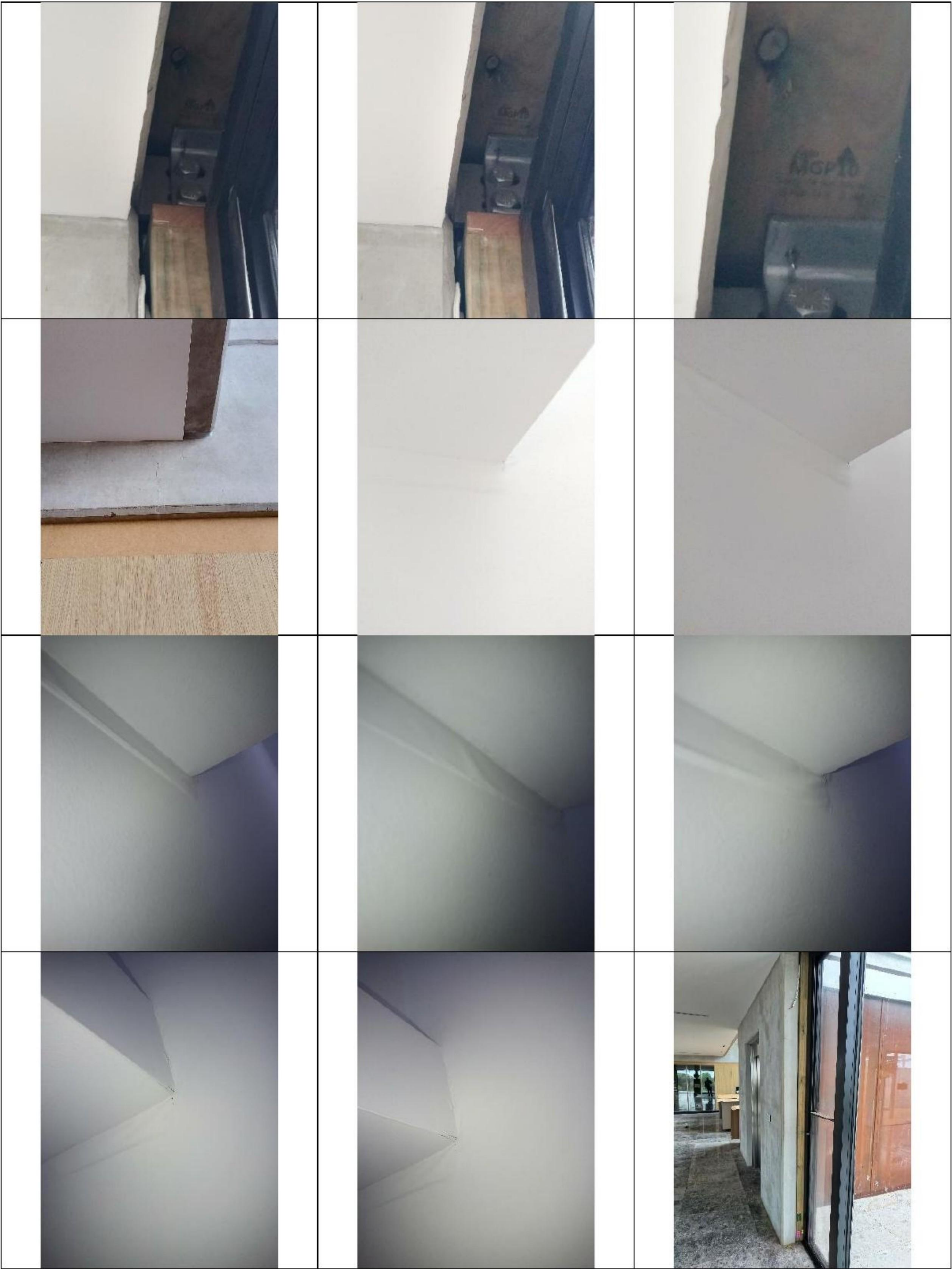
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