Surface preparation for application of patch repairs, sealers and coatings — Indian approach

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The main purpose of surface preparation is to provide maximum coating adhesion and to increase the surface area by increasing the roughness of the surface. In this paper, the author describes the types of surface preparations that are commonly adopted in Indian conditions and their limitations. The precautions to be taken in the selection of coating systems in view of these limitations are also discussed.

Surface preparation is one of the important works to be carried out before application of any resin-based coating or sealing system. In the present paper the scope is limited to application of such systems on concrete surfaces. Much of the success of such systems depends on proper surface preparation. It is therefore necessary to keep in mind the importance of surface preparation before undertaking such works. The present day awareness among the applicators about this aspect of work is far from satisfactory. The paper describes the commonly used surface preparation techniques in India and different aspects to be combined in the selection of coatings and sealants.

Types of surfaces

Generally one comes across either fresh concrete surfaces or damaged surfaces for application of coatings/sealants. The fresh concrete surface usually has a lot of surface laitance. The surfaces also have a large number of small and large size holes. In the case of surface preparation before repairing the damaged concrete surface such as in corrosion or fire damaged structures, a variety of contaminants has to be removed, *Fig* 1. These include rust scales, soot, oil, grease, salts, barnacles, etc. Though the overall protective coating or sealer is not likely to be applied over such areas, these surfaces receive the bonding coat before the application of repair mortar. Adhesion of bonding coat is a very important requirement in the repair system and surface preparation requirements are even more critically followed for surfaces being repaired.

Types of concrete grades and surfaces

Most structures, which are being presently repaired in India represent a grade of concrete which is generally M 20 or so. Only infrastructural projects such as marine structures and

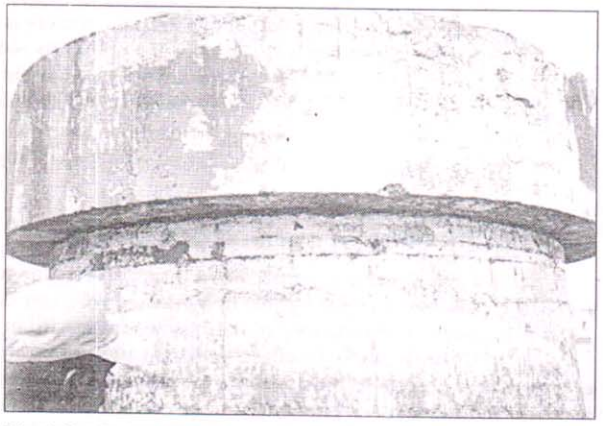

Fig 1 Typical concrete surface before surface preparation

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Fig 2 Sandblasting reinforcement before coating

bridges have a higher grade than this. With this quality of concrete in mind, heavy equipment such as electrically-operated chisels need to be used very judiciously.

Concrete surfaces may also contain a surface residue called laitance. This is derived from some of the non-reactive materials in the cement or in the aggregate that rise to the surface during placement. Trowelled surfaces that appear to have a glaze often have a thin layer of laitance which gives the glazed appearance. The laitance, either heavy or thin is a weak powdery material that has little adhesive strength. It usually acts as a separating agent between the concrete surface and the coating.

In order that the coatings adhere satisfactorily to the concrete, laitance must be removed by acid etching or light sandblasting. However, the best concrete surface for application of coating is a hard trowelled surface since it produces the most uniform surface for concrete. It is also quite dense so that a smooth continuous film can be easily applied.

One of the major problems in coating all substrates, is the development of a continuous film. Poured concrete is filled with pin-holes so that it is almost impossible to obtain a continuous coating. Under these conditions, concrete must be specially treated with a coat of cement paste/mortar over the surface, or by using some of the resinous materials to fill the pores and still provide a base over which a coating may be applied.

Significance of surface preparation

It has been stated that paints fail in direct proportion to their lack of adhesion. Stating this in a positive way, one can say that paints or anti-corrosive coatings are successful in direct proportion to their bond strength to the substrate. The purpose of surface preparation is to ensure that the maximum bond-strength will develop at the interface between the substrate and the coating. Failure within the coating is referred to as cohesive failure; failure at the interface between the substrate and the coating is referred to as adhesion failure. The goal of surface preparation should be to achieve a level sufficient to ensure cohesive failure of the coating. From a surface preparation point of view, the ideal type of coating failure is 100 percent cohesive. Another type of adhesion failure occurs where the substrate itself fails rather than the coating. Such failure is not uncommon on concrete. Polymer coating applied to concrete often has a greater tensile strength and cohesion than the concrete.

The primary objective of surface preparation is to provide maximum coating adhesion. The actual mechanism of surface preparation has a two-fold purpose. The first purpose is to remove any extraneous, loose material from the surface, as well as to eliminate chemically bonded scales, oxide films, similar surface reaction products that cover active adhesion sites on the surface. The removal of such materials exposes the reactive sites so that the primers can have contact with them and develop the maximum adhesion possible.

