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**A Code of Practice for the Petrographic Examination of
Mortars, Plasters, Renders and Related Materials.**

Applied Petrography Group

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on behalf of the

Applied Petrography Group.

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Foreword

Lime binders in mortar and concrete were replaced progressively by cement during the 19th Century and since the early 20th Century have been uncommon in UK building materials. As a result many petrographers who are experienced in the petrographic examination of concrete might not be aware of issues relevant to the analysis of lime-based materials.

The heterogeneity of many lime based construction materials, in particular in historic buildings or structures with small batch sizes and use of local materials, means that quantitative analysis is prone to significant error when compared to analysis of modern concrete samples. For this reason this document includes discussion of both microscopic and macroscopic analysis techniques.

Petrographic examination of such materials should form part of a suite of analyses including macroscopic inspection and assessment of the context in which the sample has been taken. There are few situations where a petrographic examination in isolation will be sufficient to address an issue concerning construction materials.

Other techniques, such as mineralogical analysis by X-ray diffraction, elemental analysis by X-ray fluorescence or chemical methods and examination by scanning electron microscopy, might be used as part of the suite of methods, if appropriate. Laboratory analysis of mortars and their constituents are covered by British Standard BS 4551, with reference to additional documents such as BS 890, BS 6463, European Standard documents prEN 459 and EN 13139 and American Society for Testing and Materials ASTM C1324.

The terms mortar, plaster and render commonly refer to binder / aggregate mixes produced for a range of building purposes. In the following sections of this document, the word mortar is used to describe a binder / aggregate mixture regardless of origin or function.

Sections in the Code of Practice that cover sample investigation contain a listing of which features should be examined at each stage of analysis and a discussion of some of the problematic issues associated with investigation of mortars and other similar materials.

This Code of Practice is one of three being drafted by the Applied Petrography Group. The other two cover the petrographic examination of cement based materials and aggregates.

1. AIMS

This Code of Practice describes methods for the microscopical examination of lime based mortars, renders, plasters and other building materials. Suggested procedures are given for the preparation of thin sections and for the techniques of examining thin sections with the petrological microscope. In many cases the equipment used and preparation techniques are similar to those used in examination of samples of concrete. Some aspects of sampling and examination, however, require additional information to ensure that the analysis is of maximum benefit.

2 EQUIPMENT

2.1 Equipment for thin section preparation

2.1.1 Diamond saws

Two diamond saws with water-based lubricant are desirable, one with a large diameter cutting wheel (~500 mm diameter) and one with a small diameter cutting wheel (<300 mm diameter). A narrow bladed (<1 mm thick), oil-lubricated trim saw is also useful for cutting fragile specimens and for cutting off flattened specimens mounted onto glass slides.

2.1.2 Vacuum impregnation equipment

A vacuum chamber capable of containing large samples up to 5 kg, with means of introducing epoxy resin after the sample is evacuated is required.

2.1.3 Polishing, lapping and grinding equipment

A very wide range of grinding and polishing equipment is available. The following types of grinding and polishing equipment are in common use in the UK but other equally suitable types of equipment are in use elsewhere in Europe and the USA. A petrographic preparation laboratory will require an appropriate combination of the following items of equipment:

- High-speed vertical spindle grinding wheel with diamond abrasive bonded in brass. This can be oil or water lubricated. This can be used for rapid grinding and fine diamond grinding wheels lubricated with oil are suitable for flattening impregnated specimens prior to polishing.
- Lapping machines fitted with resin-bonded diamond abrasive pads. These can be used in the same way as the high-speed vertical-spindle grinding wheel and the coarser grades are suitable for rapid stock removal and the finer grades are suitable for polishing. They can be used with either oil or water abrasive.
- Lapping machines with cast iron lapping plates and with a controlled abrasive slurry feed. Common abrasives include carborundum and aluminium oxide. Suitable grinding medium would be oil or water. The water-lubricated laps are suitable for the production of large-area polished plates and the oil lubricated laps can be used to flatten impregnated specimens prior to mounting on glass for thin sectioning.
- Vacuum chucks such as those manufactured by Logitec to be used in conjunction with an oil-lubricated lapping machine for the controlled grinding of thin sections to thicknesses of down to about 4.0 µm.