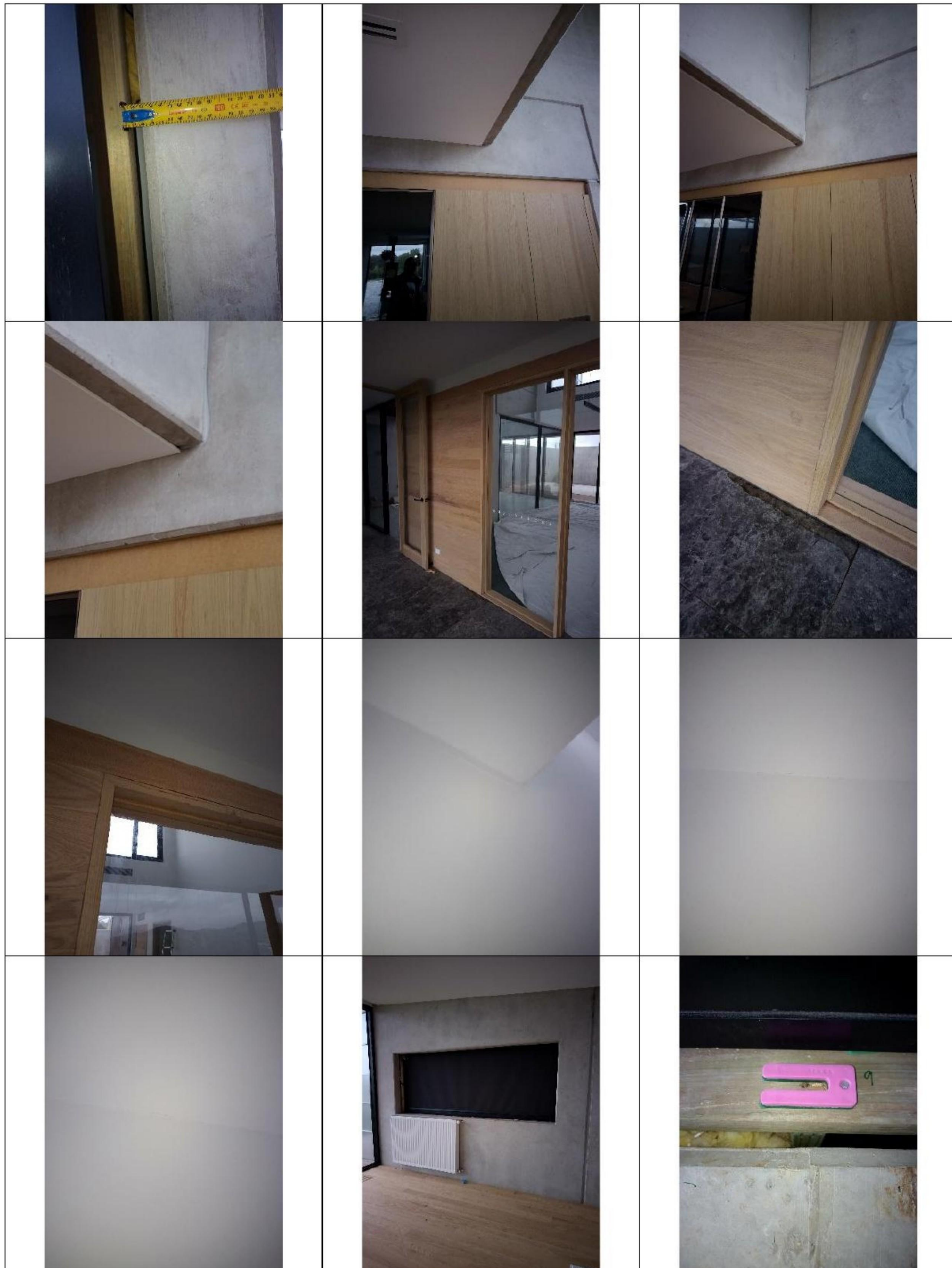
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