The second purpose of surface preparation is to increase the surface area by increasing the roughness and anchor pattern of the surface. By this means, the actual exposed surface area per unit of actual area is greatly increased. This is extremely important, since increasing the scope of either primary or secondary valence bonding with the coating system is the key to the best possible adhesion of any coating.

The purpose of surface preparation is to ensure that the maximum bond-strength will develop at the interface between the substrate and the coating

Basic steps in surface preparation

Depending upon the damaged concrete surface, it is first of all necessary to chip off loose concrete. This is usually achieved by using a chisel and hammer. Care has to be taken to ensure that only the loose and damaged portion is removed and that the sound concrete is left untouched. Any use of extra force to chip off sound concrete may only be more harmful to the structure since this can result in micro-cracks in sound concrete. Only hammers upto one kg weight should be used. This should be followed by the use of a suitable system or a combination of systems to prepare the surface.

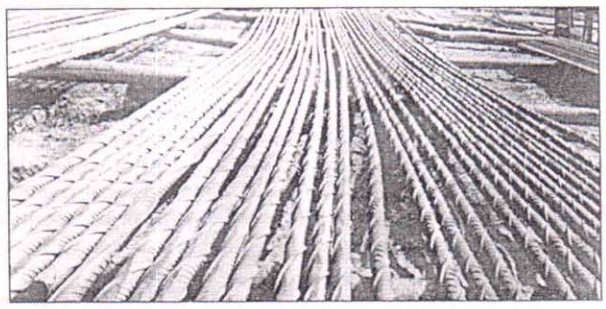

Fig 3 Sandblasted cleaned surface

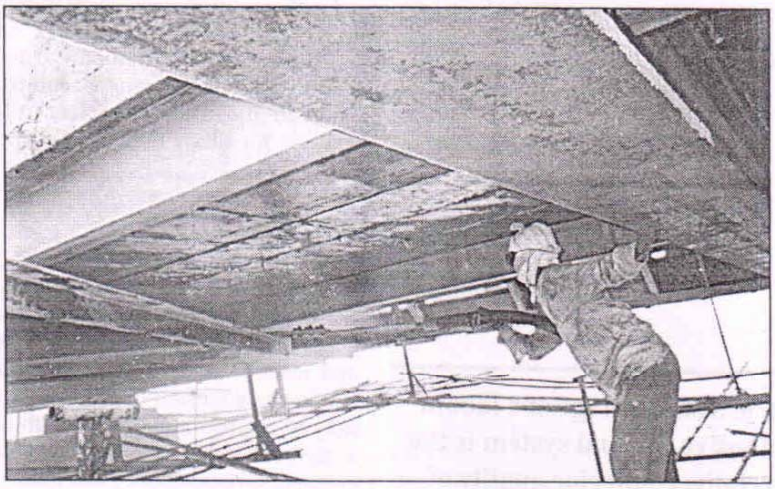

Fig 4 Sandblasting new surfaces of concrete before coating

Types of surface preparations

The method of surface preparation to be used depends upon a variety of factors. Given below are the types of surface preparations commonly adopted.

(*i*) For steel structures of significant importance such as bridge girders, thermal power station buildings and equipment areas, chimneys, silos and reinforced concrete structures located in highly corrosive areas, standard sand blasting conforming to Swedish standard SA 2.5 is usually adopted, *Figs* 2 and 3.

(*ii*) For large concrete structures belonging to infrastructure projects such as prestressed concrete bridges — brushed blasting is adopted where specific mention of sand blasting is done in the specifications. In this procedure, the gun is held at a considerably greater distance from the surface compared to standard sand blasting. The purpose here is only to remove the surface laitance without really roughening the surface which works out to be faster and cheaper. This would lead to adequate surface preparation for newly cast concrete surface, *Fig* 4.

(*iii*) *Power tool cleaning*: This is one of the most common forms of surface preparations used for preparing surfaces of fire-damaged and corrosion-damaged structures. The commonly used tools are electrically operated shaft type grinders and angle grinders. Using these tools, it is possible to remove corrosion scales from reinforcement and loose, unbonded and weathered cover portions from concrete. Surface laitance could also be removed to a considerable extent. Though it is not possible to achieve the kind of surface compared to (*i*) and (*ii*) above, one has to keep in mind that these are probably the most sophisticated tools that are likely to be used on any rehabilitation site in India today. It is necessary therefore, to lay down detailed surface preparation methodology using these tools in a qualitative and to some extent illustrative manner.

(*iv*) *Acid etching*: This is being widely recommended as a means of surface preparation for reinforcement as well as concrete surfaces. However, it is likely to cause harm, rather than do any good to the cause of surface preparation. This is because, on most occasions, the specifications are silent on the strength of acid to be used, and the kind of acid to be used. Moreover, in highly porous concrete, the acid is likely to affect reinforcement inside the concrete that is being cleaned. It is therefore not advisable to adopt this method of surface preparation unless strict quality control is administered.

