Lime mortars for the repair of masonry

HTC 1:2020

June 2020

Heritage Technical Codes

HERITAGE COUNCIL VICTORIA

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Environment, Land, Water and Planning

Cover image

A 150-year-old lime mortar high up in an exposed church tower. The large lumps of lime show that it was made in the traditional way by sand-slaking (i.e. slaking quicklime with sand). The mortar is beginning to erode, particularly from perpendicular joints which are less well-compacted. Repointing with a similar lime mortar will ensure compatibility with the bricks.

Acknowledgment

We acknowledge and respect Victorian Traditional Owners as the original custodians of Victoria's land and waters, their unique ability to care for Country and deep spiritual connection to it. We honour Elders past and present whose knowledge and wisdom has ensured the continuation of culture and traditional practices.

We are committed to genuinely partner, and meaningfully engage, with Victoria's Traditional Owners and Aboriginal communities to support the protection of Country, the maintenance of spiritual and cultural practices and their broader aspirations in the 21st century and beyond.

All photographs and diagrams by David Young

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Preface

This Heritage Technical Code (the Code) is intended for application to places of heritage value, including those on the Victorian Heritage Register (VHR) and on the local Heritage Overlay (HO). The Code can also be applied to other buildings of similar age and materials. It has been developed to formalise successful traditional construction practices and techniques that are not documented in current commonly available construction manuals.

The Code has been designed to ensure that owners, government agencies, and heritage and building practitioners (including specifiers and contractors) use best practice in the repair, maintenance and conservation of heritage buildings and structures and other building types to which the Code applies.

The Code is suitable for building work addressed in the Building Code of Australia (BCA), which forms part of the National Construction Code (NCC). Appendix D to this Code is a Performance Solution assessment that provides evidence that construction in accordance with this Code will comply with the applicable NCC Performance Requirements.

The Code includes Normative and Informative clauses. To satisfy the requirement of this Code the Normative clauses must be followed. These clauses (and the Code as a whole) can be used as conditions for Heritage permit approvals issued by Heritage Victoria or local councils. Informative clauses, including diagrams and photographs, are advisory only, providing amplification and explanation of the Normative requirements.

This Code is only relevant to the construction system or process identified in section 2 Scope and application, and does not cover any other legislative or regulatory requirements that may apply to the work.

This Code has been compiled by David Young OAM, BAppSc, M. ICOMOS. Stuart McLennan (M. Eng, MAIBS) completed the Performance Solution Assessment in Appendix D.

It has been reviewed by the Heritage Council of Victoria’s Heritage Fabric Specialist Committee, a body whose members have broad expertise in the conservation of buildings and structures, and has been endorsed by the Heritage Council of Victoria and Heritage Victoria.

1. Introduction

Lime was the principal binder in mortars and plasters of nineteenth century buildings in Australia. Though lime mortars continued to be used for domestic construction until the middle of the twentieth century, they were gradually replaced by those based on Portland cement, including composition mortars of cement and lime.

The Building Code of Australia (now part of the National Construction Code) identifies Australian Standards 3700 Masonry structures and 4773 Masonry in small buildings as acceptable manuals for masonry construction. These Standards provide for a range of cement and composition mortars for contemporary use. They do not endorse the use of lime mortars, except for the repair of existing buildings that were originally made with lime mortars. The guidance on lime mortars provided by AS 3700 is very limited and is not sufficient for specification of repairs to buildings of heritage value. Hydraulic limes are increasingly being used in repairs (as well as in new building work) yet they are not recognised by Australian Standards. For these reasons this Heritage Technical Code should be used for the selection and specification of lime mortars for the repair of masonry.

Due to their high strength and relative impermeability, modern Portland cement-based mortars are incompatible with lime mortars and with many of the masonry materials used in older buildings. For similar compressive strengths, lime mortars are more elastic, more thermally compatible, more permeable and contain much less salt than cement-based composition mortars. These are important attributes of repair mortars for older buildings.

2. Scope and application

2.1 Scope

This Code is about the design and specification of lime mortars for the repair of masonry. It covers mortars made from hydraulic and pure (non-hydraulic) lime binders in combination with aggregates (such as sand), identifies acceptable materials and sets out steps for developing specifications and the selection of appropriate mortar mixes. It also identifies important practical aspects of the use of lime mortars that may be unfamiliar to the contemporary building industry.

This Code does not cover:

- cement-based mortars—lime mortars contain no cement
- historic composition mortars (contemporary composition mortars are covered by AS 3700 and AS 4773)
- patch repair of masonry units with lime-based materials
- grouting, plastering or rendering with lime mortars
- structural design of new work using lime mortars.

2.2 Application

The lime mortars in this Code are for use in the repair of buildings and structures that were originally constructed with lime mortars. These were typically built before the middle of the twentieth century.

There are also many circumstances where the repair of older buildings, constructed with cement or composition mortars, warrant the use of hydraulic lime mortars instead of those based on cement. These include situations where:

- relatively impermeable cement is incompatible with porous masonry units
- high salt loads need to be managed, requiring porous and permeable mortar
- the breathing capacity of the masonry needs to be improved to promote drying
- the stiffness and thermal expansion of cement mortars would be too high for the masonry units
- the high strength of modern cement mortars would be incompatible with the masonry units.

A key principle of heritage conservation practice is that whenever materials need to be replaced the new should match the old—i.e. like-for-like repairs. However, changes in sources and availability of materials often mean that this is impractical, and so matching should be as close as possible, using materials with similar properties and appearance to the original.

The new material must also be compatible with what remains so that it does not damage the existing material of heritage value. Because time and circumstance may have caused decay of the remaining masonry, a compatible repair mortar (see Definitions, below) may need to be quite different from the original.

Repairs undertaken in accordance with this Code will provide a level of structural integrity to the masonry consistent with the original construction.

Where the works involve structural intervention which would require a building permit or similar approval, a structural engineer with experience in the use of lime mortars in heritage conservation must be involved in the design of the solution.

Accurate assessment of condition and repair needs is an essential step in successfully specifying lime mortars. Seek advice from a specialist experienced in historic masonry.

HTC 2:2020 *Repointing with lime mortars* specifies the appropriate methodology for repointing mortar joints.

Lime mortars include hazardous materials (limes and pozzolans) and appropriate safety measures must be adopted in accordance with the relevant Safety Data Sheets (SDS).

2.3 Key references

AS 1141:2015. *Methods for sampling and testing aggregates* (Parts 11, 12 & 13). Standards Australia, NSW.

AS 2701:2001 (R2015). *Methods of sampling and testing mortar for masonry construction.* Standards Australia, NSW.

ASTM C1324-15. *Standard test method for examination and analysis of hardened masonry mortar*. ASTM International, West Conshohocken, PA.

Australia ICOMOS. 2013. *The Burra Charter: the Australia ICOMOS Charter for Places of Cultural Significance, 2013.* Australia ICOMOS, Melbourne.

EN 459-1:2015. *Building lime—Part 1: Definitions, specifications and conformity criteria.* CEN, Brussels.

HTC 2:2020. *Repointing with lime mortars.* Heritage Technical Code, Heritage Council of Victoria, Melbourne.

Young, D 2008. *Salt attack and rising damp: a guide to salt damp in historic and older buildings*. Heritage Council of NSW, South Australian Department for Environment and Heritage, Adelaide City Council, Heritage Victoria, Melbourne.

Young, D 2020. *Mortars: materials, mixes and methods—a guide to repointing mortar joints in older buildings.* Heritage Councils of Victoria, New South Wales, Queensland, South Australia, Tasmania and Western Australia.