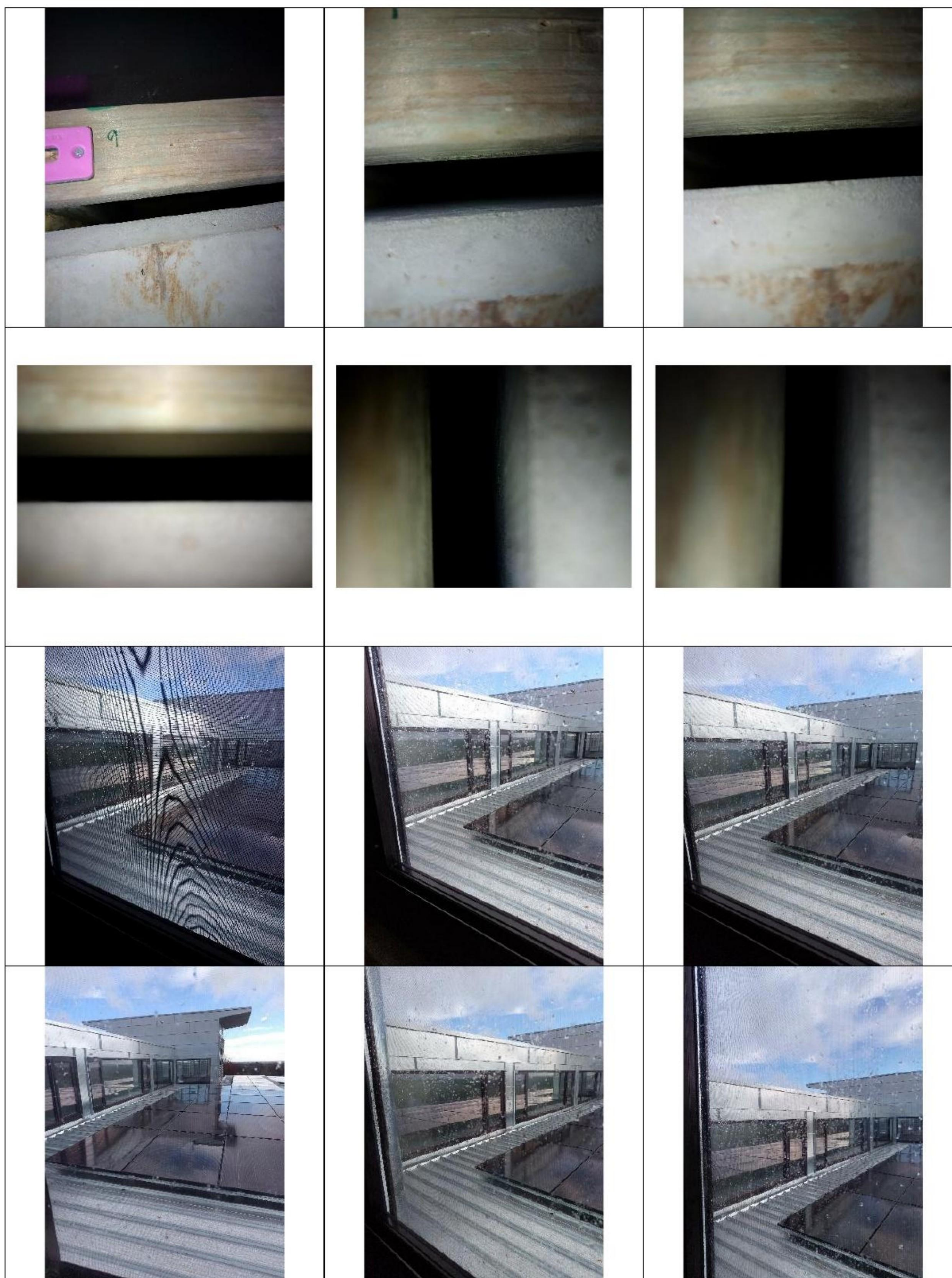