- Plate glass sheet to be used for final hand finishing of thin sections using an oil / carborundum abrasive slurry.
- Polishing machines with felt pads for use with abrasive diamond pastes for polishing to a mirror finish suitable for reflected light examination and for quantitative SEM microanalysis.

2.1.4 Ovens

For drying of samples prior to preparation a temperature of $70^{\circ}\text{C} \pm 5^{\circ}\text{C}$ (or 40°C if the binder contains gypsum) is recommended. Elevated temperatures of curing are required for some types of epoxy resin. The curing of such resins should be carried out at temperatures not exceeding 45°C . Ovens of this type are also suitable for drying specimens prior to their vacuum impregnation with epoxy resin.

2.1.5 Cleaning equipment

An ultrasonic cleaning bath is useful for the cleaning of impregnated and polished surfaces.

2.1.6 Consumables

Common materials used in the UK for the preparation of thin sections would include the following:

- Low viscosity epoxy resin for vacuum impregnation of samples. Some cure exothermically and need to be kept cool during curing if used in large volumes. Some need slightly elevated temperatures (no more than 45°C to cure).
- Fluorescent dye that can be dissolved in epoxy resin. Note these are not commonly used in Petrographic examination of mortars, etc.
- Coloured dyes that can be dissolved in epoxy resin.
- Solvents for cleaning purposes such as petroleum spirit, acetone and methylated spirits.
- Coolant other than water such as cutting oil.
- UV-Curing adhesive for mounting and covering of thin sections.
- Carborundum abrasive of various grades. One of the most commonly used grades would be 600-grade.

2.2 Equipment for the petrographic examination of samples

2.2.1 Essential equipment

These items are indispensable and need to be of high quality:

- A zoom stereo binocular microscope with magnification of at least x40.
- A high quality petrological photomicroscope with magnification of at least x500 fitted with a digital camera.
- A point counting stage for the petrological microscope to enable point counting of thin sections.

2.2.2 Recommended equipment

For more detailed petrographic studies, the following equipment is desirable:

- A petrological microscope with the facility to work in reflected as well as transmitted light.
- Point counting equipment for the measurement of the air (void) content of hardened in accordance with ASTM C457.
- A petrological microscope with appropriate filters and light source allowing the ability to carry out fluorescence observations in either reflected or transmitted light.

2.2.3 Specialist equipment

The following equipment can be used in conjunction with more conventional petrographic techniques to investigate some of the more detailed aspects of mortar composition and deterioration:

- A scanning electron microscope (SEM) with X-ray microanalysis capability for examining uncovered thin sections, broken surfaces or specially prepared polished surfaces.
- X-ray diffraction equipment is useful for identifying the composition of complex binders, reaction products of chemical attack and identifying deleterious materials in aggregates.
- An infra-red spectrometer can be used to determine the presence of some types of organic admixtures.

3. SAMPLING

Diamond core drilling, or samples taken in lump form are both appropriate. It should be noted, however, that in the case of historic construction the heterogeneity of the material can be far greater than that of modern buildings. Great care should, therefore, be taken in selecting a sample or samples for analysis. Sampling should as far as possible follow the methods described in section 3 of the APG Code of Practice for Petrographic Examination of Concrete, BS 4551: Part 2, or other appropriate standard.

Ideally, there should be discussion with professionals to determine the reasons for sampling and the information required. Such issues are covered in Building Research Establishment (BRE 1995), Ellis (2002), English Heritage (1988) and Historic Scotland (1995 & 2007).

During the site visit as much information as possible should be gained regarding the sample and its context within the building. The function of the sample in the structure, the type of mortar (pointing, plaster, render, etc.) and the condition of the material should be described. Other data of value include (where relevant):

- The location of the sample in the structure
- The aspect of the wall
- The location and soundness of rainwater goods
- Sources of heat within the building
- Original sources of materials
- The repair history
- The condition of surrounding materials

The age of the sample, if known, along with any historical information relating to the building / structure, or specific area, such as exposure to fire, blast damage, etc., will all aid the petrographer in the interpretation of their observations. If sampled by a third party, photographs of the structure and the sample location will also be of value.

