Repairing the surface of concrete casting defects and minor damage

CONCRETE SOCIETY OF SOUTHERN AFRICA

1. Introduction

With very few exceptions, concrete elements are formed by a casting process: the fresh concrete is placed and compacted in formwork or a mould which is removed when the concrete has hardened. The quality of any cast product depends on material selection, equipment used and workmanship. Surfaces of acceptable quality and accuracy are difficult to achieve and, depending on functional and aesthetic requirements, some repairs may be necessary.

Repairs may also be necessary where surfaces are damaged in service.

This publication is intended to assist those responsible for specifying, supervising or carrying out such repairs.

Types of defects and their causes are given. Repairs of various types and the use of different techniques are described. The selection of materials for repairs is discussed in an appendix.

Only relatively superficial repairs are discussed. Repairs to effect structural changes and repairs of cracks are outside the scope of this publication. Repair materials are limited to formulations based on portland cement.

2. Types of defects

Minor defects may be categorized as follows:
Small cavities such as those formed by tie-bolts and by impact damage to the surface.

- Honeycombing, i.e. concrete in which mortar is partially or completely absent. Honeycombing is usually caused by the use of concrete which contains too much stone, or by segregation of the stone and mortar.

- Misplaced surfaces which are usually the result of incorrectly aligning or positioning formwork or movement of formwork while the concrete was being placed. Under or overfilling of formwork may also be a cause.

- Blowholes, i.e. relatively small voids of roughly spherical shape which often occur in surfaces formed by formwork or moulds. They are usually caused by inadequate compaction of the thin layer of concrete in contact with formwork.

Repairs to small cavities, honeycombing and misplaced surfaces are discussed in section 3. Filling of blowholes is dealt with in section 4.

3. Repairs to small cavities, honeycombing and misplaced surfaces

3.1 Basic types of repair materials

Repairs are carried out usually after some drying, and consequent shrinkage, of the concrete has taken place. Repair material therefore tends, when it dries out, to shrink relative to the concrete being repaired. Cracking of the repair, which may result from this relative shrinkage, is functionally and aesthetically unacceptable. Repair materials are therefore formulated in order to reduce the likelihood and severity of cracking. This is done by reducing potential drying shrinkage which will reduce the tendency to crack.

Two approaches are possible:

- The use of “semi-dry” mixtures of cement, water and aggregate which are compacted by being rammed into position.

- The use of plastic mixtures of cement, water, polymer emulsion and aggregate (polymer-modified mixtures) which are applied by means of a trowel or spatula.

The implications of these approaches are discussed below.

3.1.1 Semi-dry mixtures

Semi-dry mixtures have, because of their low water content, very low potential drying shrinkage and consequently a low tendency to crack. But water content is critical: if too low, thorough compaction is impossible; if too high, the repair may slump or crack in the fresh state or crack in the hardened state. These mixtures can be used only in confined spaces such as cavities. For effective use, semi-dry mixtures must be applied by trained, experienced and skilled operators.

3.1.2 Plastic mixtures

The inclusion of a suitable amount of specially formulated polymer in a cement-water-aggregate mixture has the following important effects:

- the amount of water required for a given consistence is reduced.

- the hardened material, which incorporates a three-dimensional network of coalesced polymer, exhibits greater creep and toughness.

Consequently, potential drying shrinkage is relatively low; tensile stresses resulting from restrained shrinkage are low (because of low shrinkage and high creep); cracking is significantly reduced (because of low stresses and good toughness).

Polymers are usually based either on styrene-butadiene rubber (SBR) or acrylic, and are used in emulsion form.

Plastic mixtures are relatively easy to apply.

3.2 Principles of repairing

3.2.1 Timing

Repairs to new concrete should be done as soon as possible after formwork has been removed. This reduces differential shrinkage and improves bond between original concrete and repair material.

3.2.2 Edges to repairs

Feather edges to repairs must be avoided. Where necessary the outline of a repair should be cut with a masonry cutting disc or saw to ensure a square edge. See Figure 1.

