# Learning Text

# Part 12

# Properties of Rendering Mortar

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## Introduction

This learning text considers the role played by rendering mortar as an element of masonry construction and complements the MIA learning text on masonry mortar (Learning 6: Masonry Mortar). The current situation with regard to specifying rendering mortar is reviewed and the various properties of rendering mortar in the fresh and hardened state are discussed. An overview of rendered finishes is given and a glossary of terms and bibliography are provided, the final section of this learning text is self-assessment questions and answers.

A render is a mortar consisting basically of cement and fine aggregate, usually together with lime or a plasticizer, which is applied to a wall surface, generally in two or more coats. When correctly matched with the background, the hardened render provides a durable weather resistant finish that will enhance the surface of a building.

Rendering is a traditional craft that has evolved over many centuries. Originally wattle and daub was used to fill gaps in walls constructed from wood or stone, to minimise the ingress of wind and rain. A drawback of these early mortars was their inability to prevent the ingress of water, which was partially compensated for by having roof overhangs and adequate drainage at the base of the wall. The development of Portland cement led to a mixture of cement and sand being applied to the external walls of structures, both for protection and decoration. Historically, in some countries there has not been available the range of suitable indigenous facing material to construct external walls and rendering has been used for this purpose. A walk around some of the towns and villages in the UK will provide testimony to the wide range of rendered finishes that may be produced.

Aesthetic fashions in the final coat of a rendering system have changed over the centuries and an examination of buildings with a rendered finish provides an interesting insight into construction history. The outer walls of the Colosseum in Rome were covered with stucco. Stucco or ashlar finishes are often to be found on late 18$^{th}$ and early 19$^{th}$ century town houses. Pebbledash and Tyrolean finishes are both characteristic of more recently constructed properties, especially semi detached houses built in the period 1920-1940.

A satisfactory render depends not only upon a knowledge of the properties of the constituent materials, but also on selecting suitable mix proportions so that the render is compatible with the background to which it is applied.

The two principal reasons for using a rendering mortar are:

- To provide a barrier to prevent rain from penetrating into the background masonry.
- To enhance the appearance of a plain masonry structure.

An ideal rendering mortar should generally be slightly weaker than the background to which it is to be applied, this also applies to the coats in a multi-coat rendering system, each successive coat should be no stronger than the previous coat. In practice this is frequently achieved by maintaining constant mix proportions, but using successively thinner coats. It should be noted that there are some specially formulated rendering mortars available that can be applied in a single coat.

## Properties of Rendering Mortar

Confusion sometimes arises over the use of the terms rendering and plastering. Rendering mortar is applied to external surfaces, plastering mortar to internal surfaces.

## Specifying rendering mortar

The principles for specifying a rendering mortar are similar to those for specifying a masonry mortar, which are discussed in greater detail in the MIA learning text on the properties of masonry mortar (Learning Text 6: Masonry Mortar). The specification of a rendering system requires consideration of a number of parameters:

- The nature and condition of the background (i.e. its strength and absorptivity).
- The nature and conditions of exposure.
- The functional requirements.
- The type of render.
- The type of finish/appearance (e.g. textured/smooth).

The properties of the background that should be considered include:

- Strength. Strong backgrounds generally require relatively strong rendering mixes.

- Mechanical key. Some backgrounds have an inherently good physical key, others require a key to be provided.

- Suction. The degree of suction can be a significant factor in achieving proper adhesion. It may be necessary to adjust this by pre-treatment or the use of admixtures.

- Durability. Some backgrounds are inherently durable while others such as wood rely on the render to provide the durability.

- Resistance to damp penetration: Many backgrounds are themselves resistant to moisture penetration while others rely on the render to provide this resistance. Additionally, some backgrounds can themselves be degraded by the effects of saturation.

The informative National annex to BS EN 13914-1 which is entitled Design, preparation of external rendering and internal plastering- Part 1: External renderings, lists mixes suitable for rendering. Table 1 is based on this.

| Mix Designation | Cement: lime: sand | Ready-mixed lime:sand | Cement: ready mixed material | Cement:sand using plasticiser | Masonry cement sand |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| i. | 1:_:3 | 1:12 | 1:3 | - | - |
| ii. | 1:_ :4 to 4_ | 1:9 | 1:4 to 4_ | 1:3 to 4 | 1: 2_ to 3_ |
| iii. | 1:1:5 to 6 | 1:6 | 1:5 to 6 | 1:5 to 6 | 1:4 to 5 |
| iv. | 1:2:8 to 9 | 1:4_ | 1:8 to 9 | 1:7 to 8 | 1:5_ to 6_ |
| v. | 1:3:10 to 12 | 1:4 | 1:10 to 12 | - | - |

