Successful plastering

1. Introduction

Sand-cement plaster is used extensively in building work as a decorative or protective coating to concrete and masonry walls and concrete ceilings.

The aim of this publication is to provide the technical information needed for successful plastering. It is intended for architects, building contractors, building inspectors, and anyone in need of guidance to achieve a satisfactory standard of work.

Aspects dealt with include selection of materials, mix proportions, surface preparation and correct plaster application.

This publication deals with conventional architectural applications of plaster. Special applications such as squash courts and swimming pools are outside its scope.

2. Requirements

Plaster has important requirements in the fresh and hardened states.

In the fresh state, plaster must be workable and cohesive, i.e. it must be plastic, and have good water retention. The properties of fresh plaster depend on the materials used, especially the sand, and on mix proportions.

In the hardened state, plaster must be: strong enough to hold paint and withstand local impact and abrasion; free of unsightly cracking; well bonded to the substrate; have an acceptable surface texture; and have acceptable surface accuracy (with reference to a plane or curved surface). The properties of hardened plaster depend on the properties of the fresh plaster and the substrate, and on workmanship.

The following sections give information that should make it possible to meet these requirements.

3. Selecting materials

As discussed in section 2, the properties of plaster in both fresh and hardened states depend to a large extent on the properties of the materials used. This section gives guidance on selecting materials.

3.1 Cement

Use "common" cement complying with SANS 50197-1, or masonry cement complying with SANS 50413-1 strength class 22,5X or higher. Always ensure that the cement used bears an SABS mark. Note that it is illegal to sell cement which does not bear this mark.

The choice of cement should be based on the properties of the sand (see sections 3.2 and 3.3).

3.2 Sand

Sand is by far the major constituent of a plaster mix and has a significant influence on its performance and material cost.

In South Africa, natural sands, i.e. pit, river and dune sands, are almost invariably used for plaster mixes.

An essential requirement is that sand should be free of organic matter such as roots, twigs and humus.

Note: "Karoo" sands, which consist mainly of disc shaped dark-coloured particles, should not be used for plastering. This is because they exhibit excessive swelling and shrinkage with increasing and decreasing moisture content. Crusher sands are also not generally suitable due to their angular particle shape. However, crusher sands are used successfully in rich mixes for special applications such as squash court plastering.

Important properties of sands are:

- Clay content
- Grading
- Maximum particle size
- Particle shape

SANS 1090:2002 the standard covering sand for plaster and mortar gives limits for certain properties of sands but these should be regarded as no more than a guide. It has been found that sands meeting this standard do not necessarily produce satisfactory plaster; conversely sands that do not meet this standard may produce acceptable mixes.

Grading

Ideally, the sand should have a continuous grading, from dust to the largest particles. The fractions passing the 0,15 mm and 0,075 mm sieves ("fines") are important because they significantly influence the water requirement, workability and water retentivity of the mix. Increasing these fractions results in increased water requirement (with consequent lower strength and higher shrinkage), but improved workability and water retentivity. The optimum fines content is therefore a compromise between these properties.

A sand lacking in fines may be used with hydrated builder's lime, mortar plasticizer, or masonry cement (see section 3.3).

A sand with excessive fines may be improved by washing or by blending with a suitable coarser sand.

Recommended gradings are shown in Table 1.

Table 1: Recommended grading for plaster sand

Sieve size mm	Percentage passing sieve by mass
2,36	100
1,18	100–70
0,60	100–45
0,30	65–25
0,15	40–10
0,075	15–5

Note: Some coarser material may be acceptable, or desirable, for textured decorative work.

Maximum particle size

For conventional smooth plaster, all the sand should pass through a sieve with 2,36 mm square openings. For coarsely textured decorative work the corresponding sieve size is 4,75 mm.

Oversize particles (and lumps) should be removed by sieving.

Clay content

Only a small proportion of clay can be tolerated in plaster sand.