2.4 Definitions

admixture	A substance, not including aggregate, binder or pozzolan, added to a mortar mix to modify its properties.
aggregate	Hard, inert, granular material used as a filler in mortars and concrete; includes natural sand, crushed brick and stone, and ground mineral filler.
air-entraining agent	Admixture to improve the durability, workability and rate of carbonation of lime mortars by increasing porosity. Air-entrainers can be used to partly overcome the poor size grading of some sands.
alkali-stable pigment	Pigment that is stable in the alkaline conditions found in lime and cement mortars and concretes.
ashlar masonry	Stone masonry, dressed to fine tolerances and regular shapes, and laid with narrow (nominal 3 mm) mortar joints, sometimes in mason’s putty.
batching	Process of proportioning the constituent materials for a mortar mix.
bedding mortar	Mortar used for laying masonry units (bricks, blocks, stones and terracotta).
binder	Materials, such as limes and cements, used in powder, paste or putty form, which harden to hold the aggregate particles together and bind to the masonry units.

carbonation	Hardening of calcium hydroxide (lime) by absorption of carbon dioxide from the air (in the presence of water) to form calcium carbonate.
cement	Binder that consists only of hydraulic materials (e.g. Portland cement). Cements harden by reacting with water (hydration).
compatible mortar	A compatible mortar will have physical properties such as strength, elasticity, porosity and permeability that are appropriate to the adjacent masonry. Mortar strength should be lower, while elasticity, porosity and permeability should be higher than those of the adjacent masonry units.
composition mortar	A mortar in which the binder is a composition of cement and lime, also called ‘compo’.
curing	The process of ensuring (by maintaining appropriate moisture and temperature conditions) the chemical hardening of a binder, such as lime or cement, to form a solid material.
cutting out	Removing mortar from the face of a joint that is too hard to be raked out and must be cut out with sharp chisels and/or mechanical tools.
desalination	The removal of salt, in this case from masonry materials.
durability	The ability of materials to withstand the action of the weather over an extended period. Durability is not necessarily related to strength.
elastomeric sealant	Elastic polymers, commonly known as mastics, are viscous liquids that cure to become an elastic, sealing compound. They are widely used in modern construction.
fly ash	Fine glassy ash, a by-product from burning coal; used as a pozzolan.
formulated lime	Term used in EN 459 for a hydraulic lime mainly consisting of pure lime and/or natural hydraulic lime with added hydraulic and/or pozzolanic material.
GGBFS	Ground granulated blast-furnace slag, used as a pozzolan; also written GGBS.
hardening	The chemical hardening of a binder, such as lime or cement, to form a solid material.
high-calcium lime	Pure lime. Quicklime or hydrated lime containing at least 80% available lime as calcium oxide or calcium hydroxide, respectively. Its EN 459 designation is CL 90.
hydrated lime	Calcium hydroxide. It is the result of combining quicklime with water to produce either a wet hydrate (putty) or a dry hydrate (powder). The term is normally used for the dry powder form. It is also known as builders’ lime.
hydration	The reaction that results from combination with water. It applies to quicklime, which reacts to become hydrated lime, and to hydraulic limes and cements, which harden by reacting with water to form hydrates.
hydraulic lime	A lime that hardens partly by reacting with water (hydration) and so can harden underwater. Hydraulic limes contain silicates and/or aluminates which harden by hydration, and calcium hydroxide which hardens by carbonation.
jointing	The process of laying masonry and finishing the mortar joints in one operation with a single bedding mortar; also see ‘pointing’.
knocking up	Making a matured lime mortar workable by further mixing; also see ‘reworking’.
larry	A mason’s hoe, used for mixing mortars.
lime	Confusingly, the term is used for quicklime, for slaked or hydrated lime and for hydraulic limes. It is also loosely used for other calcium compounds.
lime putty	A putty of calcium hydroxide made by slaking quicklime in excess water and allowing it to settle out until it is stiff enough to retain its shape without slumping.
masonry	Clay bricks, concrete bricks or blocks, stone and terracotta (the masonry units) laid in mortar to form walls or other structures.
mason’s putty	A putty-like mortar made with lime putty, whiting, linseed oil and very fine sand (which is sometimes omitted). It is used in narrow-jointed ashlar masonry.
maturing	Ageing of lime putty, leading to finer particle sizes and greater workability. Also applies to lime mortars, which improve with maturing before use.
mortar	Any material that in wet paste form can be used to lay masonry or make plasters and renders, which then sets and hardens. Applies to clay-bound materials as well as those bound with limes or cement. Mortars generally consist of a binder and an aggregate.

natural hydraulic lime	Hydraulic lime made by calcining impure limestone that naturally contains silica or aluminosilicates in suitable proportions, without any additions. Three classes are identified by EN 459: NHL 2, NHL 3.5 and NHL 5.
non-hydraulic lime	Relatively pure limes, including lime putty and hydrated lime, that harden by reacting with carbon dioxide in the air (carbonation) rather than with water. Air lime, fat lime and high-calcium lime are alternative terms.
permeability	The property of a porous material that allows gas (such as water vapour) and fluids (such as water) to pass through it. Permeable materials ‘breathe’.
plasticiser	An admixture for mortars and concretes, used to improve workability and to reduce required water content of mixes.
pointing	Original finishing of a mortar joint by raking out some of the bedding mortar and inserting a separate pointing mortar.
pointing mortar	Mortar used to finish joints by pointing. May differ from the bedding mortar in materials, mix proportions, colour and durability.
poorly graded sand	A sand that has a uniform grainsize, or a narrow range of grainsizes.
porosity	The void (or pore) space in a material, expressed as a percentage of the total volume.
porous aggregates	Crushed porous bricks or stones added to mortars in place of some of the sand to increase their porosity and permeability.
Portland cement	The principal hydraulic cement of contemporary construction made by calcining a blend of raw materials including limestone and clay or weathered shale. The resulting clinker is ground with gypsum to prevent rapid hardening.
pozzolan	Fine-grained, glassy materials containing reactive silica, and often alumina, that have no binding power of their own but combine with pure lime to make binders that are similar to hydraulic limes.
pozzuolana	Volcanic ash, pumice and related material from Pozzuoli, Italy, used by the ancient Romans in their mortars and concretes; origin of the term pozzolan.
pre-wetting	Process of thoroughly wetting walls prior to repointing to control, or ‘kill’, their suction, so that mortars do not dry out prematurely.
pure lime	Lime made from relatively pure limestone, resulting in a non-hydraulic, high-calcium lime. Pure limes are also known as fat limes or air limes.
putty	see ‘lime putty’ and ‘mason’s putty’
quicklime	Calcium oxide produced by calcining (burning) limestone, marble, chalk, coral or shells. It is also known as rock lime or lump lime.
quicklime mortar	Mortar made directly from quicklime by sand-slaking.
raking out	Removing mortar from the surface of a joint, using a raking tool or other tools, to enable pointing or repointing.
repointing	Replacing the outer part of a mortar joint in masonry, which may have been originally jointed or pointed.
reworking	Making a matured lime mortar workable again by a period of further mixing; see also ‘knocking up’.
rising damp	Upward migration of water in masonry due to capillary suction; often the medium for transporting soluble salts into walls.
sacrificial mortar	A mortar designed to fail in preference to (and so protect) the adjacent masonry. A sacrificial mortar will be significantly more porous and permeable, and of lower strength than the masonry units.
salt attack	The progressive decay of masonry materials due to cyclic crystallisation or hydration of soluble salts within the pores of the material.
salt damp	salt attack and rising damp
sand-slaking	Slaking of quicklime in conjunction with sand to produce a mortar which is then matured before use.
sharp sand	Sand that is angular and so feels sharp when rubbed in the hand.

size grading of sand	The distribution of particle sizes in a sand; also known as granulometry.
slaked lime	Lime putty or hydrated lime, both of which have been produced by slaking quicklime, though the term is commonly limited to lime putty.
slaking	Like a thirst, quicklime is slaked (or slacked) by adding water.
slurry	A thin mixture of solid material in water. Mortar mixes intended for grouting are made into slurries by the addition of plasticisers.
suction	The negative force exerted by the capillarity of porous materials. It draws water into walls and aids in adhesion of plaster and mortar.
tamping	Finishing a partly hardened mortar joint by direct striking of the surface with the ends of the bristles of a stiff-bristled brush. The end grain of pieces of wood can also be used.
trass	A compacted volcanic ash that is ground and used as a pozzolan.
tuck pointing	Finishing a mortar joint with a narrow ribbon of mortar over a different coloured background mortar that is coloured to match the bricks or stones.
vapour permeability	The rate of passage of vapour (e.g. air and water vapour) through a permeable material. Loosely described as breathability.
void ratio	The proportion of voids in a dry sand (the porosity) expressed as a percentage.
water-retainer	Water-retaining agent or water thickener; an admixture that improves the water retentivity of a fresh mortar, slowing its loss into the surrounding masonry.
well-graded sand	A sand that has a broad range of grainsizes, in roughly similar proportions, meeting the grading requirements of Table 1.
workability	The relative ease with which a fresh mortar can be spread and worked; it is related to its plasticity, water retentivity and consistency.

3. Decision Requirements

	Normative	Informative
3.1	Undertake the following investigations and steps to develop an appropriate specification and schedule of works for the use of lime mortars in the repair of older buildings.	Figure 1 shows the steps of the Lime mortars investigation process. Appendices A to C describe the documentation needed to substantiate the work.
3.2	**Hazardous materials**	
	Check for hazardous materials such as asbestos and lead white in old mortars and sealants.	This should involve close inspection by an experienced person and/or chemical analyses. Hazardous materials such as asbestos and lead white require particular responses which are beyond the scope of the Code. Refer to statutory and other requirements for the safe management of these materials and involve a heritage professional in their removal to ensure the protection of the surrounding original fabric.

Normative | **Informative**

3.3 Existing Materials

Document the existing bedding mortars and pointing mortars (if any), their constituent materials and the finished profile of the joints.

Closely examine the mortars with a hand lens. Laboratory analysis of the existing mortar may be warranted, depending on the significance, complexity and circumstances of the particular project (see Appendix A.2).