Sample size is difficult to specify and there might be constraints of how much material may be removed through building type or considerations of conservation aesthetics. As historic mortars can contain coarse-grained aggregate and quantities of unmixed binder larger samples than those commonly obtained through diamond core drilling might be required. An important point to emphasise if samples are to be taken by a third party is that samples comprising powder (sampled by abrasion causing disaggregation of the mortar) are of limited use. It is often advisable to obtain more than one sample to ensure that the report will be applicable to the materials in the building / structure under investigation. This is of particular importance if the structure has been extended, modified or repaired.

Selection of a sub-sample for thin sectioning is also dependant in part on the reasons for analysis. Commonly a sample will be analysed with the intention of examining the mortar / air or mortar / stone interface, in which case the thin section will be cut perpendicular to this interface. It is therefore recommended that samples include a part of the adjoining masonry material (stone or brick in the case of bedding and jointing mortars), and cross-layer interfaces (in the case of plasters, renders and pointing mortars).

In examining older mortars it is of value to take note of the geology in the area that the building / structure is situated, or, if known, the source of the lime. There are few limestone sources in the north of the UK that produced pure, high calcium limes. Many limestones in the UK contain a proportion of dolomite.

4. MACROSCOPIC ANALYSIS

4.1 Features to be described (see Section 9, Table 1)

During examination of the hand specimen all samples should be described in terms of:

- 4.1.1 Condition of the external surface and other interfaces
- 4.1.2 Any evidence for damage or degradation to the sample including surfaces and interfaces
- 4.1.3 Size and distribution of fractures
- 4.1.4 Size and distribution of aggregate grains
- 4.1.5 Condition of the binder (paste) including the presence of relict limestone and relict fuel
- 4.1.6 Colour of the mortar (Munsell[©] Color if possible)

4.2 Discussion

The function of the sample should be described with respect to the observations made in section 3. This is best determined in macroscopic analysis as a thin section might provide no information on sample origins.

In wall coverings the number of coats and the thickness of each coat should be measured and the bond at each interface assessed. The presence of admixtures or additives should be noted and a visual estimate of the proportions made. If hair, straw or other fibres are present then their distribution throughout the mortar should be noted along with their orientation relative to any interfaces. A description of the condition of such fibres e.g. brittle, denatured, replaced by calcite or gypsum can also be of value.

In lime based materials the amount of carbonation can be examined using a solution of Phenolphthalein¹ (Vogel, 1948). This reacts with calcium hydroxide to give a strong pink colouration. This is commonly of use in modern materials but uncarbonated calcium hydroxide has been found in dense mortars in excess of 100 years old. An assessment of carbonation should only be made using a freshly exposed, clean surface or an uncovered thin section as contamination from other building materials is a common problem.

The hydraulicity of the binder (i.e. the amount of chemical set) is best assessed by a combination of hand specimen and thin section examination (ASTM C25-06, Crisci et al., 2004). There might not always appear to be a clear relationship between binder microstructure and hydraulic content, but this is dependant on the sample condition.

¹ A solution comprising 1g phenolphthalein, 100ml of ethyl alcohol and 100ml water.

Additional analysis, such as by XRD XRF and SEM or quantification of soluble silica content, might assist in clarifying situations where doubt exists.

The use of polished surface examination is more common in the analysis of concrete and the method is described in sections 4.1 and 5.3 of the Code of Practice for Petrographic Examination of Concrete.

5 THIN SECTION PREPARATION

5.1 Introduction

This section provides a description of a possible method for thin section preparation. This method of preparation is commonly employed in the UK, however it should be noted that many other procedures and types of equipment are available. For all methods employed it is essential that the following precautions be taken:

- 5.1.1 Excessive heating (temperatures of $>45^{\circ}\text{C}$) is avoided during the preparation of the thin sections.
- 5.1.2 Exposure to water should be kept to a minimum in order to avoid the occurrence of secondary hydration and the loss of water soluble compounds from the sample.

