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Repair and Rehabilitation of Structures

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Abstract

This paper deals with the latest techniques in repair and rehabilitation of structures. The various causes of structural failure and the principles of rehabilitation of structures are discussed. Major repair that are to be carried out in Brick walls, Plaster walls and RCC members are explained in detail and an in-depth analysis into Reinforced Cement Concrete repair options like Shotcrete method (Guniting) and Form and Pump Method. The paper also deals with the comparatively new Form and Pump technique developed for the past 10 years are discussed.

Keywords: Seismic evaluation, rehabilitation, seismic regions, repair, concrete, plaster.

Introduction

A large stock of existing structures and infrastructure are deteriorated with use and time and might have passed their design life and require retrofitting and rehabilitation. The cost of retrofitting various infrastructures is estimated in the lakhs of rupees. To overcome the ill effects caused by these deteriorated buildings Repair and Rehabilitation works are carried out from time to time. Many of the existing structures were designed to codes that have since been modified and upgraded. Change in use or higher loads and performance demands require modifications and strengthening of structural elements.

Why do some structures fall down?

➤ Site Selection and Site Development Errors:

Failures often result from unwise land use or site selection decisions. Certain sites are more vulnerable to failure. The most obvious examples are sites located in regions of significant seismic activity, in coastal regions, or in flood plains. Other sites pose problems related to specific soil conditions such as expansive soils or permafrost in cold regions.

➤ Design Errors:

These failures include errors in concept; lack of structural redundancy; failure to consider a load or combination of loads; deficient connection details; calculation errors; misuse of computer software; detailing problems including selection of incompatible materials, failure to consider

maintenance requirements and durability; inadequate or inconsistent specifications for materials or expected quality of work and unclear communication of design intent.

➤ Construction Errors:

Such errors may involve excavation and equipment accidents; improper sequencing; inadequate temporary support; excessive construction loads; premature removal of shoring or formwork; and non-conformance to design intent.

➤ Material Deficiencies:

While it is true that most problems with materials are the result of human errors involving a lack of understanding about materials, there are failures that can be attributed to unexpected inconsistencies in materials.

➤ Operational Errors:

Failures can occur after occupancy of a facility as the result of owner/operator errors. These may include alterations made to the structure, change in use, negligent overloading and inadequate maintenance.

Principles of rehabilitation

➤ ELIMINATION

Remove the materials that cause damage to buildings. This is no easy matter, because everything from the floor to the roofing may contain various undesirable materials in the form of additives and admixtures.

➤ SEPARATION

Some things just can't be eliminated, but can still be protected. Use sealants or foil backed drywall to separate structures from damage causing sources.

➤ VENTILATION

Controlled, filtered ventilation may be the only way to insure that the air we bring indoors is ideal. High humidity air or extremely low humidity air can cause significant damage to concrete, plaster and brick walls.

General areas of repair/rehabilitation work

- Repair, removal, replacement and maintenance of mechanical supports, sanitary treatment plant and pipelines.
- Repair and modifications to diffuser ports, aeration systems, and discharge pipelines.
- Installation and maintenance of dewatering structures.
- Pile restoration and wood pile concrete encapsulation.
- Anode installation for cathodic protection.
- Repair and replacement of trash-rack and debris screen.

Major types of repair

- Brick Wall Repairs
- Plaster Wall Repairs
- RCC Repairs

BRICK WALLS

Basically, brick is durable and long-lived as long as the mortar joints are sound. Brick houses are susceptible to moisture - more so than wooden framed houses - but require very little maintenance.

Problems With Brick (Structural Problems)

- Deteriorated Pointing affects many old houses. Mortar starts to disintegrate between the bricks, which can cause the entire wall to collapse, or single bricks to crumble.
- Dirty or stained brickwork can be caused by moisture, time, dirt along with rain or sprinklers.
- Efflorescence results from bricks getting wet, which leaves deposits of salts that are drawn out of the masonry as the moisture evaporates the brickwork and find the source of the moisture.
- Spalled brickwork is also common. Once bricks have been wet, the expansion of freezing water breaks off the top surface of the brick, leaving the inner surface exposed. After a time, most of these bricks will crumble completely.