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15. Appendix H: Photo Logs

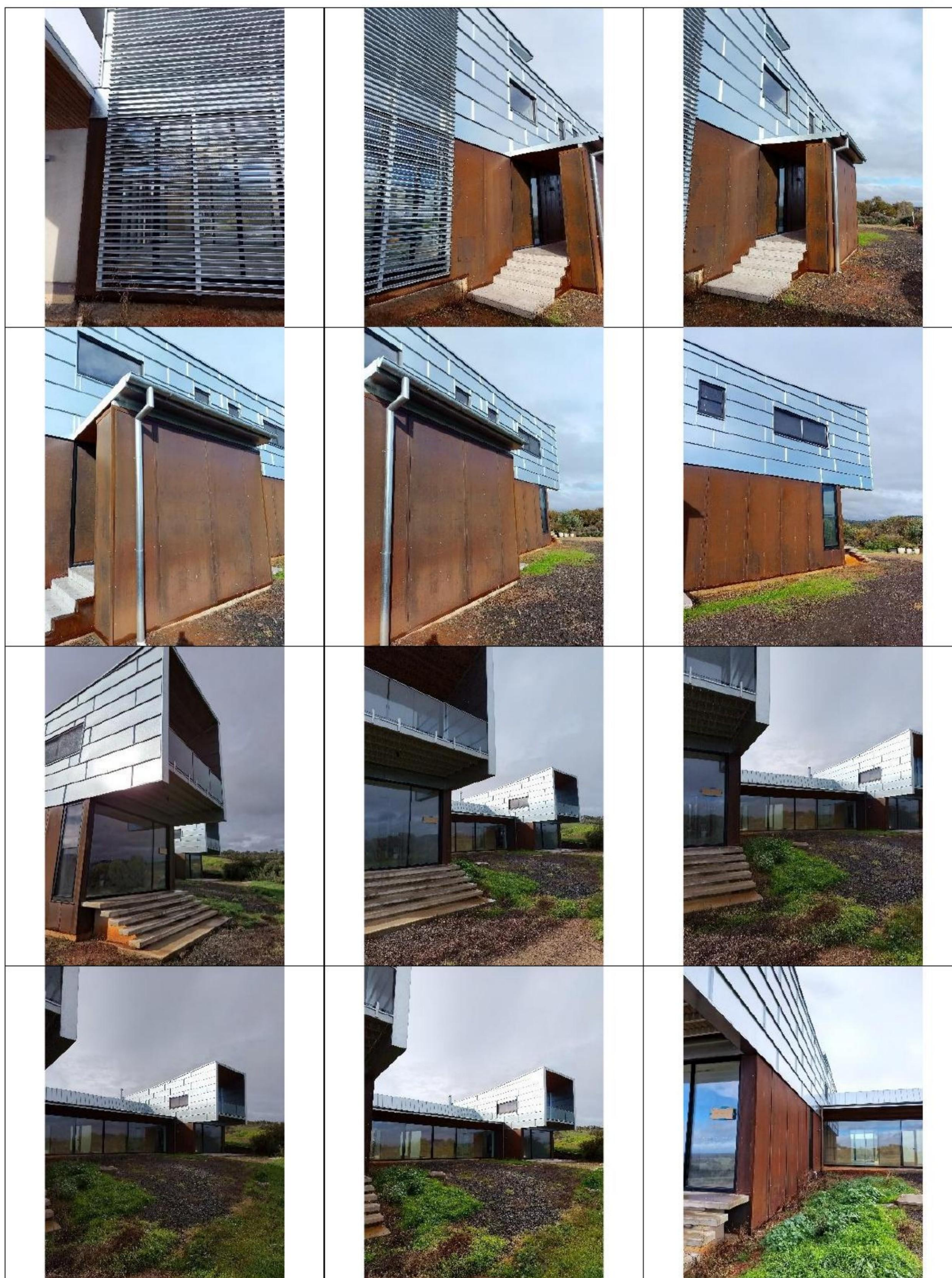