5.2 Preliminary impregnation and cutting

In most cases it is possible to carry out initial cutting using a water-lubricated large diameter diamond saw. In the case of very weak or friable samples, such those affected by fire damage or acid attack, it is essential that the sample surface be vacuum impregnated with resin in order to consolidate the surfaces prior to any cutting being carried out.

It is desirable that the final states of cutting be carried out using a precision small-diameter saw in order to minimise the amount of damage in the cut surface that needs to be removed prior to mounting on to glass microscope slide.

5.3 Impregnation

In order to produce high quality polished surfaces – particularly if the sample is very porous – it is essential that the sample be vacuum impregnated with a low viscosity epoxy resin prior to polishing and grinding. The use of a coloured dye is recommended in order to assist in the determination of porosity and microcracking. Fluorescent dyes may also be employed for this purpose. The most effective means of impregnation is to place the sample in a vacuum chamber and evacuate prior to the introduction of the impregnating resin.

5.4 Initial lapping

Prior to mounting the specimen on to a glass slide, it is necessary to remove the damage introduced into the surface of the sample during cutting. This is generally done using a combination of grinding and lapping to produce a high quality optically flat surface that can be bonded on to a glass microscope slide.

5.5 Mounting onto glass slides

The flattened specimen should be fully cleaned – preferably using an ultrasonic cleaning bath and a solvent such as petroleum spirit. The polished surface should then be wiped over with a soft tissue using a solvent such as methylated spirits or acetone. The cleaned surface is then bonded on to a frosted glass slide using a UV-curing

adhesive. It is important in mounting the specimen on to the glass that the thickness of the bond is of a controlled thickness and is kept to a minimum under the specimen.

5.6 Removal of excess material

Once bonded on to glass the specimen is then ready for the excess material to be cut off. This is done using a precision, oil lubricated diamond saw and when complete should leave a section thickness of the order of 1mm.

5.7 Final lapping

The thin sample is then ground down in stages to a thickness of approximately 150 to 200 μm using diamond surface-grinding equipment lubricated by oil. Further lapping using a precision vacuum chuck is used to take the section to a thickness of about 40 μm if it is to be hand finished. With some types of equipment it is possible to take the thin section down to its final thickness using very fine diamond grinding wheels.

5.8 Hand finishing

Using a petrological microscope to measure the thickness of the thin section the section can be hand finished down to its final thickness of 25 – 30 μm . The birefringence of quartz particles present in the aggregate commonly provides a convenient way of judging the thickness of the thin section during hand finishing.

5.9 Covering

It is important that on completion the final section be thoroughly cleaned and then covered using a glass cover slip. This is to prevent damage to the sample after its preparation and is also important to reduce light scattering during the examination of the thin section.

6. PETROGRAPHIC ANALYSIS

6.1 Features to be described (see Section 9, Tables 2 & 3)

- 6.1.1 Details of the minerals and rock types present within the aggregate
- 6.1.2 The size distribution of the aggregate
- 6.1.3 Any potential deleterious reactions associated with the aggregate
- 6.1.4 Details of the type, condition, crystallinity, and if present degradation of the binder
- 6.1.5 Evidence for relict limestone and relict fuel
- 6.1.6 Pore (void) sizes and distribution

6.2 Discussion

At least one thin section and preferably more depending on the specific objectives of the investigation should be prepared for each sample as appropriate and each thin section should measure ideally 45 x 70 mm. The location and number of thin sections required should be decided by the petrographer during the preliminary macroscopic examination of the samples. However it is often advantageous that at least one section be made from a plate cut at right angles to the external surface of the sample, so that the outer ~70 mm are included in the section. Pore geometry should be noted as there is some evidence that pore shape evolves over time.

The heterogeneity of historic building materials is such that quantitative analysis (i.e. point counting) should be used only if considered essential to the examination (ASTM C457, Leslie & Gibbons, 2000).

Binders made using gypsum (calcium sulphate hydrate) or a mixture of gypsum and calcite are difficult to identify in thin section unless there is recrystallisation of coarse crystalline gypsum within binder cavities. Gypsum rich binders are relatively easy to identify in hand specimen. If there is a need to identify microcrystalline gypsum within a binder then a stain using mercuric nitrate can be used.