Sands with high clay content may generally be recognized as follows:

- The fraction that passes a 0,075 mm sieve* can, after being moistened, be rolled into a thread about 3 mm or less in diameter.
- Plaster mixes made with such sands are:
  - Very "fatty" and tend to cling to a trowel
  - Have a high water requirement

(See Assessing the suitability of sand for plastering below.)

Specialist advice should be sought if there is any doubt about the content and type of clay in a sand.

Assessing the suitability of a sand for plastering

A sand may be assessed by doing both of the following:

- Comparing grading and maximum particle size, and – if necessary – apparent clay content, with the recommendations given.
- Making a mix to assess water requirement and workability.

Mix assessment is done as follows:

(i) Weigh out the following amounts of material:
5 kg of cement
25 kg of *dry* sand
5 kg (ℓ) of water
1 kg (ℓ) of water
1,5 kg (ℓ) of water

(ii) Mix the cement and sand to a uniform colour on a non-absorbent surface.

(iii) Mix, in succession, each of the amounts of water (5 ℓ, 1 ℓ and 1,5 ℓ) until the mix reaches a consistence suitable for plaster.

If 5 ℓ of water is enough the sand is of *good* quality,
If 5 ℓ + 1 ℓ is enough the sand is of *average* quality,
If 5 ℓ + 1 ℓ + 1,5 ℓ is enough, the quality of the sand is *poor,* and
If more water than that is required, the quality is *very poor.*
Only "Good" sands are suitable for use in all plaster work;
"Average" sands may be used for interior plaster; and
"Poor" and "Very poor" sands are **not** recommended and should be avoided.

(iv) Assess the workability of the mix (at plastering consistence) by forming a flattened heap about 100 mm high and 200 mm in diameter on a non-absorbent surface. Place a plasterer's trowel face down on top of the heap and try to push the trowel down.

A workable plaster will squeeze out from under the trowel and it will be possible to push the trowel to within a few millimetres of the underlying surface.

An unworkable mix will "lock up" once the trowel has moved a few millimetres and prevent further downward movement of the trowel.

If the mix appears to be workable, pick up some of the plaster on a trowel then tilt the trowel. The plaster should slide off easily. If it clings to the trowel the mix is too "fatty", an indication of excessive clay content of the sand.

3.3 Workability improvers

These materials may be used in cases where a mixture of sand and portland cement only does not have satisfactory workability, usually because of a deficiency in the sand.

Workability is improved by increasing the amount of very fine material in the mix, entraining air in the mix, or a combination of these.

The following materials are used as workability improvers:

Hydrated builder's lime

This is in the form of very fine plate-like particles. The amount added to the mix may be as much as the amount of cement (by volume, see Table 2). Only hydrated lime

* Such sieves are expensive and normally found only in laboratories. For a field test, place a few handfuls of dry sand in the foot of a nylon stocking and tie closed. Shake the sand and collect the dust in a bowl.

complying with SANS 523 : 2002 *Limes for use in building* should be used. Use type A2P if possible for better plasticity.

Note that the limes used in South Africa do not have cementing properties. They cannot therefore be used to replace cement but are used in addition to portland cement.

Air-entraining agents (AEAs)

These are chemical admixtures that cause millions of tiny air bubbles to be entrained in the mix.

Accurate dosage is essential because over-dosage results in excessive air entrainment with consequent loss of strength. Because dosage is difficult to control on site, the dosing of AEAs on site is not recommended.

Masonry cement

These products comprise a blend of portland cement, ground limestone or hydrated lime and an AEA. Masonry cements are normally used in plaster as a substitute for portland cement.

Plasters made with masonry cement will have lower strength than those made with portland cement at the same ratio of sand to cement. For similar strength therefore, masonry cement mixes should be richer than portland cement mixes (see Table 2).

Note: Builder's lime and AEAs should not be used with masonry cement.

> **Important Note**
>
> Gypsum-based plaster should never be mixed with a plaster made with portland cement. This is because gypsum is a sulphate compound which attacks portland cement paste especially in damp conditions. This attack causes swelling, softening and disintegration of the plaster.