**Table 1: Composition of rendering mixes**

Table 2 lists recommendations for prescribed render mixes for different applications based on the advice in the National Annex to BS EN 13914-1

| Mix Designation | Rendering mix characteristics | Typical Backgrounds |
|---|---|---|
| i. | Strong, relatively impervious rendering with high drying shrinkage | Engineering bricks, in situ concrete, dense blocks |
| ii | Moderately strong | Calcium silicate bricks, some facing bricks |
| iii | Medium strength, greater permeability than Designation i mixes but less likely to crack and craze | Lightweight aggregate blocks, some common bricks |
| iv | Moderately low strength | Autoclaved aerated concrete, some softer bricks |
| v | Low strength | Weak materials in sheltered locations |

**Table 2: Applications of rendering mortars**

Rendering is normally subjected to environmental exposure (e.g. frost, wind, sun and rain). The location of the structure to which the rendering has been applied will also affect the ability of the rendering to withstand the environmental actions applied to it. The National Annex to BS EN 13914-1 provides details of an exposure classification system. The categories of exposure are based on a driving rain index and can be described as follows:

- Sheltered conditions. These are classified as areas of moderately low rainfall in which walls are protected from the weather by overhanging eaves and the close proximity of other buildings. Typical examples are ground and first storey buildings in urban areas.

- Moderate conditions. This classification applies to walls partially protected from the weather by overhanging eaves and by adjacent buildings of similar height. Typical examples are to be found in many urban areas.

- Severe conditions. This classification applies to walls which are exposed to the weather but are not located on hill or coastal sites.

- Very severe conditions. Buildings that are exposed to the full force of wind and rain. Examples of this classification would be buildings on hill sites, near the coast and those projecting above surrounding buildings in built up areas.

The compilation of a specification for rendering requires a number of factors to be taken into account. These include the characteristics of the substrate or background, the exposure conditions and the type of finish required.

## Properties of fresh rendering mortar

A fresh rendering mortar must have the ability to adhere to the background to which it is applied.

### Workable life

This property is a measure of the length of time after mixing that the mortar remains workable. There are many ways of testing for the workable life, but all rely on the assumption that workable life is taken to have been reached when a certain arbitrary test value has been attained, using a laboratory test.

The test procedure given in the BS EN 1015-9, is based on the former test method in BS 4551 (Determination of stiffening rate) and is simple to carry out, although a laboratory facility is generally required. Although the time itself may not match exactly the time that a bricklayer might deem to be appropriate, it is nevertheless a reasonable compromise and represents a good way of comparing different mortars.

### Air content

All factory made mortars and many but not all site made mortars are air entrained. The use of air entrainment produces mortars that have much improved working properties in addition to being far more durable and resistant to the effects of freezing and thawing. Indeed, it is not recommended to use mortars for rendering that are not air entrained. This situation is reflected in current British and European standardisation.

The topic of air entrainment in mortars is dealt with in the learning text on admixtures (Learning Text 4: Admixtures) in this series of texts.

## Properties of hardened rendering mortar

The properties required of a hardened rendering mortar are:

- Good adhesion.
- Fitness for purpose (i.e. weatherproofing and appearance).
- Durability.

A rendering mortar does not attain its final characteristics until it has hardened after application. As previously stated, different exposure conditions require the use of rendering mortars with different properties and performance levels.

An undercoat must compensate for uneven surfaces of the background, provide uniformly moderate suction and good adhesion for intermediate and/or finishing coats. The final coat must act as the main barrier against rain penetration and provide a visually acceptable surface.

The thickness of an undercoat should be approximately 9-13 mm. The final coat should be thinner than the undercoat. Using the same general principle, where three coat work is undertaken each successive coat should be no thicker and no stronger than the previous.

Differential drying, moisture movements and thermal movements greater than those occurring internally, lead to shear and/or tensile stresses between the background and renders or between coats. In persistently wet conditions sulfates emanating from the masonry units or from the environment may attack Portland cement based rendering.

**Compressive strength**

BS EN 998-1 lists four categories of compressive strength:

| Category | Strength range N/mm$^2$ |
|---|---|
| CS I | 0.4-2.5 |
| CS II | 1.5-5 |
| CS III | 3.5-7.5 |
| CS IV | $\geq 6$ |

**Table 3: Compressive strength categories (BS EN 998-1)**

The compressive strength is determined in accordance with BS EN 1015-11. The stronger a rendering mortar is:

- The more impervious it is.
- The more susceptible it is to cracking.
- The greater its drying shrinkage.