A couple of Don'ts for brick

- Don't assume that old mortar needs to be replaced. Old mortar is usually of higher lime content than the newer replacement mortar we are likely to find to repoint, and the high Portland cement content of new mortar can damage old walls beyond repair.
- Don't seal bricks with a water repellent (i.e., water seal) - it can mean that any moisture that is already in the brick stays in the brick, and interior moisture may not be able to escape.
- Don't use hydrochloric acid to clean brick, it can cause discoloration or mottling that is permanent.
- Never sandblast old brick! Sandblasting can damage the hard surface of fired brick and open the bricks up to water damage.
- Never use expansion joints in historic masonry - they can pulverize brick and ruin mortar joints.

REPAIR WORK

Cleaning Brickwork

- For normal dirt and grime, simply use plain water, rinsing with a hose and scrubbing with a stiff bristled brush.
- For stubborn stains add 1/2c ammonia to a bucket of water.
- Don't use a power washer except as a last resort - if we have a crumbling brick problem, this will make it worse (old windows don't stand up to high pressure water very well).

Removal of Organic Growth

A moist brick will often lead to growth a variety of molds and mosses.

- First, scrape the moss or mold off the surface with a non-metallic spatula (the same kind used on Teflon).
- Second, apply a wash of 1 part bleach to 4 parts water to kill the spores.
- After a couple of days, scrape again and rewash. It will probably take a few applications to kill everything off.

PLASTER WALLS

Should you repair or replace?

It is usually better to go in favour of repairing plaster walls, regardless of what they look like. But honestly, this is not always possible. Basically, if:

- there is more than 1 large hole per 4 x 8 area, or
- there are more than 3-4 cracks in 100ft², or
- the cracks are more than 1/4" wide

Then replace the section of wall. It will take more time and failed attempts to repair this wall than it is worth. Old plaster should be cherished - it is stronger and more soundproof than current walls made of gypsum board or sheetrock. Even cracking or crumbling plaster walls should be repaired, not replaced.

Plaster Damage (Non-Structural Problems)

Plaster is pretty tough stuff, but like any wall, it's going to get banged or gouged, and age will take its toll.

- Impact Damage can be serious problem in an old house. Over the years, the walls are going to get banged and dented. Generally we have to replace the plaster 6-12" from the visible hole to reach plaster that is still keyed to the lath tightly.
- Nearly every wall has a few nail holes. These can usually be fixed with a tiny bit of spackle applied with the finger. Not perfect, but they will be unnoticeable when the wall is painted.
- Water is the enemy of plaster. Brownish stains on the walls or ceilings are evidence for bowing out of plaster. Water-damaged plaster can be very friable.
- Old walls and old houses often have cracks. Stress cracks are a sign of possible structural shifting, extreme temperature changes, incorrect plaster mix, improper curing or leaks. Diagonal cracks over doorways signal settlement, or a nearby source of vibration, such as a highway or railroad.
- Bulging plaster is an indication that the plaster keys have broken off and allowed the plaster layers to separate from the lath behind them. Bulging can be repaired with plaster washers.

Repairs

- For repair of minor cracks, use fiberglass mesh tape then go over with a wide trowel and joint compound. There are also plaster patch compounds available that are excellent.
- For larger cracks and holes, we need to remove all the debris and enlarge the crack until we reach solid plaster and fill the crack with joint compound or plaster patch.
- If we choose to put wallboard over the plaster, use the following tips:
 - Apply wallboard horizontally
 - Use the largest boards available.
 - Use screws, not nails, 12" apart in ceilings, 16" on walls

- Use a floating joint - the wall holds up the ceiling sheets
- Use corner clips at all corners
- Use fiberglass meshes tape, not paper, and special compound that is available for plaster walls.
- Seal interior corners with acrylic latex caulk its not historically correct, but the effect is smooth and unnoticeable

RCC STRUCTURES

Problems In RCC Structures (Structural Problems)

- Flexure, Shear, Torsion, Shrinkage And Tension cracks
- Splitting, Diagonal, Horizontal cracks in Columns
- Rusting, Buckling, Bending, Twisting Distress in Steel structures