3.2.3 Surface preparation

Good adhesion between original concrete and repair is essential. To ensure good adhesion, the surface of the original concrete must be strong, rough and clean. Any loose or weak material must therefore be removed. It is important to remove concrete in such a way that the remaining concrete is damaged as little as possible. Sharp chisels driven by relatively light hammers are suitable. Sand-blasting, which can remove small volumes of concrete, is an excellent means of achieving a rough surface free of loosely adhering material. Before doing the repair, all dust and detritus must be removed from the surface. Washing with clean water may be used for vertical and near-vertical surfaces. An industrial vacuum cleaner is an effective means of cleaning all surfaces.

3.2.4 Mechanical fixing

In cases where repairs are large, say in excess of 0,1m^2, and especially where persons could be injured by falling fragments, it is prudent not to rely solely on adhesion between repair and background concrete but to provide mechanical fixing. Such fixing should be in the form of corrosion-resistant metal devices such as screws or rods. Austenitic stainless steel is preferable. Fixing devices, which are shown in Figure 2, should be installed after surface preparation is complete but before the surface is cleaned.

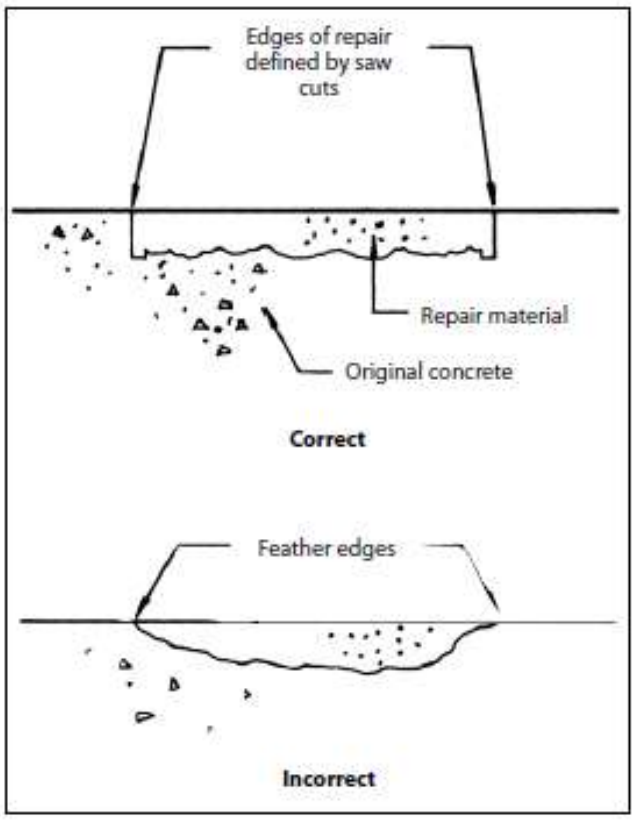

Figure 1: Edges to repairs – use saw cuts to avoid feather Edges

3.2.5 Bonding

To ensure good adhesion of fresh concrete or mortar to a substrate of hardened concrete, the substrate should have enough suction to absorb the water film at the interface but should not desiccate the repair material.

This condition of limited suction can be achieved in different ways, depending on the age and denseness of the concrete. If the concrete is fairly young - say within 48 hours of being placed – it should be sufficient to allow the surface to become visibly dry.

Older concrete should be assessed for absorptiveness by wetting the surface: if water is rapidly absorbed, absorptiveness may be regarded as high; if water is hardly absorbed, absorptiveness may be regarded as low.

Concrete with high absorptiveness should be saturated for some hours before repairs are to be carried out. Surface water must then be removed and the surface allowed to become visibly dry. Repairs must be started as soon as this state is achieved.