Binders with a clay component (i.e. where unburned clay was used either exclusively as the binder material or mixed with lime) require the application of additional analysis techniques. The mineralogy can be determined by employing XRD analysis and this is often assisted by the examination of recovered residue following a simple acid dissolution of any lime binder component.

The use of organic additives in lime based binders cannot be identified in thin section. However it is not uncommon to distinguish the effects of the presence of organic components in the mortar. Simple spot tests using oxidising agents and the textural

appearance in thin section might highlight the presence of organic material but identification of the form of the component present will require the use of complex analysis. It must also be born in mind that organic materials are prone to degradation and the residual components detected may not be representative of those added.

Care should be taken to identify areas of binder where there has been either dissolution or re-precipitation of calcium carbonate. The mobilisation of calcium carbonate binder is a common occurrence in lime-based materials and can cause a significant change in the bulk chemical composition of the sample (Leslie & Hughes, 2002). If this is not identified then there is a risk of significant error in the reporting of mortar composition. This mobilisation cannot be identified through wet chemical analysis and petrographic analysis is required to ascertain the dissolution and reprecipitation of binder.

These comments are equally applicable to dolomitic and gypsiferous binders. Where reprecipitation occurs, caution should be exercised not to misinterpret the result of chemical attack such as those produced by externally derived sulphates.

In addition to dissolution and reprecipitation of binder, the method of production of a mortar can lead to differences in the quantity of unmixed binder material. Mortars produced by mixing calcium oxide (quicklime) and damp aggregate commonly contain high proportions of unmixed binder in the form of lime inclusions which effectively form part of the aggregate.

The mortar aggregate analysis should be carried out in accordance with BS 812:103 and the APG Code of Practice for the petrographic examination of aggregate.

Other materials in a mortar might include additions of fibres such as hair (particularly common in internal plaster work, brick dust or other pozzolanic materials (Gibbons, 1997) and impurities from the kiln in the form of relict fuel and relict limestone (either under burnt or over burnt) might also be present (Leslie & Hughes, 2005).

7. QUANTIFICATION

Materials can be (semi-) quantified in thin section examination providing sufficient sample material is available.

If necessary quantification of binder and aggregate proportions can be made using point counting in the modified procedure described in ASTM C457 and the RILEM method for quantification of binder and aggregate proportions (RILEM, 2000, 2001). Determination of the water / cement ratio is not commonly carried out in analysis of lime-based mortars.

In historic materials an additional complication lies in the variety of ways in which binder could be mixed with aggregate. The different forms of lime all have different densities (see Table 4) making conversion of weight proportions to volume proportions prone to significant error.

Petrographic examination of a material in thin section is an ideal method at arriving at the character of a mortar and also allows an assessment of its past and future, performance. Consideration of the aggregate type and range of grain sizes, along with binder type, will assist in the interpretation of the results reported from standard chemical analysis, particularly where there is some ambiguity in the relationship between composition and visual appearance or performance.

8. REPORTING

A report should include the following information. It is recommended that the data are recorded in table form as shown in section 9 of this document.

- A qualitative description of the mortar function, composition, and structure derived from macroscopic examination.
- A qualitative description of the binder composition and structure, aggregate composition, interfaces within the sample and the relationship between binder and aggregate derived from microscopic examination.
- Where appropriate a semi-quantitative determination of the proportion of constituents.
- Reference to additional analysis methods used and / or recommendations for further work to be carried out.
- If appropriate, comment may be given on the age of the sample, its response to exposure / weathering, etc, and if required guidance given on its conservation, replication or the design of a compatible restoration mortar.