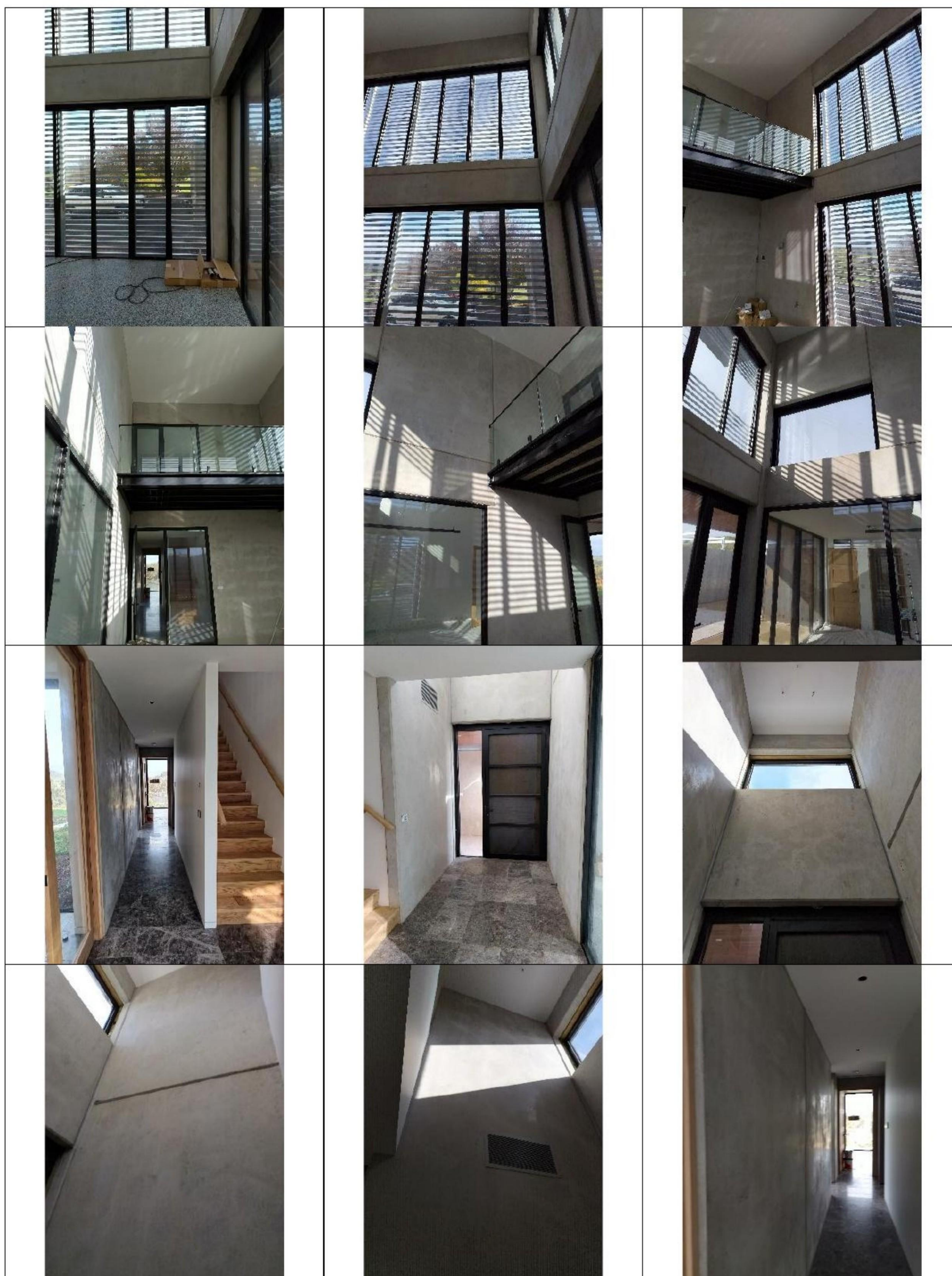


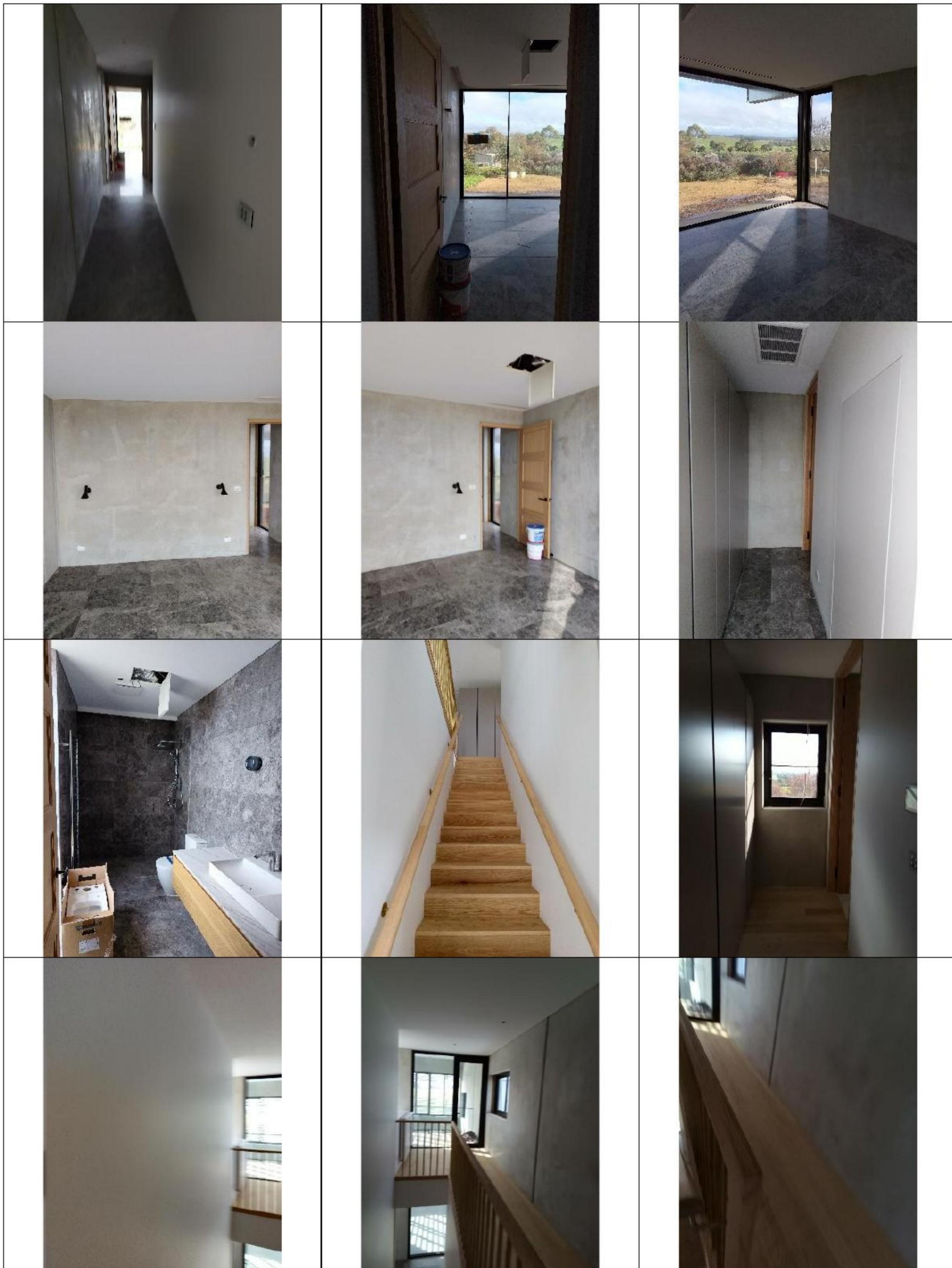