Rendering mixes with a lower strength are less liable to cracking and crazing.

**Durability**

To ensure a durable render, a number of factors have to be considered in its specification:

- The penetration of rain and rising damp.
- Problems associated with soluble salts.
- The corrosion of embedded metal.
- Damage from abrasion and impact.
- Crazing and cracking.

One of the principal functions of a render is to assist in the exclusion of water. If a render becomes cracked, rainwater can penetrate into the rendering system and may freeze during periods of cold weather causing partial disintegration of the render. In addition rain penetration may lead to adhesive failure between the render and the substrate. Render should not be applied to saturated walls as there is a high risk that it will become detached.

**Capillary water absorption**

A render should restrict the penetration of rain into the fabric of the building. The ingress of water can be a serious problem as if the water freezes loss of adhesion to the substrate may develop. In sheltered and moderate conditions of exposure a render which conforms to the requirements of BS EN 998-1 with a capillary water absorption of Class W/1 or W/0 should be used. Where severe conditions of exposure exist a render which conforms to the requirements of BS EN 998-1 with a capillary water absorption Class W/2 should be used.

**Water vapour permeability**

BS EN 998-1 specifies that the water vapour permeability shall be determined for mortar used in external situations. The test is undertaken in accordance with the requirements of BS EN 1015-19 and determines the passage of water vapour through a specimen under standard conditions.

**Thermal conductivity**

The majority of rendering mortars have little direct effect upon the thermal transmittance of an external wall. This is due to the fact that only a thin coat of material is applied and the conductivity of the rendering mortar is relatively high.

However, it is possible to obtain thermal insulating mortars that have enhanced properties. BS EN 998-1 has created a category of designed mortar entitled thermal insulating mortar; this material is further classified into two classes T/1 and T/2 based on their thermal conductivity. Thermal insulating render may be applied in thicker coats than normal renders.

**Fire resistance and combustibility**

Cementitious external rendering is classified as non-combustible when the organic material content is less than 1%. Where the organic material is greater than 1% the render should be tested and classified in accordance with BS EN 13501-1. A render contributes to the fire resistance of a wall, but generally no separate values are calculated for the rendering system.

## Rendered finishes

Many types of finish can be produced, some of which are smooth while others are textured or mixed with coarse aggregate. The decision on the type of finish is generally based on

serviceability and aesthetic merit. Local custom or tradition may favour a particular finish, but in some locations the degree of exposure or the type of background may restrict the choice. Due to the fact that rendering has evolved as a craft over hundreds of years, there are a wide variety of terms applied to some of the finishes that can be produced. Some textbooks and guides to renders classify rendered finishes into four types:

- Those applied with a trowel directly by hand.
- Those thrown onto the wall and left in this state.
- Those applied with a trowel and subsequently tooled or imprinted.
- Those applied by machine.

However, this learning text discusses rendered finishes under six main headings:

- Smooth.
- Scraped.
- Textured.
- Tooled.
- Thrown.
- Special ornamental.

**Smooth finishes**

The final coat is finished by using a float to produce a smooth surface. It should be remembered that a smooth finish may become somewhat drab as time progresses. A variation on this type of finish is to remove the surface matrix to expose the fine aggregate. Traditionally, some plain finishes were described as Stucco finishes, which were generally painted.

**Scraped finish**

The aggregate is selected for its colour and grading and the render allowed to harden for a few hours. The surface is then scraped, sometimes with a float faced with a piece of expanded metal. This process removes some of the cement rich surface and drags some of the coarser sand particles out of the matrix, whilst exposing others.

**Textured finish**

The plain smooth finish can also be textured to produce a criss cross pattern by scoring through the finished mortar using a trowel blade or a hacksaw blade and a straightedge. An alternative finish pattern is to score the finished render to produce a stone block effect (ashlar finish). A stiff bristle brush can also be used to give a textured finish.

A texture that is popular in some areas is the so called "English cottage" finish, which is achieved by hand texturing and produces a random rugged effect which looks old fashioned, hence the name. This type of finish may be seen in many English villages and contributes to the quintessential charm of the surroundings. The workmanship in producing this finish is unique in that application of the render commences at the bottom of the wall, all the others types start at the top and continue downwards.

The "Travertine" finish is achieved by incorporating rounded particles of approximately 5 mm in size, which move under the wooden float to produce a dragged or torn surface, which is said to resemble marble. It should be noted that a textured finish gives greater protection against rain penetration and is less prone to cracking.