9. EXAMPLE TABLES FOR THE COLLECTION OF PETROGRAPHIC DATA

Table 1: Macroscopic features

Laboratory ref.
Sample ref.
Sample preparation details
Sample dimensions:
Core diameter (mm)
Core length (mm)
Number of pieces
Description of outer surface
Description of inner surfaces and other interfaces
Binder colour
Binder texture
Lime inclusions:
Size
Proportion of binder
Coarse cracking: (>0.1 mm wide)
Fine cracking: (0.01-0.10 mm)
Carbonation: Typical depth (mm)
Coarse aggregate distribution:
Measured / estimated porosity (voids) (Vol. %)

Supplementary notes:

Table 2: Petrographic description of the aggregate

Laboratory ref.	
Sample ref.	
Coarse aggregate:	
Maximum size (mm)	
Typical shape	
Major rock / mineral types	
Minor rock / mineral types	
Trace rock / mineral types	
Fine aggregate:	
Grading (estimated BS 882 (fine-medium-coarse) grading classification)	
Maximum size (mm)	
Typical shape	
Major rock / mineral types	
Minor rock / mineral types	
Trace rock / mineral types	
Evidence for aggregate reactions (e.g. alkali reaction, unstable slag, pyrite)	
Aggregate surface details (include evidence for aggregate shrinkage, DEF or AAR)	
Artificial aggregate (e.g. brick, slag, clinker)	
Other material (e.g. hair, straw)	

Table 3: Petrographic description of the binder

Laboratory ref.	
Sample ref.	
Binder type	
Binder texture (details of porosity, grain size)	
Portlandite (approx. vol.% of binder)	
Lime inclusions	
Size	
Texture	
Vol. % of binder	
Porosity (voids)	
General vol. %	
Porosity distribution	
Micro cracking	
Void fillings and abundance	

Table 4: Compositional data (optional)

Laboratory ref.	
Sample ref.	
VOLUME PROPORTIONS:	
Binder (set) %	
Fine aggregate %	
Coarse aggregate %	
Porosity (voids) %	
Form in which binder was mixed (if known)	
Binder constituents	
WEIGHT PROPORTIONS:	
Fine aggregate (kg/m ³)	
Coarse aggregate (kg/m ³)	
Binder (unset) ¹ (kg/m ³)	
Water (kg/m ³)	
Aggregate / binder ratio	
Binder content (Wt. %) ²	

1 Note different and approximate densities of lime binder in the form of putty ($\geq 1350 \text{ kg/m}^3$) dry hydrate (1000 kg/m^3) and quicklime ($< 900 \text{ kg/m}^3$).

2 Calculated on an equivalent oven dried basis.

10. REFERENCES

ASTM C25-06 Standard Test Methods for Chemical Analysis of Limestone, Quicklime, and Hydrated Lime

ASTM C 457 Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete

ASTM C1324-05 Standard Test Method for Examination and Analysis of Hardened Masonry Mortar

BRE 1995 *Assessing external rendering for replacement or repair*. BRE.

BS 812 : 103 Testing aggregates. Method for determination of particle size distribution.

BS 890 Building limes

BS 4551: Part 2 Methods of testing mortars, screeds and plasters. Chemical analysis and aggregate grading

BS 6463 : 103 Quicklime, hydrated lime and natural calcium carbonate. Methods for physical testing

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11. DEFINITIONS²

(See also the *Glossary of terms used in petrographic examination of building materials produced by the APG.*)

In addition to those given below further definitions are given in the codes of practice covering cements and aggregates.

Aggregate Any material which, when combined with a binder, forms a mortar. This can include sand, crushed rock, brick dust or other mineral fillers.

Binder A material such as lime, gypsum, clay, cement, etc, or a combination of two or more which binds together aggregate particles.

Builders lime Non hydraulic, powdered dry hydrate lime, available in building suppliers.

Carbonation The process of transformation of lime (calcium hydroxide) to calcite (calcium carbonate) through loss of water and absorption of carbon dioxide. This process creates a set in a lime mortar but can be deleterious in concrete.

Cement Commonly taken to be the modern, commercially available binder known as OPC, or Ordinary Portland Cement, or a modified cement to BS EN197-1, the main component of which is produced by burning calcium carbonate and clay at high temperatures. Less common, but occasionally encountered in specific situations are proprietary blends, containing modifiers and organic components, and High Alumina Cements (HAC).