Types of tools

The following tools are found to be economical, handy, easy to use and maintain:

- chisel and hammer
- angle grinder

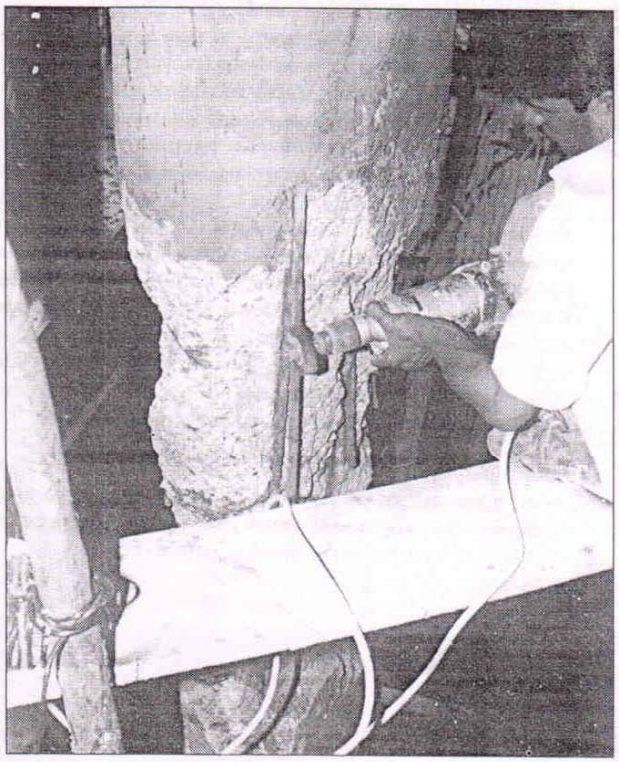

Fig 5 Rotary angle grinder with wire brush attachment for cleaning small and inaccessible areas

- angle grinder with wire brush cup
- wire brush wheel attached to a drill machine
- shaft type grinders with wire brush attachment
- sandpaper/emery paper.

Apart from these, special tools are available for applications such as flooring. These tools are economical while treating large areas. These include:

- scarifier
- frazer.

Apart from the tools for surface preparation, ensuring dry concrete surface is also equally important since most of the coatings used for applications are not moisture compatible. Simple tests of fixing a plastic sheet over a representative area overnight would show the extent of moisture present in concrete. Tools such as hot air blower, compressed air blower would come handy. After such drying methods are used, one more test of moisture content is necessary before proceeding with the application of sealers and coatings.

Limitations of surface preparation

Exhaustive surface preparation systems such as sand blasting were not practised in the west until the late 1930s. Although it has become a common standard of surface preparation in advanced countries, in India, we are still far from adopting it as a standard method of surface preparation. Unless it is specially called for in the specifications, sand blasting is generally not preferred in India. One of the main reasons is that sand blasting is uneconomical for isolated areas and small quantities of execution. Sand blasting is practical only when the surface to be treated is sufficiently large. On a small scale it is highly uneconomical to bring in the equipment for surface preparation. It has been found that with the judicious use of rotary grinders and with rotary wire brushes adequate surface preparation can be achieved. The laitance can also be removed out using light sand blasting.

Sand blasting becomes even more uneconomical when small areas are to be repaired. In such situations, a rotary angle grinder with a wire brush attachment works better for removal of rust from the reinforcement, *Fig* 5.

With cheap labour and with minimal professional training for jobs such as chipping, scraping, wire brushing, etc, these labour intensive systems work out more economical than sand blasting. Having accepted the fact that sand blasting can only be feasible on large scale operations, one has to lay down detailed specifications for other means of surface preparation.

Selection of coating systems

Some of the most advantageous coatings for concrete surfaces are those which use the porosity of the concrete to advantage. These are usually epoxy type products which penetrate the pores of concrete and react in place. This provides for maximum adhesion of the coating. It may be appropriate here to highlight a case of a bridge repair. Here, concrete surface laitance was removed by hand operated grinder before protective coating. This bridge protective coating system was done about 10 years back and has withstood severe corrosion conditions without showing any signs of peeling off even with such a moderate surface preparation method. The primary reason for this is the deep penetrating sterate-based primer coating deployed in this system.

The disadvantage of a labour intensive manual system is the relatively inferior quality of surface preparation. A failure in workmanship could result in the failure of repair — in the performance of its structural, protective and aesthetic functions

Vinyl coatings, which are applied as a dilute solution, will penetrate into the concrete surface and obtain good adhesion. Coatings that remain mostly on the surface, such as water-based emulsion type coatings are not recommended for concrete where severe corrosion is a problem.

The disadvantage of a labour intensive manual system is the relatively inferior quality of surface preparation. A failure in workmanship could result in the failure of repair in the performance of its structural protective and aesthetic functions. However, since most coating work is also done by brush application, physical brushing action increases penetration of coating through surface contamination and imperfections. Therefore, at least the primer coat should be applied by brush where it is not possible to adopt sand blasting as the surface preparation method. Another factor that can contribute to overcoming the above disadvantage is selection of a coating system that has a high wetting ability.

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