Document the brick, stone or terracotta masonry units.

Are the existing materials original or later changes? Do they vary around the building?

Understanding the properties of the masonry units, such as permeability, porosity and strength, is essential to designing compatible repair mortars. An informed understanding of the materials may suffice in many circumstances.

3.4 Significance

Do the existing mortars contribute to the significance of the building or structure?

Are the existing mortars:

- significant in their own right (likely to be rare)
- contributory (likely to be original or early)
- neutral (such as a sympathetic repair)
- intrusive (non-matching, poorly executed repairs).

See Appendix A.3

3.5 Condition

Assess and rank the condition of the existing masonry using the methodology in Appendix B. Investigate deeply eroded joints, which may warrant further investigation of wall cavities or the cores of solid walls.

Rank aspects of the condition of mortars and masonry units on a scale of good, fair, poor or very poor in order to help determine the nature and extent of work required.

3.6 Reason(s) for condition

Explain why the masonry is in its present condition.

Possible explanations include general surface loss (particularly on more exposed faces), biological growths, inherent vice, dampness and salt attack, earthquake, flood, and inappropriate treatment including aggressive cleaning and repointing with incompatible materials.

3.7 Risks

Evaluate the risks associated with the building, its materials and their condition, and plan a response.

What risks derive from the particular circumstances of the building or structure? These risks may arise from its condition, from any hazardous materials, and may also include its use and state of maintenance or abandonment (see Appendix B).

Normative | Informative

3.8 Mortar mix selection

Select mortar materials and mixes identified in this Code that:

- match significant materials and mixes
- are compatible with the masonry units
- respond to the condition, exposure and risks.

Retaining the overall significance of the building or structure should be the principal factor guiding decisions. However, changes in the availability of the original materials, and the critical need to ensure compatibility may require use of alternatives, which should still comply with this Code.

3.9 Specification and schedule of works

Develop a specification and schedule of works that address clauses 3.2 to 3.8 and:

- respect the existing fabric
- retain significance
- respond to the identified risks
- minimise unnecessary work.

In the specification include clauses on:

- materials—binder(s), sands, admixtures, etc.
- mixes and how they are to be batched
- mixing and knocking up
- cleaning the masonry, using biocide if needed
- pre-wetting—to control suction of the masonry
- protection—to prevent rapid drying
- curing—to ensure thorough hardening
- site practices—storage of materials
- compliance inspections and testing
- treatment of non-compliant work.

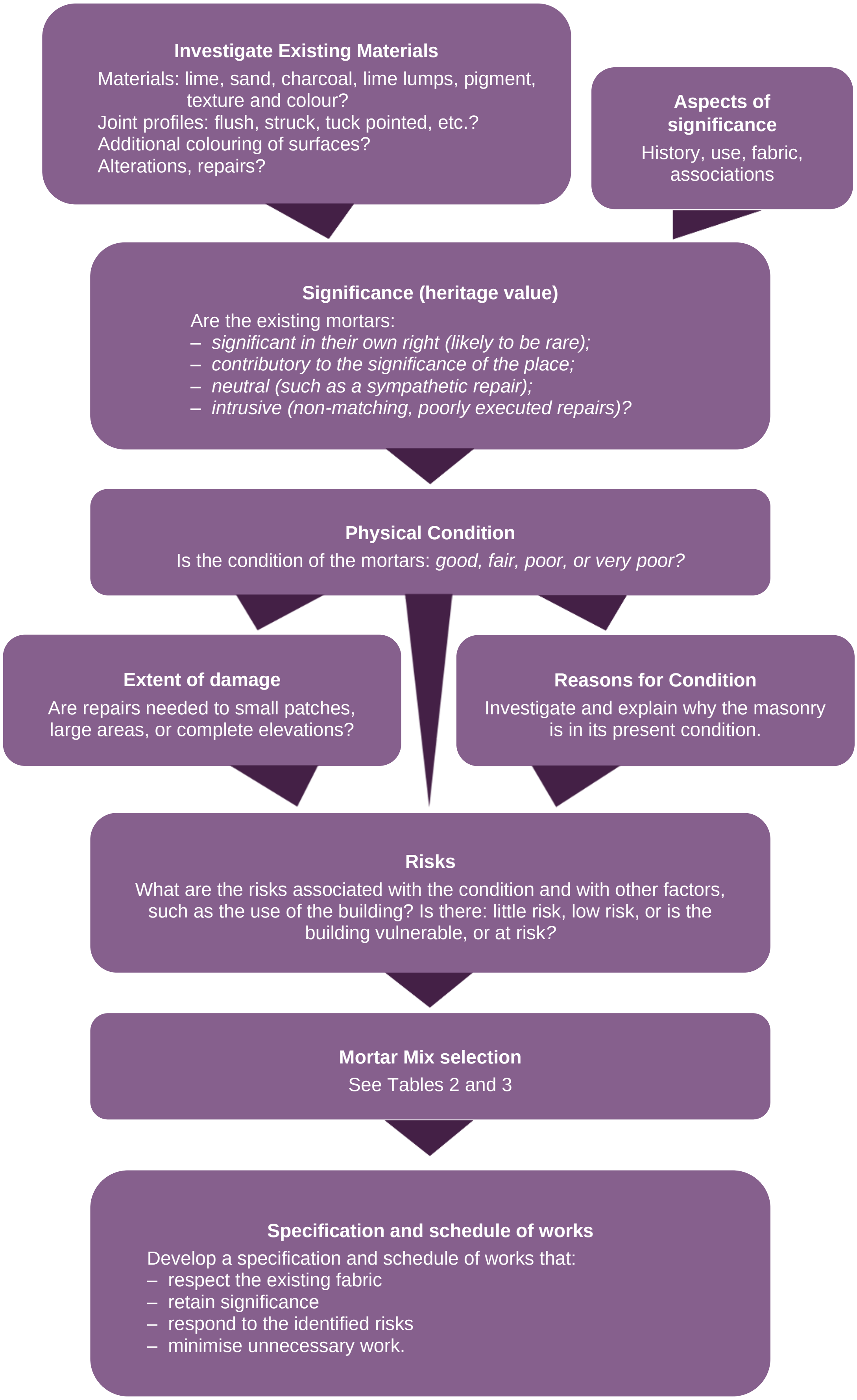
Workability is a key requirement of all mortars. To ensure workability, specifications should allow for the final adjustment of the mix proportions (within specified limits) to be made by the mason on site.

For repointing also include clauses on:

- mortar samples and reference panels
- raking and cutting out joints
- repointing with tools that fit within the joints
- finishing with a known profile and/or a tamped finish.

See HTC 2:2020 *Repointing with lime mortars*

Figure 1: Lime mortars investigation process: steps for developing specifications for the repair of lime mortars



4. Materials and components

Normative / **Informative**

4.1 Binders

Binders shall conform to EN 459-1:2015 and be:

Pure (non-hydraulic) lime as:

- fresh quicklime
- lime putty (minimum density 1.35kg/l)
- hydrated lime (of known density).

or

Hydraulic lime as:

- pure (non-hydraulic) lime plus pozzolan
- natural hydraulic lime (NHL) as NHL 2 or NHL 3.5
- NHL plus pozzolan
- NHL plus pure (non-hydraulic) lime.

Do not add cement to lime mortars.

Informative:

Slaking quicklime with sand (sand-slaking) produces excellent sticky mixes that are more akin to traditional mortars than those made from putty.

Directly slaked lime putty is preferred to hydrated lime, but use the latter if there is no alternative, provided it is fresh.

Hydraulic limes may be Natural Hydraulic Lime (NHL), or may be produced by combining pure lime with a pozzolan. EN 459-1 refers to the latter mixes as Formulated Limes (FL).

NB: Recent research in the United Kingdom has revealed widely varying test results between brands of NHL and between classes from the same brand. Specifiers should seek up-to-date test data before deciding on a particular product.

4.2 Pozzolans

Pozzolans shall be natural materials such as trass or *pozzuolana*, or by-products such as fly ash (FA) or ground granulated blast furnace slag (GGBFS).

Do not use metakaolin or silica fume.

Informative:

Some manufactured pozzolans, such as metakaolin and silica fume, are too reactive for use in lime mortars.

4.3 Sand (aggregate)

Sands shall be washed and be free of clay, organic matter, salt and other impurities. The sand shall be sharp, well graded and, when tested to AS 1141, shall generally meet the grading specifications of Table 1 (as illustrated in Figure 2). The void ratio shall be measured and made available to the specifier.

However, where the significance of the existing mortar warrants accurate matching using a 'dirty' clayey sand, the mortar must be made by sand-slaking quicklime (see 5.2 Mixing mortars).

Informative:

Table 1 has two specifications for size grading of sands, a fine–medium sand for narrow (3 mm wide) joints and a medium–coarse sand for normal (10 mm wide) joints.