3.4 Bonding agents

These are specially formulated water-based emulsions of polymers such as styrene butadiene rubber (SBR), acrylic, and polyvinyl acetate (PVA). They are used as a part replacement for mixing water in spatterdash coats (see *Roughness* in section 5.2).

Emulsions become effective by coalescing which happens only when the mixture dries out. Uncoalesced emulsions can be leached out of the mix by water. Mixes containing an emulsion should therefore be cured by maintaining moist conditions and not by applying free water; they must then be allowed to dry out before being exposed to wet conditions.

Polymer emulsions must not be used on their own because they may form a plastic skin that will act as a debonding agent. Note also that PVA should be used only for plaster work that will be permanently dry in service. (This is because PVA is unstable in moist conditions.)

4. Mix proportions

Mix proportions for conventional plaster are shown in Table 2.

5. Surface preparation

This section deals with the preparation of the surface to which the plaster is applied, i.e. the substrate.

Aspects discussed are substrate properties; techniques of surface preparation; and methods of preparing different types of surface.

5.1 Surface properties required for successful plastering

The surface to be plastered should be accurately positioned overall and zones should not deviate excessively from a plane (or curved) surface. Ideally, the substrate should be rough; absorbent to a limited extent; strong; and clean, i.e. free of any film, such as dust, oil or paint, that could impair bond between plaster and substrate.

Plaster thickness should be as recommended (see section 6.3) and as uniform as possible. The more accurate the substrate the easier it is to meet these requirements.

Roughness improves adhesion by providing a positive "key" for plaster to grip. Absorption removes the water film, between substrate and plaster, that would tend to weaken adhesion. Excessive absorption will however dry out the plaster (see *Absorption* in section 5.2). The strength of the substrate material should be greater than, or equal to, that of the hardened plaster.

5.2 Techniques of preparing surfaces

Accuracy

In new work, surface preparation starts with accurate setting out and construction of walls and soffits.

The aim should be to provide a surface that can be plastered to the required lines and levels by applying a coat (or coats) of uniform thickness. Excessively thick plaster, or plaster of uneven thickness should not be relied on to hide inaccurate work.

Where zones of the substrate surface deviate from the required plane (or curved) surface by more than about 10 mm, the first option is to remove high areas by hacking or cutting. If this is not practicable, apply undercoats to low areas in such a way that the final coat is of uniform thickness (see section 6.3).

In cases where overall thickness exceeds the recommendations given in section 6.3, it is advisable (and safer) to mechanically anchor the plaster to the substrate, e.g. with stainless steel studs. This is also recommended when plastering dense non-absorbent substrates.

Strength

For new work, masonry units strong enough to survive handling and transport prior to being built in should be strong enough to hold plaster. Similarly, in situ concrete should have ample strength.

Table 2: Mix proportions for plaster

Description	Using common cement			Using masonry cement	
	Cement[1] kg	Hydrated builder's lime[2] kg	Sand, measured loose and damp litres	Masonry cement[3] kg	Sand, measured loose and damp litres
Mix A Foundation walls, constantly damp conditions, aggressive soils	50	0–10	130	50	100
Mix B Exterior and interior plaster above DPC level	50	0–25	200	50	150
Mix C Plaster applied to a very weak substrate, e.g. poorly burnt or sundried clay brick	50	0–80	300	50	200

1. Complying with SANS 50197-1 strength classes 32,5 and 42,5 only.
2. A 25 kg bag of lime has a nominal volume of 40 litres.
3. Complying with SANS 50413-1; strength class 22,5X.

In some cases, it is necessary to plaster existing walls of soft clay brick. Methods of plastering such surfaces are discussed later (see section 5.4).

Roughness

Background surfaces should ideally be at least as rough as coarse sandpaper or rough-sawn timber.