Never apply repair material to concrete which has a water sheen

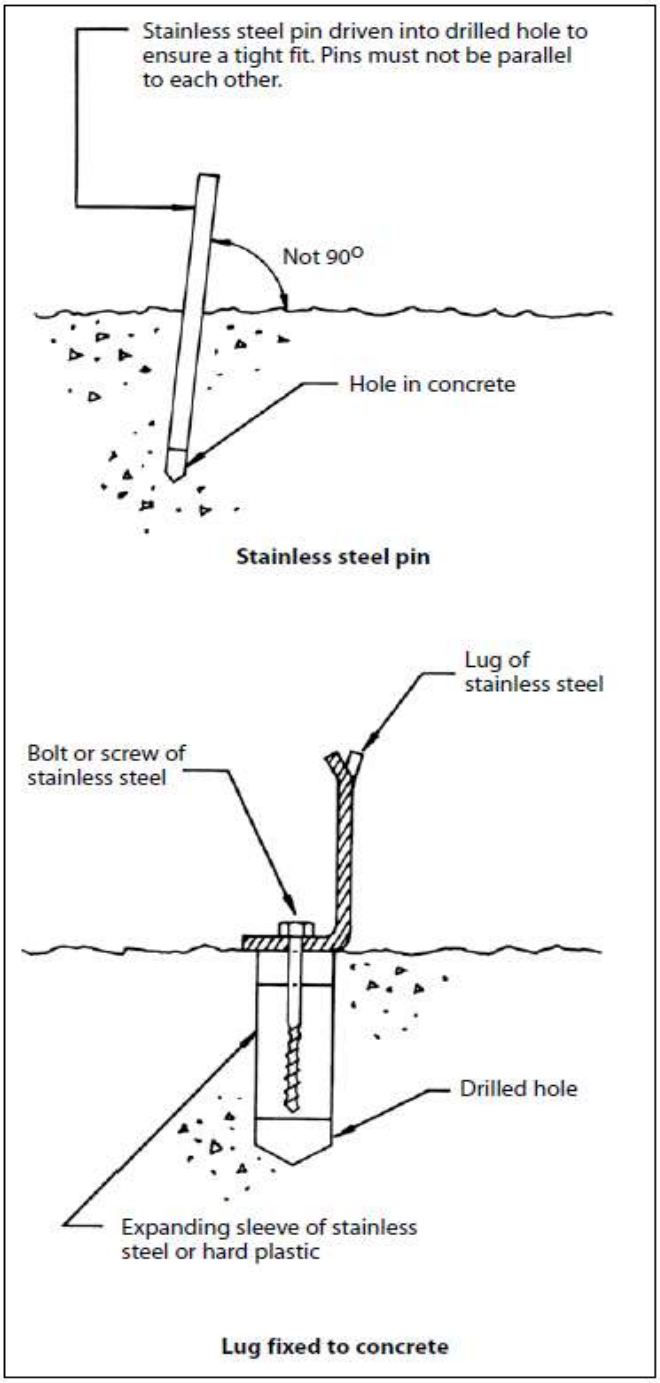

Figure 2: Mechanical fixing devices

Concrete with low absorptiveness does not require pre-wetting and should be repaired in a dry state.

The substrate should be primed with a slurry immediately before the repair material is placed.

Priming slurry should be a mixture of equal volumes of cement and dry plaster sand with sufficient water to achieve a paint consistence. (Neat cement paste is difficult to mix and is therefore not recommended). Polymer emulsion may be added to the mixing water – 1 part emulsion to 2 parts water is usually satisfactory.

Polymer emulsion on its own must never be used as a primer.

Primer slurry must be applied as a thin coating to the substrate using suitable brushes. Do not allow primer to accumulate in depressions in the surface. Do not allow primer to dry before applying repair material.

Priming must therefore be done immediately ahead of repairing and is best done in a small area at a time.

3.2.6 Compaction

Good compaction is essential. Semi-dry mixes must be compacted by heavy tamping.

Plastic mixes must be applied with heavy pressure on the trowel or spatula.

3.2.7 Finishing

Where appearance is important, repairs should be finished to match the texture of the surrounding concrete. (Colour matching is discussed in section A1 of the appendix). Finishing tools include wood floats, steel trowels, sponges, wire and nylon brushes, etc.

3.2.8 Curing

Repairs must be moist cured for at least seven days. Plastic sheeting, fixed along the edges to the concrete with pressure-sensitive tape, is an effective way of trapping moisture and ensuring good curing. Good quality membrane-forming curing compounds may also be used.

After completion of the curing period, polymer-modified repairs must be allowed to dry out completely before being subject to wet conditions. This allows the emulsion to coalesce and so become water-resistant. Note that drying may be retarded if curing compounds are used for curing and not removed from the surface.