Dry sands are preferred as they overcome bulking issues and ensure better contact with the lime. On account of water already in the putty, dry sands should be used whenever the binder is specified as lime putty.

Where mortars are to match the existing materials, the colour and texture of the sand will be important. Sometimes colour matching may be improved with judicious use of pigments.

Blending of sands from different sources may be needed to match colour and texture and to achieve a satisfactory size grading (see Table 1 and Figure 2).

Normative | **Informative**

4.4 Other aggregates

Other acceptable aggregates include:

- crushed porous materials (limestones, bricks)
- finely ground limestone or marble filler
- charcoal, cinders, coke breeze, crushed slag
- sands blackened by their use in foundries
- shells, or shell fragments.

Porous aggregates store water for curing and add to the permeability of mortar. Finely ground limestone may improve the grading and workability of some sands, as well as promoting hardening of mortar. Charcoal and related materials darken the tone.

Other aggregates such as these should generally not constitute more than a third of the total aggregate.

4.5 Pigments

Alkali-stable inorganic pigments may be used to improve colour matching, provided that the proportion of pigment does not exceed 10% of the volume of the binder, or 2% in the case of carbon black.

Organic dyes fade with time and are not acceptable.

4.6 Admixtures

Acceptable admixtures include:

- plasticisers and superplasticisers
- air-entraining agents
- water-retaining agents.
- Admixtures that are not acceptable include:
- detergents
- water repellents.

Bonding agents may be acceptable, but only where the particular circumstances are independently assessed by an experienced historic masonry specialist.

Except for deliberately sacrificial mortars, admixtures should not be the first port of call for improving the workability of a mix. First, add more lime.

Some bagged lime products already contain air-entraining agents. Do not add more as the interaction between two different agents may cause problems.

4.7 Water

Mixing water shall be potable with a maximum salt content of 2,500 mg/kg.

The electrical conductivity of the water can be measured with a conductivity meter and the result converted to an approximate salinity (3.9mS/cm ~ 2,500mg/kg).

The salt content should be minimised wherever practicable.

	Normative	Informative
4.8	**Mortar mixes**	
	Mortar types and mixes shall conform to Table 2. Select mortar types and mixes based on the design requirements of section 3 and the need to produce mortars which are compatible with the masonry units and which respond to the exposure conditions of the site.	Table 3 provides advice on the selection of mortar types for a range of materials in different conditions and exposures. Weak, porous materials such as low-fired bricks and many limestones and sandstones need low-strength, elastic mortars such as the Pure lime, or Lime + (5%) pozzolan in Table 2. Strong mortars, such as those based on NHL 3.5, should only be used with dense bricks and stones in sound condition.
	Use the void ratio of the sand and its average grainsize as the basis for determining the approximate ratio of binder to sand.	A void ratio of 33% suggests a binder to sand ratio of 1:3, while 40% suggests a 1:2.5 ratio. As the particle size of the sand gets finer the proportion of sand needs to be reduced to account for larger surface areas. Thus, while a medium–coarse sand (Table 1) may require ratios between 1:2 and 1:3, a fine–medium sand may need ratios between 1:1 and 1:1.5.
	Mortars that are stronger than those specified shall not be used.	Addition of more pozzolan to a mix, or the use of a higher grade of NHL, will produce stronger but less permeable mortars, which will be incompatible with weaker, more porous materials.
	Cement or composition mortars must not be used for repointing lime mortar joints.	Mortars of similar strength to composition mortars, but made from pure lime with appropriate pozzolans, or from NHLs, have equal flexural strength, better elasticity, greater porosity and permeability, lower salt contents, and better thermal compatibility with masonry materials.
4.9	**Premixed mortars**	
	Premixed or proprietary mortars may be acceptable. It is the responsibility of the specifier to establish that they and their components conform to the requirements of this Code including Tables 1 and 2.	Specifiers should confirm with the manu-facturer or supplier the proportion and nature of the binder(s) and aggregates, as well as the amount and nature of any additives and admixtures.
4.10	**Mason's putty**	
	Do not use linseed oil in mortars, except in small proportions and with dense masonry units such as granite or marble.	Because linseed oil in mason's putty restricts 'breathing' by blocking pores, it is not appropriate to use it in conjunction with porous masonry units such as sandstones and limestones. Where the existing mortar is mason's putty, a satisfactory match can generally be made by omitting the linseed oil.
4.11	**Elastomeric sealants**	
	Do not use elastomeric sealants for normal mortar applications in masonry.	Sealants may have a role in special circumstances, such as sealing movement joints to prevent water entry, but only where they are independently assessed by an experienced historic masonry specialist.

Table 1: Sand size grading specifications

Table 1: Sand size grading specifications		
	Fine–medium sand	**Medium–coarse sand**
Sieve size	% passing	% passing
4.75 mm	100	100
2.36 mm	100	90–100
1.18 mm	95–100	70–100
600 µm	70–100	40–75
300 µm	35–70	10–40
150 µm	10–25	2–15
75 µm	0–5	0–5

Figure 2: Sand size grading envelopes (Informative)

This a graphical illustration of the sand size grading specifications in Table 1. Each pair of lines define an envelope within which a complying sand should plot. Fine–medium grained sands are intended for narrow (3 mm wide) joints that are typically found in ashlar masonry, and medium–coarse grained sands for normal (10 mm wide) joints. A medium-grained sand, suitable for 5–7 mm joints, should plot close to the overlap between the two envelopes shown here. Plots for individual sands should ideally lie approximately parallel to the envelop boundaries. Small variations from either envelope should not preclude the use of a well-graded sand that is otherwise acceptable.