**Tooled finishes**

The hardened render can be tooled with a needle gun or by abrasive blasting to expose the aggregate.

**Thrown finishes**

These types of finishes can be further sub-divided into wet dash and dry dash.

A wet dash finish is achieved by incorporating 6-14 mm coarse aggregate in the final coat, with the mortar being thrown onto the wall and left untrowelled. The coarseness of the texture depends on the size and shape of the aggregates, this type of finish is known as roughcast in some parts of the country. Traditionally, in Scotland it is known as harling.

A dry dash finish is a rough textured finish in which dry aggregates in the size range 6-14 mm are thrown onto a freshly applied coat of mortar (often called a butter coat) and left exposed. The aggregate can be selected in combination with a pigmented mortar to give a range of colours. In some areas this type of finish is referred to as pebble or spar dash (dependent on particle characteristics).

**Special ornamental finishes**

Although most renders are to some extent ornamental, special techniques or materials may be used to accentuate visual features.

A variety of impressions can be made in freshly applied rendering using for example profiled tools or the base of bottles. This type of finish is called pargeting in some areas, the word being derived from medieval English and meaning "ornamental plasterwork".

A "Tyrolean" finish is a proprietary finish, which is supplied in a number of colours and is applied as thrown material, where a machine is used instead of hand application. It is also possible to sand down this type of finish with a carborundum stone to produce a "rubbed Tyrolean finish". Render may also be applied by spraying, where the texture obtained will depend primarily upon the render material used and the type and size of spray nozzle.

## General

**Metal lathing and expanded metal**

## Properties of Rendering Mortar

When it is desired to apply a rendering to steel or timber framed structures or to other surfaces which provide an unsatisfactory bond/key (e.g. friable masonry or unsound renderings), support for the rendering can be provided by metal lathing. To minimise the risk of corrosion the lathing may be initially coated with a workable cement rich mix, although a preferable alternative is to use stainless steel or zinc coated steel.

### Curing

In common with all cementitious materials, adequate curing is essential to allow the strength of the render to develop. Fresh rendering should be protected from the effects of drying winds and wind funnelling and from direct sunlight.

### Fibres

Many ancient rendering mortars incorporated animal hair. The inclusion of fibres in a mix improves the toughness and impact resistance of a rendering.

### Polymers

Polymer dispersions may be incorporated in rendering mixes to improve bond strength, resistance to rain penetration and durability. Care should be taken to utilise only those polymers that are known to be suitable for external use.

## New developments

### Organic binders

A new standard is in the final stages of the approval process (prEN 15824). This standard is applicable to factory made rendering/plastering products based on organic polymer binders. Organic rendering/ plastering products are classified according to:

- The chemical nature of the principal active binder.
- The type of finish obtained.
- The properties and/or use.

Organic binders may be applied by brush, roller, trowel, spray machine or other special tools.

### ETICS (External Thermal Insulation Composite Systems)

External thermal insulation composite systems are popular in some parts of continental Europe. The system consists of prefabricated insulation products which are bonded and/or mechanically fixed onto external walls. The insulation is faced with a rendering consisting of one or more layers one of which contains reinforcement, the rendering is applied to the insulating panels without any air gap. ETICS are designed to give the walls to which they are applied superior thermal insulation.

## Glossary of terms

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|---|---|
| **Adhesive strength (bond strength)** | The maximum adhesive strength of a mortar applied onto a substrate, which can be determined by a shear or tensile strength test. |

## Properties of Rendering Mortar

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|---|---|
| **Ashlar finish** | A plain rendered finish scored to simulate stone blocks. |
| **Butter coat** | The soft final coat to which the aggregate is applied in dry-dashing. |
| **Crazing** | Cracking of the surface layer into small irregular shaped contiguous areas. |
| **Final coat** | Ultimate coat of a multicoat rendering system. |
| **Lathing** | Mesh which when fixed to a background provides a key for rendering and in some cases support and stability. |
| **Rendering coat** | A layer applied in one or more operations or passes with the same mix, with the previous pass not being allowed to set before the next one is made. |
| **Rendering mortar** | Mortar, which is applied in the fresh state to an external wall or other surface and which hardens after application. |
| **Rendering system** | A sequence of coats applied to a background which can be used in conjunction with a support and/or reinforcement and/or a preparatory treatment. |
| **Renovation render** | Designed render for use on moist backgrounds containing water soluble salts. |
| **Stucco** | A smooth external rendering with a painted finish.. |
| **Surface coat** | See Final coat |
| **Thermal conductivity** | A measure of the rate of heat transfer through unit thickness and area of material and from face to face. The thermal conductivity (k) of a material is technically defined as the quantity of heat that passes through $1m^2$ of the material of 1m thickness for $1^oC$ difference in temperature of the inner and outer surface. The units used to measure thermal conductivity are W/mK where **W** represents Watts and **K** represents Kelvin. |
| | |
| **Thermal insulating mortar** | A designed mortar with specific thermal insulating properties. |
| **Thermal resistivity** | The resistivity of a material is a measure of resistance to heat flow through unit thickness and is the reciprocal of the conductivity value (i.e. 1/conductivity). |