Surface roughness can be achieved in one of the following ways:

- Using formwork with a rough surface, e.g. sawn timber for concrete
- Stripping formwork early and wire brushing concrete
- Hacking
- Abrasive blasting (e.g. sand blasting)
- Applying a spatterdash layer

Spatterdash is a mixture of one part of cement to one and a half parts of coarse sand with enough water for a sluggishly pourable consistence. A polymer emulsion may be substituted for part of the mixing water (usually a quarter to a third, but in accordance with the manufacturer's instructions). The mixture is thrown forcibly on to the wall, using a scoop or a brush with long, stiff bristles. (The impact drives out the water film at the interface between spatterdash and substrate and hence improves adhesion.) The spatterdash should cover the substrate surface completely and form a rough texture with nodules about 5 mm high.

Spatterdash must **not** be allowed to dry out for at least three days. (See comments on curing in section 3.4 if a polymer emulsion is included in the mix.) It should be tested for adhesion and strength by probing with a screwdriver or knife before plaster is applied to it.

Cleanliness

Surfaces must be free of loose material, such as dust, and films that can interfere with bonding, such as curing compounds.

Background surfaces may be cleaned by:

- Water jetting
- Blowing with (oil-free) compressed air
- Vacuum cleaning

Solvents should not be used to remove films formed by curing compounds. (Such films must be removed by mechanical means.)

Absorption

First assess absorptiveness by throwing about a cupful of water against the surface.

The surface will fall into one of the three categories:

I No water is absorbed.
II Some water is absorbed but most runs off.
III Most of the water is absorbed.

Category **I** surfaces, which would include hard-burnt clay face bricks, glazed bricks and very dense high-strength concrete, should be prepared by applying a spatterdash coat that includes a polymer emulsion. Such surfaces must not be prewetted.

Category **II** surfaces should not require any treatment to control suction.

Category **III** surfaces should be wetted thoroughly and then allowed to become surface dry before the plaster is applied.

5.3 Preparation of various types of substrate

Monolithic concrete

Concrete is normally placed in situ but may be precast.

Provide a rough surface by using rough-textured formwork, early stripping of formwork and wire brushing the concrete, hacking or abrasive blasting. (If none of these is practicable, apply a spatterdash coat after ensuring that the surface is clean.)

Ensure that no form-release oil is left on the surface to be plastered. Clean down by water jetting or vacuuming. Remove curing compound, if any, by mechanical means. Conventional structural concrete should not require wetting to control suction. High-strength concrete may require the application of a spatterdash coat.

Concrete masonry

The texture of the masonry units should be sufficiently rough without further treatment. If not, apply a spatterdash coat.

If the surface is dusty, clean by brushing, water jetting or vacuuming.

It should not be necessary to control suction of the surface by prewetting, unless the masonry units are very absorbent.

Burnt clay stock brickwork

The texture of the bricks should be sufficiently rough without further treatment. If not, apply a spatterdash coat.

If the surface is dusty, clean by brushing, water jetting or vacuuming.

Burnt clay stock bricks normally have a very high suction; this can be assessed by wetting the wall (see *Absorption* in section 5.2). If suction is high, prewet the wall and allow it to become surface dry before applying the plaster.

Burnt clay face-brickwork

Such walls are characterized by low suction. Brick texture may be smooth, almost glazed, or rough.

Provide a key by cutting out mortar joints about 10 mm deep. (A key would not normally be made while the wall is being built because there is no point in using facebricks if the wall is to be plastered.)

If the brickwork has been treated with a sealer or water-proofing agent, the surface layer containing this treatment must be removed.

Apply a spatterdash coat if the brick surface is smooth. Rough bricks should not require this.

It is normally not necessary, or advisable, to prewet the wall before plastering.

Sundried or poorly burnt soft clay brickwork

This type of walling may be found in very old buildings, usually when restoration or repairs are being done.

Care should be taken when removing the old plaster so as not to damage the bricks. Protect the wall from rain or running water once the bricks are exposed.

Rake out the joints about 10 mm deep (the mortar is normally very soft).

Brush down the wall to remove any loosely adhering material.