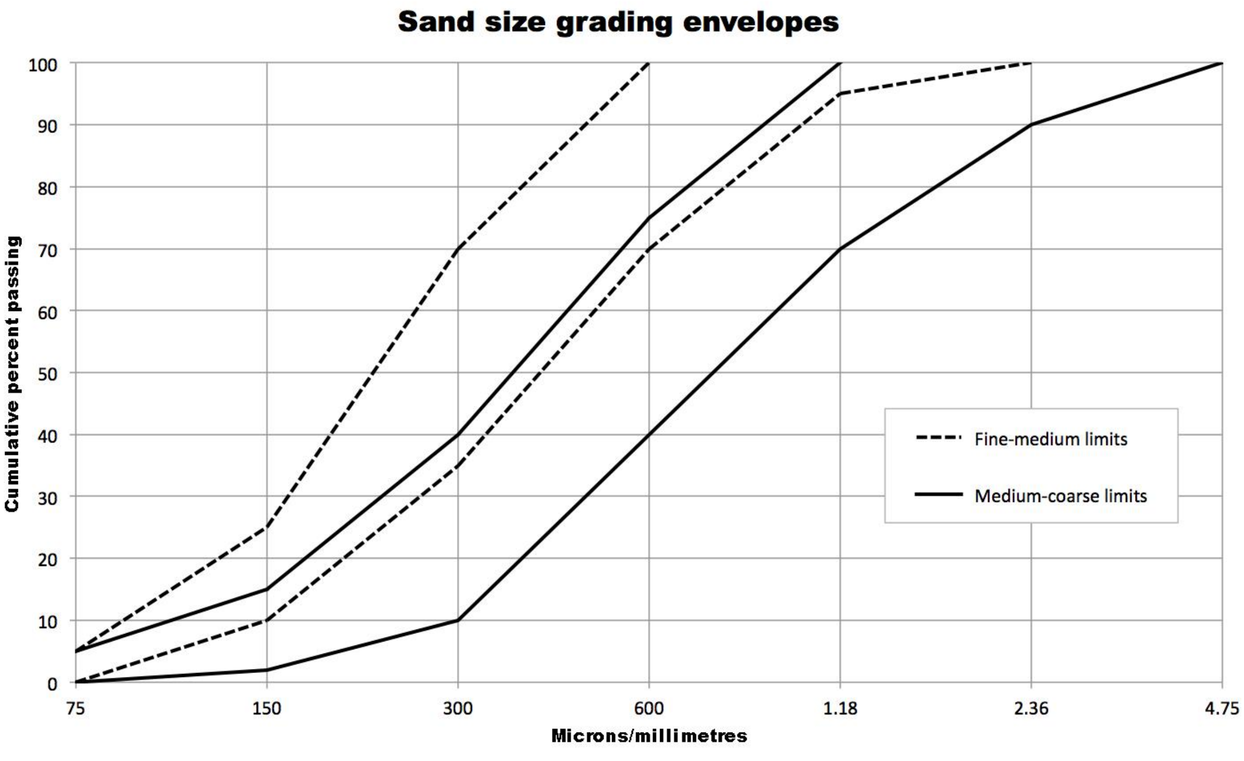


Table 2: Lime mortar types and mixes

Table 2: Lime mortar types and mixes					
Mortar type	**Pure lime**	**Lime + pozzolan**	**Natural Hydraulic Lime (NHL)**	**Sacrificial lime**	**Narrow joint**
Nominal mix	1:3	1:3	1:2.5[1]	1:4	1:1.5
Binder	Quicklime or lime putty[2]	Quicklime or lime putty[2]	NHL 2 or NHL 3.5	Quicklime or lime putty[2]	Lime putty
Pozzolan		10% FA, GGBFS or 20% trass[3]			± 5% FA, GGBFS or 10% trass[3]
Sand	2–3 parts	2–3 parts	1.5–2.5 parts	3–5 parts	1–1.5 parts
Porous aggregate	± Por. agg. replacing 0.5 part of sand	± Por. agg. replacing 0.5 part of sand	± Por. agg. replacing 0.5 part of sand	Por. agg. replacing 0.5–1 part of sand	
Filler	± Finely ground limestone/ marble	± Finely ground limestone/marble	± Finely ground limestone/ marble		Finely ground limestone, up to 0.5 part
Admixtures	± Air-entrainer ± Water-retainer	± Air-entrainer ± Water-retainer	± Air-entrainer ± Water-retainer	Air-entrainer Water-retainer	± Air-entrainer ± Water-retainer
Alternative mixes	Fresh hydrated lime can be used but its density must be allowed for	Less pozzolan (e.g. half the above %); Other pozzolans; NHL mixes	NHL + putty; NHL + pozzolan; Lime + pozzolan mixes	Lime + 5% pozzolan or NHL 2 + 25% putty for exposed locations	NHL 2 + 25% putty for exposed locations

Notes:

1. Nominal mixes for NHLs (1:2.5) are richer than for pure limes (1:3) because NHLs contain a proportion of inert material.
2. Quicklime produces richer mixes than lime putty, that are more akin to traditional mortars.
3. Pozzolans are measured as a percentage of the lime content; their proportion depends on their hydraulic reactivity.

±. This symbol means 'plus or minus' the pozzolan, porous aggregate, filler or admixture, depending on the circumstances.

Additional information on Table 2: Lime mortar types and mixes

Nominal mixes: These are shown for each mortar type and are shown with lime as one part (e.g. 1:3 under pure lime indicates one part of lime to three parts of sand). The actual mixes may vary depending on the nature of the binder and the sand, and importantly, on the need to ensure good workability.

Sand: The proportion of sand in a mix will depend on its properties, particularly its grainsize and its void ratio. The nominal mixes assume well-graded sands. Poorly graded sands, or those with finer grainsizes, require richer mixes with less sand as they will have higher void ratios. Mixes richer than the nominal ones are often required when using lime putty or hydrated lime binders.

Porous aggregate: Porous aggregates, such as crushed porous limestone, may be used in place of some of the sand to retain water and so improve curing, as well as improving the breathing characteristics (permeability) of the hardened mortar.

Fillers: Fillers, such as finely ground marble or limestone, may be needed to improve the grading, and hence workability, of a sand, or to make a mortar suitable for narrow joints in ashlar masonry, which are commonly 2–4 mm wide. Depending on the sand, fillers may be used at 0–25% of the lime content (i.e. up to ¼ part) for normal width (10 mm) joints.

Admixtures: These may be required to improve working and curing behaviour, particularly where poorly graded sands must be used. Air-entrainers and water-retainers are recommended for sacrificial mortars because of the need to provide additional pore space and because the higher proportion of sand reduces workability.

Alternative mixes: These show how the binders might be varied within each type. Other components remain as shown, except for the mix proportions of NHLs, which are different from those of other limes (see note 1 above).

Mortar selection: See Table 3 for advice on selection of mortar types. Choose a mortar based on the significance of the existing mortar, on the exposure conditions and, particularly, on the need to ensure compatibility with the surrounding masonry.

Table 3: Selection of mortar types

Table 3: Selection of mortar types			
This table provides a guide[1] to selecting the mortar types identified in Table 2.			
Exposure / situation	**Masonry materials**		
	Weak	**Moderate**	**Strong**
Sheltered	Pure lime, or Pure lime + por. agg.[2]	Pure lime, or Lime + 5% pozz.[3]	Lime + 5% pozz., or NHL 2 + 10% putty[4]
Moderately exposed	Pure lime, or Lime + 5% pozz.	Lime + 7.5% pozz., or NHL 2 + 10% putty	Lime + 10% pozz., or NHL 2
Very exposed	Lime + 5% pozz.	Lime + 10% pozz., or NHL 2, or NHL 3.5 + 25% putty	Lime + 15% pozz., or NHL 3.5
Salt damp, sheltered	Sacrificial lime	Sacrificial lime	Sacrificial lime
Salt damp, exposed	Sacrificial lime, or Sac. lime + 5% pozz.	Sac. lime + 5% pozz., or Sac. NHL 2 + 25% putty	Sac. lime + 5% pozz., or Sac. NHL 2 + 25% putty
Narrow joints[5]	Lime putty and sand (with minimal limestone filler)	Lime putty, limestone filler and sand	Lime + 5% pozz., or NHL 2 + 25% putty, filler and sand
Cement-based mortar[6]	Lime + 5% pozz.	Lime + 10% pozz., or NHL 2, or NHL 3.5 + 25% putty	Lime + 15% pozz., or NHL 3.5

Notes:

1. This a guide only and not a substitute for careful assessment of the circumstances that apply to each case.
2. Mixes might be modified with admixtures or porous aggregates to suit the circumstances. As an example, the inclusion of porous aggregates is shown here for weak materials in sheltered environments, but is not limited to these circumstances.
3. Pozzolan proportions shown in this table are for fly ash (FA) and ground granulated blast furnace slag (GGBFS). The proportions can be doubled for less reactive pozzolans such as trass.
4. Where several mortar types are shown, selection from among them will depend on the masonry materials, their condition and the situation, as well as practicalities, such as what other mortars are being used on the site.
5. Nominal 3 mm joints found in ashlar masonry, often originally pointed with mason's putty.
6. For buildings originally constructed with cement-based mortars (either cement or composition) where the circumstances are such that modern composition mortars would be incompatible with the masonry materials.

Key to table descriptors

Masonry materials	
Weak	Very porous to porous materials; weakly bound sandstones and limestones; low-fired bricks; moderate materials in poor condition
Moderate	Porous materials; moderately well-bound sandstones and limestones; bluestones; well-fired bricks; strong materials in poor condition
Strong	Low porosity materials; granites and related stone types; bluestones; marbles; engineering bricks
Exposure	
Sheltered	Walls between plinths and cornices on sheltered sides of buildings, away from the coast
Moderately exposed	Weather side of buildings; plinths; domestic-scale parapets, cornices and chimneys; retaining walls
Very exposed	Towers, spires, parapets and cornices of larger buildings; coastal locations; retaining walls
Salt damp, sheltered	High salt situations, such as rising damp in sheltered to moderately exposed environments
Salt damp, exposed	High salt situations in exposed environments, such as prevailing weather side of buildings, plinths, chimneys, retaining walls and coastal locations

5. Execution

Normative | **Informative**

5.1 Mixing equipment

Acceptable mechanical mixing equipment includes:

- forced action (screed) mixers
- roller pan mixers (with roller height adjustment)
- heavy duty hand-held drill mixers
- conventional rotary cement mixers, provided they are equipped with heavy stone or steel balls to provide a pounding action.

Acceptable hand mixing equipment includes:

- pounding with a mattock handle in a flexi-tub
- larrying with a mortar hoe in a trough
- a shovel on a flat floor or board.

Unacceptable equipment includes conventional rotary cement mixers used without heavy stone or steel balls to provide a pounding action.

Looking down into a forced action or screed mixer. The small blades force the components together in a way not achieved by normal rotary cement mixers.

5.2 Mixing mortars

Lime mortars require thorough mixing to ensure good contact between binder and aggregate.

Quicklime mortars shall be sand-slaked with minimum water, allowed to cool and then remixed and the moisture content adjusted.

Lime putty mortars shall be thoroughly mixed with dry sand without additional water. If the mix proves unworkable it shall be corrected by adding more lime putty, not water.

Because of their inherent plasticity lime mortars are made with less mixing water than composition mortars in contemporary practice.

Sand-slaking can be undertaken on a board or in a forced action or roller pan mixer.

When all the ingredients are dry, such as an NHL and sand mix, they shall be well mixed together first, before adding about three quarters of the expected amount of water. Mix thoroughly for a minimum of ten minutes, allow to stand for at least 30 minutes, before mixing again for a minimum of ten minutes and then adjusting the water content to suit bedding or pointing applications.

NHL mortars can be made more workable by adding lime putty at up to 10% of the NHL content without significantly affecting the properties of the mortar.

Normative | **Informative**

5.3 Maturing mixes

Lime mortars made from quicklime or putty shall be matured in sealed containers for a minimum of one month (and preferably four months) prior to knocking up and use.