Cracking: Cracks are classified using the following terms:

- **Macrocrack:** These are cracks that are readily visible to the naked eye without the aid of a stereo binocular microscope and are typically >0.10 mm wide.
- **Macroscopic cracks:** These cracks are visible in the hand specimen or with the aid of a stereo binocular microscope and are typically >0.01 mm wide.
- **Fine crack:** These are cracks that are only readily visible with a stereo binocular microscope or in thin section. Cracks of this type are typically between 0.01 and 0.10 mm wide.
- **Microcracking:** These cracks cannot be detected with a stereo binocular microscope. They are typically <0.01 mm wide and are most easily seen in petrographic thin sections containing stained or fluorescent resins.

Dolomitic lime Lime derived from dolomite (mainly consisting of calcium and magnesium oxide, typically 35 to 45% by weight magnesium carbonate).

Dry hydrate A binder in which calcium oxide (quicklime) has been hydrated with sufficient water to form calcium hydroxide in the form of a dry powder.

² See also the Glossary of Terms in the *Code of Practice for the Petrographic Examination of Building Materials* produced by the APG.

Flooring / screeds / lime concrete Similar in function to flooring produced by cement based materials. Some floor surfaces described as lime / ash floors are in fact gypsum / ash floors, produced using calcium sulphate binders.

Hardburned lime Quicklime that has been exposed to prolonged calcination and that might be poorly reactive as a result. Also known as over burnt lime.

Hydrated lime Lime that has been hydrated either with sufficient water to form calcium hydroxide in the form of a powder or with excess water to form a putty.

Hydraulic lime Impure lime containing clays or other materials that give a mortar a chemical set that is commonly quicker than the carbonation of pure, non-hydraulic lime. The strength of the chemical set can depend on the quantity of clays, etc., but also on the conditions of manufacture. Natural cement is a particularly strong variant of a hydraulic lime. Hydraulic limes cannot be stored in the form of putty as in the aqueous environment the chemical set will take place.

Lime (non-hydraulic) Pure lime containing only calcium hydroxide, also known as fat lime, air lime, or high lime.

Lime putty A form of non-hydraulic lime in which calcium oxide (quicklime) has been hydrated with excess water to form soft, workable putty.

Macroscopic This is a general term referring to features that are visible to the naked eye or with the aid of a stereo microscope.

Magnesian lime Lime derived from calcite containing more than 5% by weight of magnesium oxide (typically 5 to 35%).

Mortar A general term for a binder / aggregate mix used in construction. More specifically the term mortar refers to a mix used to bed masonry blocks (pointing) or to fill a cavity between two masonry leaves (wall core). Aggregate can vary in grain size from a fine powder (<0.1 mm) filling 1-2 mm joints between ashlar masonry to coarse gravel (>50 mm) in wall core.

Natural cement Natural cements are hydraulic cements produced by mining and burning deposits of limestone and clay with a specific chemical composition within a narrow range. Strength and uniformity of natural cements are lower than for Portland cements. Natural cements were common in 19th and early 20th century construction until superseded by Portland cement.

Plaster A wall covering commonly referring to internal surfaces, but which can in some parts of the UK refer to external coverings worked to a smooth surface. Internal plasters commonly, but not always, contain gypsum (calcium sulphate hydrate) as a component of the binder.

Portland cement Portland cement is the most common form of binder used in concrete and is manufactured from the burning of limestone and an alumino-silicate rock (clay or shale) at temperatures of up to 1500°C. There are many forms of

Portland cement and it is commonly possible to distinguish sulphate-resisting and white Portland cement and ordinary Portland cement using petrographic thin sections.

Pozzolan A material containing reactive minerals that when added to a lime mortar give a chemical set. Pozzolans can be natural (volcanic ash, siliceous clays) or manufactured (brick dust, fuel ash).

Render A wall covering commonly referring to external surfaces. The covering can be smooth but also can have an application of gravel as the outer layer. The latter can be in the form of a 'wet dash', in which the aggregate is applied coated in a binding slurry (lime or cement) or as a 'dry dash', where the aggregates are thrown onto, and partially embedded in, the fresh, smoothed render finishing coat.

Roman cement A natural hydraulic limes produced by the burning of limestones containing clay materials and/or nodules of silica. The name was adopted because the distinctive brown colouration which resembled mortars of the Roman period.

Quicklime Calcium oxide, produced by burning calcium carbonate at a temperature of approximately 950°C.