3.3 Repair methods

The information in this section is arranged according to type of defect. Defects dealt with are small cavities, honeycombing, and misplaced surfaces.

3.3.1 Small cavities and zones of honeycombed concrete

Remove all weak, soft or honeycombed material to expose hard, sound concrete. Ensure that feather edges will not be formed in the repair; use saw cuts at least 10 mm deep to outline the repair if necessary.

Install mechanical anchoring devices if necessary.

Remove all debris and dust from the surface to be repaired. Check surface absorptiveness, control if necessary and prime surface as described in section 3.2.5.

Repairing may be done using one of the following techniques:

Semi-dry mixture
Depending on the depth of the cavity to be filled the mix proportions by volume are:

	cement	dry sand*	6,7 mm stone
cavity depth less than 30 mm	1	2 ½	0
cavity depth 30 mm or more	1	2	1

* A fairly coarse sand, with some plaster sand blended in if necessary

Mix the cement and aggregates dry until the colour is uniform. Add water in small increments while mixing until the mix is cohesive: a lump squeezed in the hand should remain in one piece on release of pressure.

Place the mix in a continuous operation but in layers not exceeding 20 to 30 mm thick and ram it into place using the end of a piece of reinforcing rod or hardwood. If the surface of the repair is visibly wet when compaction is complete, the mixture is too wet and the repair must be removed and redone with a slightly drier mix. A mix containing too much water will shrink and crack or pull away from the surrounding concrete.

Moist-cure the repair for at least seven days.

Plastic mixture
Use a ratio, by volume, of 1 part of cement to 2 parts dry sand. Sand should be a fairly coarse sand which has been passed through a 2,36 mm sieve. If necessary, plaster sand may be substituted for some of the coarse sand to improve workability.

Mix cement and sand dry until the colour is uniform.

Mixing liquid should consist of 2 parts water to 1 part polymer emulsion or the ratio recommended by the manufacturer.

Add mixing liquid gradually while mixing until a trowelable consistence is achieved. Thorough mixing is essential with this type of mixture.

Apply the mixture, using a suitable trowel or spatula, in layers not exceeding 20 mm thick. If the repair depth exceeds 20 mm, the repair should be built up in layers, not exceeding 20 mm thick, applied on successive days. Roughen the surface of intermediate layers to ensure good adhesion of the next layer. Cover each layer with plastic sheeting until the next layer is applied.

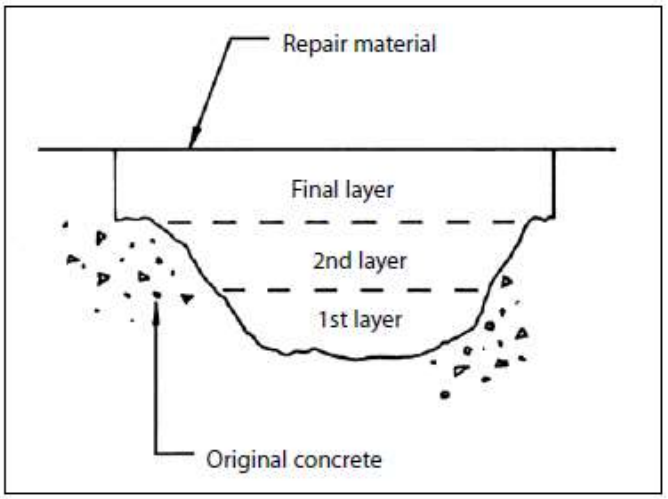

Figure 3: Filling a cavity to ensure that the final layer is of uniform thickness

If the cavity to be filled is of uneven depth, filling should be done in such a way that the final layer is of uniform thickness. See Figure 3.

3.3.2 Surface out of position
Ensure that feather edges will not be formed in the repair; use saw cuts at least 10 mm deep to outline the repair if necessary.

Minimum thickness of repair is about 10 mm.

Install mechanical anchoring devices if necessary. Such devices should be spaced at intervals not exceeding ten times the thickness of the repair.

Roughen the surface of the concrete. Abrasive blasting is recommended. Remove all debris and dust from the surface.

Check surface absorptiveness, control if necessary and prime surface as described in section 3.2.5.