Lightly dampen the wall and apply a spatterdash coat that incorporates a polymer emulsion to improve adhesion.

6. Application

6.1 Batching

Batching sand by loose volume is satisfactory. Batches based on whole bags of cement are preferable. The size of the batch should, however, be small enough for it to be used up within about two hours.

6.2 Mixing

This may be done by machine or by hand. Machine mixing is preferable.

Hand mixing should be done on a smooth concrete floor or steel sheet. First spread out the sand about 100 mm thick. Spread the cement uniformly over the sand.

Mix sand and cement until the colour is uniform. Then gradually add water while mixing until the right consistence is reached.

6.3 Plaster thickness

Recommended thicknesses are:

First undercoat: 10–15 mm
Second undercoat (if any): 5–10 mm
Finish coat: 5–10 mm

If plaster is applied in a single coat, thickness should be 10–15 mm. A single coat should not be thicker than 15mm.

6.4 Applying the plaster

Never work in direct sun. Plastering should be protected from the sun and drying winds.

The plaster should be used up within two hours of being mixed and never be retempered by mixing in additional water.

Ensure that plaster is not continuous across the line of a dampproof course. Plaster should be cut through to the substrate where different substrate materials meet, e.g. masonry and concrete.

The general procedure for applying plaster is as follows:

For accurate work, apply screed strips before the wall is plastered. These are narrow strips of plaster along the perimeter of the wall, or at suitable intervals on the wall, that act as guides for the striker board.

Using a rectangular plasterer's trowel, push plaster onto the wall or ceiling using heavy pressure to compact the plaster and ensure full contact with the substrate. The plaster should be slightly proud of the intended surface.

Once the plaster starts to stiffen, it should be struck off to a plane (or curved) surface using a light striker board. Material removed in this way should be discarded.

If plaster is to be applied in more than one coat, the undercoat(s) should be scored with roughly parallel lines about 20 mm apart and 5 mm deep. The purpose of scoring is twofold: to provide a key for the next coat and to distribute cracking so that it is less noticeable.

For the final coat, use a wood float to remove ridges made by the striker board. At the same time fill in any depressions and float flush with the surrounding plaster.

If a very smooth texture is required, a steel trowel may be used on the surface. Such surface is however not generally recommended because it tends to craze and show up imperfections.

Various decorative finishes are also possible. Techniques include brushing, flicking plaster onto the surface and lightly floating, etc.

In the special case of soft clay brickwork, plaster should be applied as follows:

Using **mix C** (see Table 2) with the maximum amount of lime, fill majour depressions in the wall and scratch well. If mesh reinforcement or metal lathing is to be used, nail it to the wall using galvanized nails driven through the spatterdash coat and use spacers to keep it away from the wall. Apply the first coat of plaster, again using **mix C** with the maximum amount of lime. This first coat is used to achieve a plane surface. (In some cases it is necessary to use two coats to achieve this.)

It must be well scratched, cured for at least two days and allowed to dry. The scratching, followed by the drying period, distributes shrinkage cracks. Apply the final coat of plaster, using the same **mix C** or preferably a slightly leaner mix. Striking off and finishing are done as described previously.

6.5 Accuracy

The permissible deviations of plaster work are 3 and 6 mm under a 2 m straightedge for grades I and II finishes respectively (SANS 10155 : 1980 *Accuracy in buildings*).

Experience has shown that a grade I finish on masonry walls is not achievable with one-coat plaster work unless the masonry units have only small dimensional differences and the accuracy of the wall is excellent.

7. Specifications

Specifications for plaster work should cover the following aspects: selection of materials, mix proportions, application, finish and surface tolerances.

8. Conclusion

Provided sufficient attention is paid to the selection of materials, mix proportions, preparation of substrate surfaces and the application of the plaster, the results should be serviceable and aesthetically acceptable.

Note: For information on plaster defects and their causes, refer to ***Common defects in plasters*** available from the Cement and Concrete Institute.

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