Provided they contain no hydraulic components (such as NHLs or pozzolans) lime mortars can be kept indefinitely in sealed pails. Prolonged maturation improves workability.

Workability of NHL mortars can be improved by maturing for short periods: NHL 2 overnight, and NHL 3.5 for up to six hours. They should be kept cool.

5.4 Knocking up and adding admixtures

Matured mixes shall be returned to a mixer and thoroughly remixed without adding water. Only after thorough mixing shall lime putty, lime slurry or water be added to correct the mix for workability.

Pozzolans and any admixtures are added at this stage and not during the initial mixing; add these in slurry form, not as a dry powder.

Deliberately lean, sacrificial mixes can be made more workable by the use of air-entraining and water-retaining admixtures.

5.5 Laying masonry vs. repointing

Mortar for repointing shall be stiff, dryish, yet still plastic and workable. Wetter mixes intended for bedding shall not be used for repointing.

Repointing requires stiff dryish mixes that can be tightly compacted into the joints. In contrast, mortar for laying masonry must flow well to ensure complete coverage of the joint surfaces.

5.6 Preparation of masonry units

Masonry units shall be clean and free of salts. Recycled masonry units shall be thoroughly cleaned of old mortar residues. Porous masonry materials shall be pre-wet to control their suction prior to applying mortar. Surfaces shall be damp but not glistening.

Removal of biological growths may require use of biocides. Salts may be extracted by soaking the bricks in fresh water and changing it frequently. Residue from old mortars will block the pores of the masonry units preventing movement of binder into the surface of the masonry, which is critical for a good bond. The amount of pre-wetting will depend on the porosity of the brick or stone.

5.7 Protection of works

Protect new work from frost, rain, sun and particularly wind for a minimum of four weeks after laying masonry or repointing joints. Refer to clause 5.10 of HTC 2:2020 *Repointing with lime mort*ars for protection requirements.

5.8 Curing

Curing is critical for successful use of lime mortars. Refer to clause 5.11 of HTC 2:2020 *Repointing with lime mortars* for curing requirements.

Appendix A Documentation

A.1 Building survey

There should at least be a basic understanding of the history of the building. Was it built in stages and when? The detail required will depend on the scale, the extent of proposed repairs and changes to the building.

Undertake a close visual examination of the different elements of the building or structure with aim of determining:

- Is there a single bedding/jointing mortar?
- Or were the joints pointed with a separate mortar that differs in materials and appearance?
- Was the building tuck pointed?
- Do the joint finishes change around the building, with more elaborate finishes (e.g. tuck pointed, or ruled and pencilled) at the front, and plainer finishes (e.g. flush jointed) on side and rear walls?
- Has the building been repointed in part or whole (look for mortars of different colours and textures and joints of different widths and profiles)?
- Is there any evidence of the original pointing, which may be hidden behind downpipes or later fixtures (such as signs or meter boards) or left in difficult to reach parts, such as chimneys?
- Does the repointing match the original in materials, appearance and joint profile?

A.2 Mortar Analysis

The nature and extent of mortar analyses to be conducted will depend on the significance, complexity and circumstances of the particular project. Laboratory analyses may be needed to clarify the significance of an uncommon mortar, or to unravel a complex series of mortars and phases of repair. Mortar analyses may also be required to understand the condition and conservation needs of a building or structure.

A.2.1 Visual examination

For straightforward cases, close examination with a 10x hand lens may provide all the information required to understand the existing mortars and to design repair mixes:

- Document the shape, size and colour of the sand and any other aggregates such as shells or charcoal.
- Document the overall colour of the mortar: a grey colour may indicate the presence of cement (at least grey cement) but may also be due to the colour of the finer particles in the sand, or to the use of pigments.
- Does the mortar contain prominent white lumps of lime, which indicate its origin as a sand-slaked quicklime mortar? Or is the binder not particularly obvious (compared to the sand), which may suggest hydrated lime, cement, or composition binders?
- How does the pointing mortar (if present) differ from the bedding mortar behind?
- Document the nature of any repair mortars.

Simple scratch tests (with a screwdriver or similar tool) have been used to distinguish between a lime mortar and those containing cement. However, this method is not recommended — a well-made lime mortar may be more resistant to scratching than a poorly made or deteriorated cement or composition mortar.

A.2.2 Basic chemical analysis

Pure lime mortars can be readily disaggregated in dilute (10%) hydrochloric acid and, provided there is no carbonate mineral in the sand, the proportions of binder to sand can be determined. Acid tests should be done on a sample of unweathered mortar taken from an unobtrusive location. Dry and weigh the sample before starting the test.

The aggregate left behind should be washed, dried and weighed to determine the ratio of binder to aggregate. If the sample is large enough, the size grading of the sand can be established by screening according to AS 1141 (see clause 4.3). Determine the void ratio by measuring the amount of water required to fill the voids in a known volume of dry sand.

Any lumps of sand and binder remaining after the initial acid digestion indicate the presence of hydraulic components—hydraulic lime, pozzolan or cement—which will require more detailed analysis to distinguish between them.

Salt analyses will be needed to diagnose and manage a salt damp problem. These can be simple TDS (total dissolved solids) measurements using a conductivity meter. These tests give the total amount of soluble salt but do not identify the type(s) of salt present. Paper indicator strips can be used to identify common salts (e.g. chlorides, sulfates and nitrates).

Detailed laboratory analyses of the salts may assist in determining the nature and origin of the salt.

A.2.3 Specialised laboratory analysis

Chemical analysis of mortars should be undertaken according to AS 2701. Complex mortars (particularly those with hydraulic components) may warrant detailed examination using a combination of polarised light microscopy (petrography) and wet chemical analyses as specified in ASTM C1324-15.

Techniques are available for documenting the physical properties of existing and new mortars (e.g. porosity, permeability and bond strength). These may be required in particular circumstances such as where structural interventions are needed, or where the condition of the masonry warrants a specialised approach.

A.3 Significance

Do the existing mortars contribute to the significance of the building or structure? Original mortars and joint profiles (even if weathered with some loss of detail) contribute to the building's significance if that significance is embodied in the fabric and form of the place.

The significance of a building may relate principally, or in part, to a later phase in its history when additions saw changes to the mortars and joint profiles. The evidence of these changes should be acknowledged and retained, not removed in favour of the original.

Where changes to a building are themselves of heritage significance it is important that repair mortars should match the respective originals in materials and joint profiles so that the story of the changes remains evident in the building.

Poor quality, poorly executed repairs (e.g. mortar smeared over the face of bricks) using inappropriate materials (such as cement or non-matching sands) have a negative impact on significance. Their replacement with compatible mortars may reveal aspects of significance (by reconstructing original joint profiles), but the sympathetic repairs themselves have a neutral impact on significance.

Mortars that are significant in their own right (as distinct from forming part of a masonry assemblage) are likely to be rare and involve unusual materials or finishes. Assessment of the significance of such mortars should include comparison with other examples in the locality, state, etc.

Appendix B Condition and risk assessment

B.1 Condition

This appendix provides a basis for assessing and ranking the condition of the mortars in a building. Because of the intimate relationship between mortar and masonry units, the condition of both must be assessed to inform decisions about repair needs. Table 4 sets out a scheme for ranking condition and assigning a corresponding risk, based on five elements of masonry walls. Note that this is a condition assessment of the materials, not an engineering assessment of the structural soundness of the walls, which may also be warranted.

Table 4: Condition and risk assessment

Element	Condition	Rank / Risk
Mortar joints	Imperceptible to slight loss of surfaces	
Masonry units	Sound, no significant sign of decay	
Repairs	Compatible materials and profiles	Good / Little risk
Wall cores	Sound, no apparent losses	
Wall cavities	Sound, no losses from internal surfaces	
Mortar joints	Joints eroding in places, but generally less than 10 mm	
Masonry units	Slight decay, less than 5 mm of surface loss	
Repairs	Compatible materials, but poor aesthetics	Fair / Low risk
Wall cores	Joints not fully filled, but no losses or water penetration	
Wall cavities	Slight loss of mortar (<10 mm) from internal surfaces	
Mortar joints	Joints deeply eroded, generally more than 10 mm	
Masonry units	Moderate decay, generally more than 5 mm of surface loss	
Repairs	Incompatible materials but in a relatively benign situation	Poor / Vulnerable
Wall cores	Some voids and losses, reduced bonding, water penetration through wall	
Wall cavities	Moderate loss of mortar (>10 mm) from internal surfaces	
Mortar joints	Joints very deeply eroded, more than 30 mm	
Masonry units	Deeply decayed or lost entirely	
Repairs	Incompatible materials causing active decay	Very poor / At risk
Wall cores	Extensive voids and losses, poor bonding, water penetration through wall	
Wall cavities	Severe loss of mortar (>30 mm) from internal surfaces	

Note: condition rank and risk should be assigned based on the worst case of any one element.