Use a plastic mixture to build up the surface to the required plane and texture to match the surrounding concrete.

Mix proportions and method are as given in section 3.3.1.

4. Blowholes
No surface preparation is necessary but it is important to fill blowholes immediately after formwork is removed. Do not pre-wet the concrete because water left in the blowholes dilutes and weakens the repair material.

Use a mixture of:

1 volume cement
2 volumes plaster sand (loose and dry)

plus enough mixing liquid to achieve a slurry consistence.

Mixing liquid consists of 2 parts water and 1 part polymer emulsion or the ratio recommended by the manufacturer.

No priming is required. Work the repair mix over the whole area with a sponge until holes are filled. Immediately afterwards, remove excess material from the surface with a wet sponge, taking care not to obscure any surface texture.

Spray surface lightly with water using a mist sprayer and cover immediately with plastic sheeting. Keep covered for seven days and then allow to dry slowly.

Appendix
Selecting materials for repairs

Repair materials are mixtures of cement, water and aggregate, with the possible inclusion of a polymer emulsion. Each of these materials is discussed below.

A.1 Cement

All cement sold in South Africa must meet the requirements of SANS 50197 for Common cement or SANS 50413 for Masonry cement and the National Regulator for Compulsory Standards (NRCS) requirements as detailed in NRCS VC9085. Bags should be clearly marked with the strength grade, notation indicating composition and a Letter of Authority (LOA) number issued by the NRCS. An LOA is issued for each cement type from each source. To verify valid LOA numbers contact the NRCS on 012 428 5199 or www.nrcs.org.za.

Note that Masonry cements complying with SANS 50413 are not permitted to be used in concrete.

Cement should comply with SANS 50197-1 strength class 42,5N or higher. If the recommended curing procedure is followed, then any SANS 50197-1 cement could be used.

Because repairs tend to be darker than the original concrete when they dry out, white portland cement may be substituted for about a third of the grey material if a colour match is required. The optimum substitution ratio should be determined by test: carry out a repair in an unimportant area and assess colour once the repair material has hardened and dried.

A.2 Water

Use potable water from a municipal supply. Water from other sources may be used if shown by testing to be suitable.

A.3 Aggregate

Particle Size

Maximum particle size must not exceed one quarter of the thickness (or least dimension) of the repair. An indication of particle size for various thicknesses is as follows:

least dimension of repair, mm	maximum particle size*, mm
10 - 20	2,36
20 - 30	4,75
30 - 40	6,7

* These are standard sieve sizes

Particle Shape

Ideally, particles should be spherical. If such materials are unavailable, particles should be rounded or roughly cubical or “chunky”. Flaky and elongated particles should be avoided.

Grading

Sand used for repair work should be graded: particle size should range from dust to the largest size. Sands with particles all of similar size produce mixes with poor workability and high water requirement. Such sands should be blended with other sands to improve grading.

Types

The following aggregate types, blended where necessary, may be found suitable:

- Plaster sand
  Useful for blending with a coarser sand to improve workability or on its own for making priming slurry and for filling blowholes.

- Concrete sand
  Naturally derived pit or river sands and well-shaped crusher sands, with coarse particles removed by sieving if necessary and blended with a finer plaster sand. (Pit sands consisting of decomposed granite usually have a high water requirement and should therefore be avoided unless suitability can be demonstrated by testing).

- Stone
  Pebbles and crushed stone with well-shaped particles as described above (see Particle shape).

A.4 Polymer emulsions

Polymer emulsions formulated for use with cement are obtainable from specialist suppliers. Such emulsions should be based on styrene butadiene rubber (SBR) or acrylic.

Do not use polymer emulsions formulated as paint.

Emulsions based on polyvinyl acetate (PVA) are best avoided unless the repair can, after curing is complete, be kept in a permanently dry state. PVA emulsions, after drying and coalescing, are unstable in wet conditions.

A.5 Proprietary formulations for repairs

Polymer-modified formulations that need only a specified amount of water to be added and mixed are available from specialist manufacturers. Although such formulations tend to be more expensive per unit volume than repair materials made up with ingredients obtained separately, they are convenient to use and should be considered especially for smaller jobs or when close supervision is not possible.

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