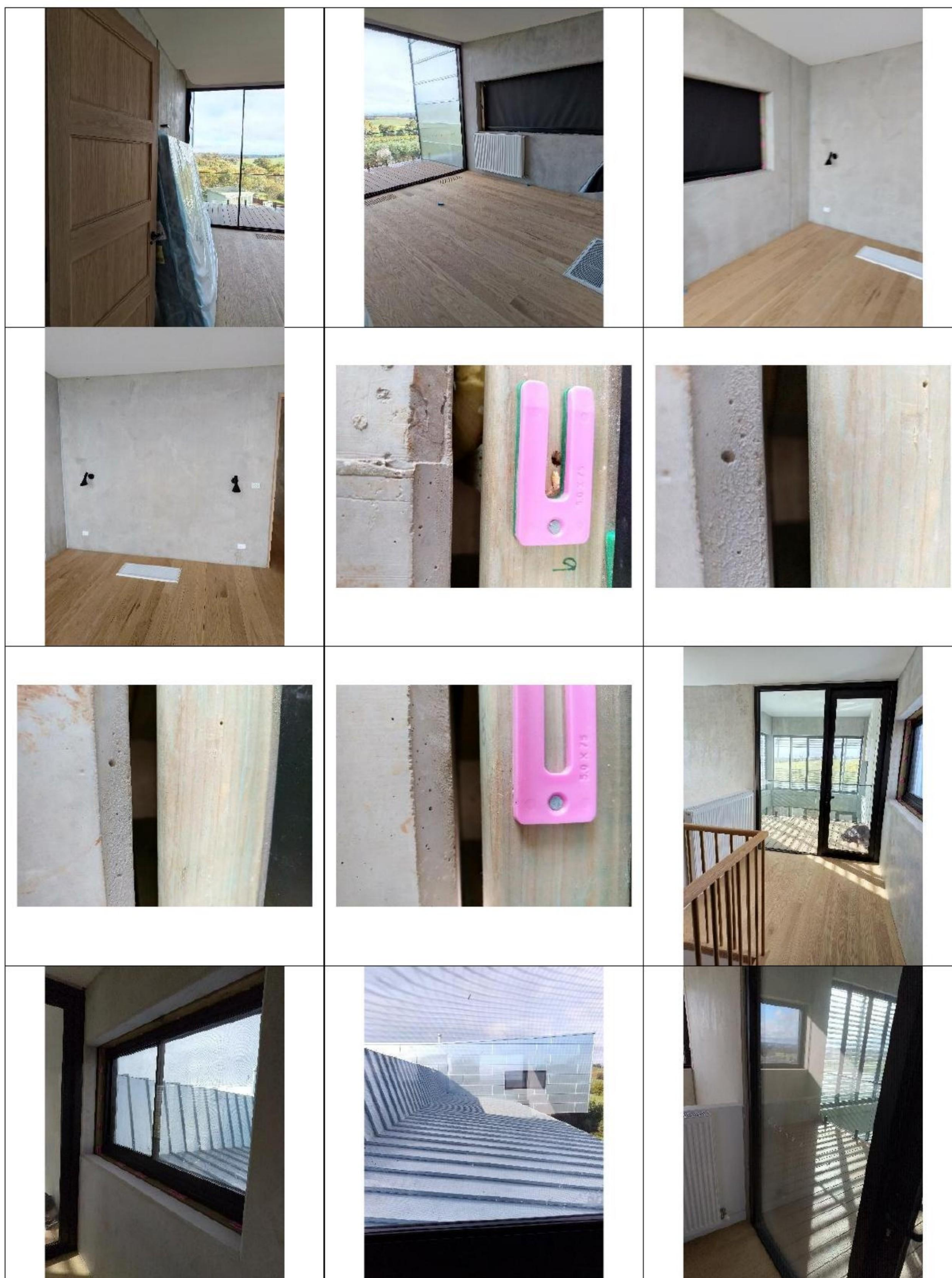


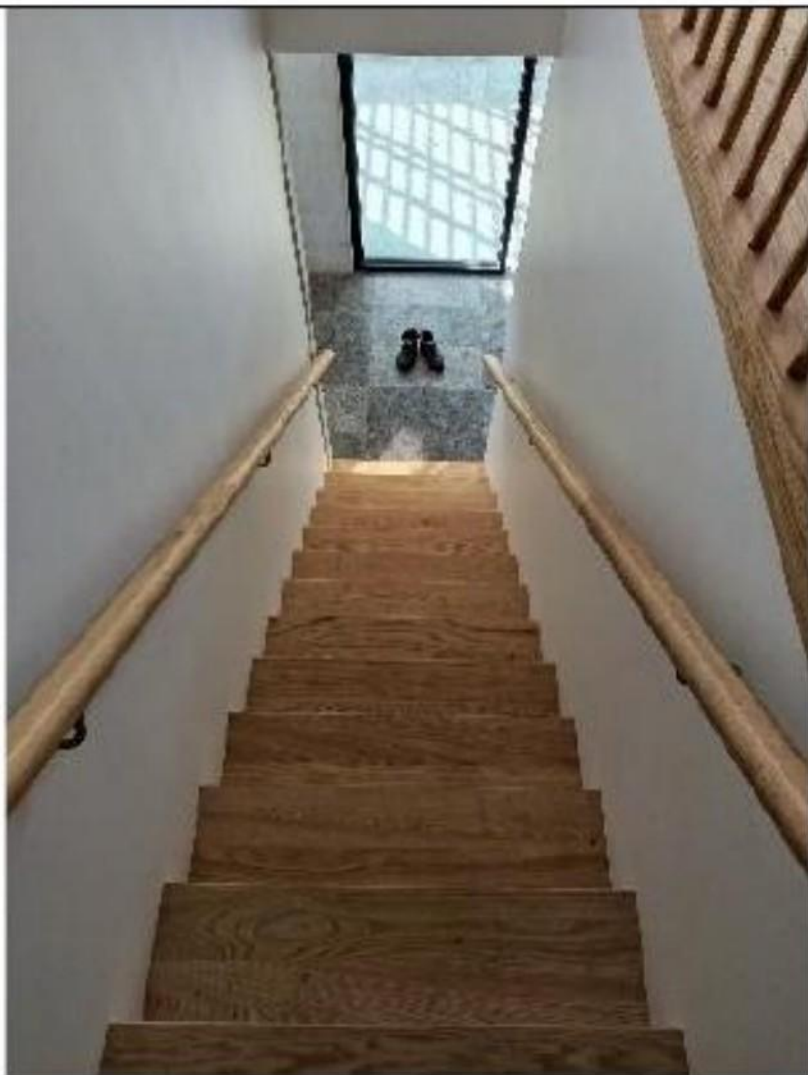










		
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