B.2 Agents of decay

The following list is provided to aid identification of the agents of decay, so that correct remedial measures can be designed:

- water—as rain strike, and as drawn into walls by capillary suction (rising damp)
- salt damp—salt attack, particularly associated with rising and falling damp, but also associated with salts originally in the masonry materials
- freeze/thaw cycling—of water, but only in cold climates
- wind—prevailing winds, keeping walls wetter on the weather side (encouraging biological growths, such as lichens); and, particularly in coastal areas, adding salts to walls

- floods—saturating the base of walls, delivering salts from backed up sewers, and mobilising inherent salts
- structural movement (earthquake/settlement)—causing cracking and allowing water entry
- inherent vice—including insufficient mortar in the body of solid walls, insufficient binder in the mortar mix, poor quality sands, brick growth and corrosion of steel cramps and bond straps
- previous treatments—cleaning and paint removal by high pressure water or sand blasting; repairs using impermeable and excessively strong cement-based mortars; repairs using compatible lime mortars, but with inadequate desalination, or insufficient curing, leading to premature failures.

B.3 Extent of damage

Planning and prioritising repairs will be assisted by mapping the extent of damage around a building or structure and assigning a condition rank to each area or element as outlined in Table 4. The extent of damage can be divided into:

Small areas

- around overflowing downpipes or other water leaks
- structural cracks—single cracks and small areas of intensive cracking
- localised patches of mortar loss as a result of aggressive graffiti removal.

Large areas

- parapet and gable copings, and the 'protected' areas immediately below copings and cornices
- around the base of the building due to rising damp and associated salt attack
- on the weather side, due to prolonged wetting and coastal winds
- inherent vice, as note above
- previous treatments such as sand blasting, inappropriate repointing.

B.4 Assessing risks

When considering risks, those arising directly from condition (B.1) should be modified to take account of external risks (such as earthquakes, exposure) and risks associated with the use (or lack of use) of the place in question. Hence a building (or part of a building) classed as vulnerable might be considered at risk in an area of seismicity, or if it is abandoned or neglected. The risk assessment should inform decisions about priorities and the selection of mortar materials and mixes to be used in the repair or stabilisation of the building.

Appendix C Compliance checklist

C.1 Introduction

This appendix sets out recommendations for ensuring compliance with this Code. The specification (clause 3.9) should include provision for inspection of works, site investigations, and sampling and chemical analysis to test mortar mixes. The specification should also prescribe how non-compliant work is to be dealt with.

C.2 Site inspections and investigations

The appropriate frequency of site inspections will depend on the scale and timeframe of the project. Inspections should be sufficiently frequent to enable realistic and timely responses from the contractor undertaking the work.

Include checking and sampling of the following during site inspections:

- the raw materials (clauses 4.1–4.7 and 4.9–4.11 and Table 1)
- the mortar types and mixes (clause 4.8 and Tables 2 and 3)
- the mixing process (clauses 5.1–5.4).

Assess these work practices for their compliance:

- pre-wetting (clause 5.6)
- protection (clause 5.7)
- curing (clause 5.8).

Check the following aspects of repointing work (refer to HTC 2:2020 *Repointing with lime mortars* for details):

- cleaning the masonry, if needed
- raking and cutting out process and tools used
- depth and cleanliness of the raked-out joints
- method of packing (repointing) the joints
- finished appearance of joints, including profiles, colour and texture
- do the finished joints match the reference panels agreed at the start of works?

C.3 Sampling and chemical analysis

Sampling of the new mortar(s) may include fresh material and hardened mortar taken from different parts of the site. Chemical analysis of mortar samples may be required to confirm the nature and proportion of the constituent materials. The contract and specification should assign responsibility for conducting testing.

C.4 Non-compliant work

How non-compliant work will be managed should be clear to all parties from the beginning of the project. Responses to non-compliant work may include defecting of all materials and mixes that are found to be not as specified. In the case of repointing, work that is to be defected, e.g. because of insufficient raking out, may warrant removal and replacement of all work undertaken since the previous inspection.

Superintendents must allow for tolerances in non-complying materials and mixes. For example, to ensure workability the specification should allow for final adjustment of the mix proportions to be made by the mason on site, within set limits. Chemical analyses of mixes will need to be interpreted with this in mind.

Appendix D Performance Solution Assessment

1.0 Introduction

This appendix has been prepared to provide evidence that the repair of existing buildings using lime mortar in accordance with the Heritage Technical Code HTC 1:2020 *Lime mortars for the repair of masonry* will comply with the Performance Requirements of the Building Code of Australia (BCA).

The BCA which forms part of the National Construction Code (NCC), is adopted by the *Building Act 1993* (Act) in Victoria and contains the technical requirements for the construction of buildings. As part of the building permit process, the Relevant Building Surveyor is required to assess the proposed work for compliance with the BCA.

In most instances, the repair of buildings using the Heritage Technical Code will be deemed as maintenance work under the Act and a building permit is not required.

However, in situations where the use of lime mortar is proposed as part of the work which requires a building permit, the permit applicant can submit this appendix and Heritage Technical Code as evidence that the use of lime mortar as defined in the Heritage Technical Code is a Performance Solution which will satisfy the relevant Performance Requirements of the BCA.

1.1 Scope of Performance Solution Assessment

The Performance Solution assessment applies to the following codes:

a. Building Code of Australia, Volume One (Class 2 to 9 Buildings)
b. Building Code of Australia, Volume Two (Class 1 and 10 Buildings)

This report proceeds on the assumption that all other aspects of the building design not addressed in the Performance Solution complies with the BCA. If the building design fails to comply with the BCA, then the proposed Performance Solution may be compromised.

The assessment is limited to the matters described in the Performance Solution description. Comment is not provided on any other matter.

1.2 BCA Performance Solution Process

The *Building Act 1993* nominates the BCA as the minimum construction standard for buildings in Victoria. The BCA is a performance-based building code that has a series of Performance Requirements which must be met.

Generally there are three options for complying with the BCA Performance Requirements. The first method is the use of a Deemed-to-Satisfy Provision, the second is a Performance Solution and the third is a combination of both approaches.

The Deemed-to-Satisfy Solutions are optional methods of compliance and often fail to reflect successful construction practices commonly used by the building industry. A Performance Solution is a method of construction that is not described in the Deemed-to-Satisfy Solutions. However, it complies with the appropriate Performance Requirement.

1.3 Regulatory Application

The Relevant Building Surveyor is required to consider whether proposed building work will comply with the requirements of the Building Act and Regulations, which includes the BCA. As part of that process, there should be documentary evidence to validate that a Performance Solution complies with the relevant Performance Requirement.

This Appendix to the Heritage Technical Code, which has been prepared in accordance with BCA Part A2, provides evidence of compliance and, as such, is suitable for consideration and approval by the Relevant Building Surveyor in accordance with Part 4 of the *Building Regulations 2018*.

2.0 Performance Solution Proposal

2.1 Performance Solution description

The proposed Performance Solution is to allow the repairs to an existing building to include the use of a lime mortar complying with the Heritage Technical Code HTC 1:2020.

2.2 Reasons for the Performance Solution

The use of lime mortars is not recognised in the BCA Deemed-to-Satisfy Solutions. Therefore the system is considered to be a Performance Solution.

2.3 Performance Solution overview

Nature of proposed building work	Details to be included by Designer
Building Classification	Details to be included by Designer
Prescribed class of building work	Design of building work
Building Code of Australia, Volume One Class 2 to 9 Buildings	
Relevant Performance Requirements	BP1.1 – Structural reliability FP1.4 – Weatherproofing FP1.5 – Rising Damp
BCA Deemed-to-Satisfy Solutions	There are no Deemed-to-Satisfy Solutions for the use of lime mortars.
Building Code of Australia, Volume Two Class 1 and 10 Buildings (Housing Provisions)	
Relevant Performance Requirements	P2.1.1 – Structural stability and resistance to actions P2.2.2 – Weatherproofing P2.2.3 – Rising Damp
BCA Deemed-to-Satisfy Solutions	There are no Deemed-to-Satisfy Solutions for the use of lime mortars.
BCA Assessment method	Clause A2.2(2)(c) – Expert judgement
Details of expert judgement	Expert judgement has been used to assess the proposed Performance Solution for compliance with the BCA. The expertise of the assessor has been used to analyse the BCA Deemed-to-Satisfy Solutions and the underlying intent of the BCA to determine whether the proposed Performance Solution satisfies the BCA Performance Requirements.
Details of any tests or calculations	There have been no tests or calculations undertaken in this report.