## Properties of Rendering Mortar

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|---|---|
| **Thermal transmittance** | Thermal transmittance (U value) is the rate of heat transfer through a construction from air to air and is the reciprocal of the sum of all the thermal resistances offered by a construction (i.e. all the components). |
| **Undercoat** | Bottom layer or layers of a render system. |

## Bibliography


| | |
|---|---|
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| BS 5262: 1991 | Code of practice for external renderings. (Withdrawn) |
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| BS EN 998<br><br>Part 1: 2003<br>Part 2: 2003 | Specification for mortar for masonry<br><br>Rendering and plastering mortar.<br>Masonry mortar. |
| BS EN 1015<br><br>Part 2: 1999<br><br>Part 10: 1999<br><br>Part 11: 1999<br><br>Part 12: 2000<br><br>Part 18: 2002<br><br>Part 19: 1999<br><br>Part 21: 2002 | Methods of test for mortar for masonry<br><br>Bulk sampling of mortars and preparation of test mortars.<br><br>Determination of dry bulk density of hardened mortar.<br><br>Determination of flexural and compressive strength of hardened mortar.<br><br>Determination of adhesion of hardened rendering and plastering mortar on substrates.<br><br>Determination of water absorption coefficient due to capillary action of hardened rendering.<br><br>Determination of water vapour permeability of hardened rendering and plastering mortars.<br><br>Determination of the compatibility of one coat rendering mortars with substrates. |
| BS EN 1745:2002 | Masonry and masonry products-Methods for determining design thermal values. |
| BS EN 13139:2002 | Aggregates for mortar |
| PD 6682-3:2003 | Aggregates- Part 3: Aggregates for mortar - Guidance on the use of BS EN 13139. |
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| PD 6682-4:2003 | Aggregates -Part 4: Lightweight aggregates for concrete, mortar and grout- Guidance on the use of BS EN 13055-1. |

| | |
|---|---|
| BS EN 13501-1:2007 | Fire classification of construction products and building elements - Part 1: Classification using test data from reaction to fire tests, excluding ventilation services. |
| BS EN 13914-1:2005 | Design, preparation and application of external rendering and plastering - Part 1: External rendering. |
| Good Concrete Guide 3: Rendering | A practical handbook (Bill Monks published by the Concrete Society). |
| BRE Digest 410 | Cementitious renders for external walls. |

## Self-assessment questions

| | |
|---|---|
| 1 | What standard is applicable to rendering mortar? |
| 2 | What type of finish is a Stucco finish? |
| 3 | What is the principal difference between a dry dash and a wet dash finish? |
| 4 | What are the principal functions of a rendering mortar? |
| 5 | Complete the following:<br>i) A plastering mortar is applied to ……..<br>ii) A rendering mortar is applied to ……. |
| 6 | What is English cottage? |
| 7 | Above what level of organic content does a mortar have to be tested for reaction to fire? |
| 8 | In a two coat rendering system what should be the approximate thickness of each coat? |
| 9 | What are the two main properties measured in a rendering mortar? |
| 10 | What parameter are exposure classes based on? |

## Answers to self-assessment questions

| | |
|---|---|
| 1 | BS EN 998-1 (Specification for mortar for masonry - Part 1: Rendering and plastering mortar). |
| 2 | A plain rendered finish, which is generally painted. |
| 3 | In a wet dash finish the aggregates are part of the mix, in a dry dash the aggregates are applied while the final coat is still plastic (fresh). |
| 4 | To provide a barrier to the ingress of water and wind.<br>To provide a decorative surface. |
| 5 | i) A plastering mortar is applied to an internal wall or other surface.<br>ii) A rendering mortar is applied to an external wall or other surface. |
| 6 | A textured rendered finish, in which the render is applied to the walling from the bottom upwards. |
| 7 | 1% organic content. |
| 8 | Undercoat 9 - 13 mm.<br>Final coat Less than the above. |
| 9 | Workable life and air content. |
| 10 | Driving rain index. |