2.4 Reference Information used in this Assessment

The following documentation has been used in the preparation of this report:

a. Building Code of Australia, Volume One, Class 2 to 9 Buildings 2019 (BCA Volume One).

b. Building Code of Australia, Volume Two, Class 1 and 10 Buildings (Housing Provisions) 2019 (BCA Volume Two).

c. AS 3700:2018. *Masonry structures*. Standards Australia, NSW.

d. AS 4773.2:2015. *Masonry in small buildings, Part 2: Construction*. Standards Australia, NSW.

e. Young, D. 2008. *Salt attack and rising damp: a guide to salt damp in historic and older buildings*. Heritage Council of NSW, South Australian Department for Environment and Heritage, Adelaide City Council, Heritage Victoria, Melbourne.

f. Young, D. 2020. *Mortars: materials, mixes and methods — a guide to repointing mortar joints in older buildings*. Heritage Councils of Victoria, New South Wales, Queensland, South Australia, Tasmania, and Western Australia.

3.0 Performance Solution Assessment

3.1 BCA comparative analysis

3.1.1 Introduction

The BCA under clause A2 requires a comparative assessment to be undertaken between the proposed Performance Solution and any associated Deemed-to-Satisfy Solutions and Performance Requirements. This is achieved by analysing:

a. The Deemed-to-Satisfy Solutions (clause A2.4(3)(a));

b. Direct Performance Requirements (clause A2.4(3)(b)); and

c. Indirect Performance Requirements (clause A2.4(3)(c)).

The intent of this process is to identify the Deemed-to-Satisfy Solutions/s (in some instances there may be no Deemed-to-Satisfy Solutions) and the relevant Performance Requirements that relate to the Performance Solution.

The BCA assessment process also requires consideration to be given to the impact on any associated Performance Requirements that may occur if the Performance Solution is adopted.

3.1.2 Deemed-to-Satisfy Solutions

There are no BCA Deemed-to-Satisfy Solutions for the use of lime mortars.

3.1.3 Direct Performance Requirements

The following is a summary of the relevant Performance Requirements that relate to the proposed Performance Solution:

A. Structural reliability, stability and resistance

The relevant BCA structural Performance Requirements Performances that apply to the proposed Performance Solution are in BP1.1 (BCA Volume One) and P2.1.1 (BCA Volume Two).

The Performance Requirement requires the building to achieve an acceptable level of structural performance:

1. So that the structure will remain stable and not collapse; and
2. Minimise local damage and loss of amenity through excessive deformation or degradation.

B. Weatherproofing and Rising damp:

Interpretation – Weatherproofing:

The relevant BCA weatherproofing Performance Requirements Performances that apply to the proposed Performance Solution are in clause FP1.4 (BCA Volume One) and P2.2.2 (BCA Volume Two).

The Performance Requirements are designed to ensure that the external walls are designed to restrict water from entering the building. The reasons for this are to:

1. Prevent moisture from creating unhealthy conditions for the building occupants.
2. Prevent dampness from causing deterioration of the building elements.

Interpretation – Rising damp:

The relevant BCA rising damp Performance Requirements Performances that apply to the proposed Performance Solution are in FP1.5 (BCA Volume One) and P2.2.3 (BCA Volume Two).

The Performance Requirement is designed to restrict ground moisture from reaching the upper levels of masonry. The reasons for this are the same as those for weatherproofing.

It is important to note that the walls are simply required to be weatherproof and not waterproof, which assumes that some dampness will occur and is acceptable provided it does not cause structural failure and unhealthy conditions for the occupants.

3.1.4 Related Performance Requirements

BCA clauses A2.2(3) and A2.4(3) requires the Performance Requirements in other Sections or Parts of the BCA that are relevant to the proposed Performance Solution to be analysed to determine if there will be a negative impact if the Performance Solution is approved.

The assessment has identified that there are no Performance Requirements that will be affected in a significant manner if the proposed Performance Solution is approved. This is due to the proposed Performance Solution achieving an equivalent level of performance to that achieved by utilising the Deemed-to-Satisfy Solutions. Accordingly, the impact of the Performance Solution on other BCA Performance Requirements will be negligible.

3.2 Performance Solution Assessment

3.2.1 Preliminary

As required by BCA clause A2.2(2) the following is an assessment of the Performance Solution and provides evidence as to why the proposal should be accepted as meeting the Performance Requirement.

3.2.2 Assessment Method

The Performance Solution is assessed using Expert Judgement, which is an accepted method under BCA, clause A2.2(2)(c).

Consideration has also been given to comparing the proposed Performance Solution against the level of function required under the BCA Deemed-to-Satisfy Solutions. This is a recognised approach under clause A2.2(1)(b) which explains that if the proposed design is at least equivalent to the Deemed-to-Satisfy Solutions then the design is deemed to meet the Performance Requirement.

3.2.3 Supporting evidence

The following evidence has been used in considering this Assessment:

a. Historical evidence as defined in previous government sanctioned construction standards. These standards have worked successfully in Victoria as reflected in the performance of buildings constructed using these standards.

b. Evidence of the long-term performance of older buildings.

3.2.4 Reasons to accept the Performance Solution

3.2.4.1 Historical use of proposed system

The proposed Performance Solution is based on “old” building systems previously enshrined in legislation and traditional practices which are still being used in Victoria and nationally in traditional and cultural heritage building practice.

Justification for the acceptance of these “old” systems is based on a satisfactory level of performance, which is clearly exhibited in the functionality of existing building stock. The number of existing buildings that have been constructed using traditional lime mortar and still maintaining the safety, weather-tightness, amenity and health for the building occupants supports the ongoing use of lime mortar in the repair and construction of buildings.

3.2.4.2 Status of Heritage Technical Code

Many current construction standards are not appropriate for heritage buildings. The application of some of these construction practices may cause unacceptable and irreversible damage to the existing building fabric.

In order to address this issue the Heritage Council of Victoria have implemented a process to codify and formalise traditional practices so that they can be adopted as part of the BCA and associated building legislation approval process. They are also suitable for other legislative purposes and building contract documentation.

The Heritage Technical Codes have been written by experts in the particular discipline and if followed will achieve acceptable construction outcomes and comply with the BCA.

3.2.4.3 Expert development and peer review

The Heritage Technical Code has been developed by David Young OAM, BAppSc, M.ICOMOS. With a background in geology, David Young has specialised in the nature and performance of masonry materials in historic buildings. He has forty years' experience in the conservation of heritage buildings and sites around Australia. He is a past member of the South Australian Heritage Committee (now Council), the NSW Heritage Council's Technical Advisory Group and the Heritage Council of Victoria's Technical Advisory Committee. He is the author of detailed technical guides on mortars and repointing, and on salt attack and rising damp, which are published by State Heritage Councils.

The Code has been endorsed by the Heritage Council of Victoria following review by its Heritage Fabric Specialist Committee and Heritage Victoria and it has been determined that the code is suitable for publication.

The expertise and assessment are considered to be consistent with BCA clause A5.2(1)(e) and A5.2(1)(f) Evidence of suitability.

The development and peer review process provide confirmation that the Heritage Technical Code will satisfy the relevant requirements of the Building Code of Australia.

3.3 Conclusion

This Assessment conducted in accordance with Part A2 of the BCA concludes that the use of mortar complying with Heritage Technical Code HTC 1:2020 is acceptable for the repair of buildings and meets BCA Volume One and Two Performance Requirements for structural stability weatherproofing and rising damp as:

a. The Heritage Technical Code HTC 1:2020 has been developed by experts in masonry construction and is considered to provide a level of performance equivalent to the BCA Deemed-to-Satisfy Solutions.

b. Historically, buildings using lime mortar have performed successfully. These buildings continue to perform with acceptable levels of safety, serviceability and amenity which provide conclusive proof of the suitability of the proposed Performance Solution.

3.4 Report Conditions

The following conditions apply to this report and must be adopted. A failure to adopt these conditions will mean that the report is no longer valid.

a. The report (including any report conditions) is to be approved by the relevant building surveyor as part of the building permit documentation.

b. The building is to be constructed in accordance with the Performance Solution, report conditions and the design documentation as detailed in this report.

c. The architectural drawings and specifications are to be amended as necessary to align with the Performance Solution and the design documented in this report.

d. The lime mortar system is limited to the repair of existing buildings.

Note: Lime mortars, particularly those with hydraulic properties, may be appropriate for new building work. However, the mortar design and structural parameters would need to be specified by competent structural engineers with appropriate experience in lime mortar use. Assessment using Australian Standard AS 3700 and AS 4773 Parts 1 and 2 are not appropriate as these standards do not recognise the use of lime mortars.

a. The level of weatherproofing achieved by the remedial work using lime mortars will be consistent with the existing use of the wall.

Note: If the existing wall use is to be changed as part of the building work (i.e. from a non-habitable room to a habitable room), the level of weatherproofing will need to be investigated to determine the need for any additional measures such as cavity wall construction or applied wall treatments.

Note: The failure to apply these conditions will make the assessment void and the report can no longer be relied upon to confirm compliance with the BCA.

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