Method of Repair For RCC Structures

➤ Wet Mix Shotcrete

Wet mix Shotcrete is a method that involves premixing of all ingredients including binder, water, aggregates and admixtures. The premixed repair materials are deposited into a pump which transports the materials to an exit nozzle where compressed air is introduced. The repair material is propelled onto the substrate with compressed air. Admixtures can be used to enhance durability. Air entrainment is required for freeze thaw resistance. Fig(a)

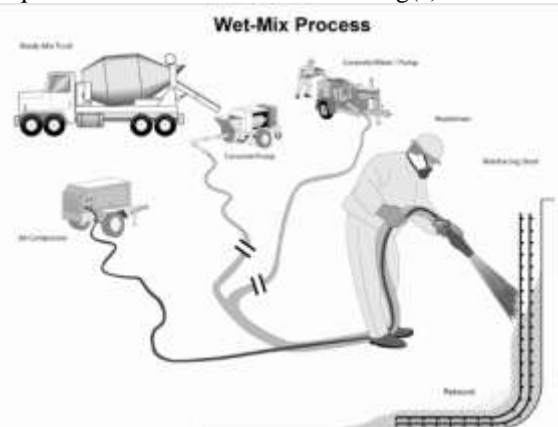


Fig. (a) Wet Mix Concrete Method

➤ Dry Mix Shotcrete

Dry mixing involves premixing of binders and aggregates which are fed into special mechanical feeder metering the premixed materials into a hose. The mix is jetted out along with compressed air from a nozzle connected to the hose having a water ring outfitted to it. This mix is injected to the repair spot. The resultant hardened properties include increased flexural, compressive strengths and more durability.

Problems associated with Dry mix Shotcrete

- Presence of voids due to encapsulated rebound
- Shrinkage cracking caused by high cement concrete, improper curing or excessive water control

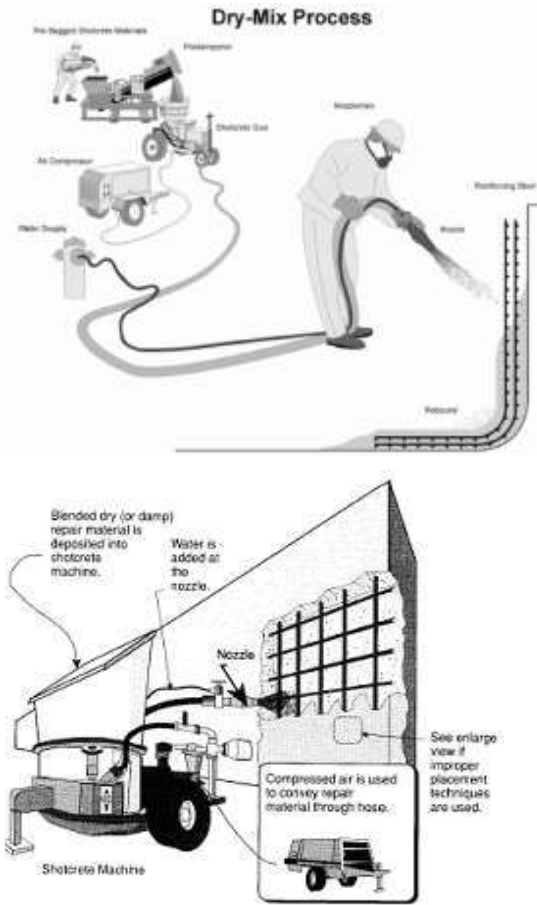


Fig. (b) Dry Mix Concrete

➤ **Form and Pump Technique**

The form and pump repair method is a two-step process of constructing formwork and pumping repair material into the cavity confined by formwork and existing concrete. The form and pump technique allows use of different materials. Repair materials are mixed and pumped into the cavity. When the cavity is full, pump pressure is exerted into the form causing the repair material to consolidate and make contact with existing concrete surfaces.

➤ **Surface Repair of Vertical Location (Column)**

One of the most common methods of surface repair of vertical and overhead location is placement of formwork and casting of repair material into the prepared cavity. The repair material must be of low

shrinkage and necessary flow ability. Rodding or internal vibration is necessary to remove air and provide intimate contact for placing concrete substrate. In some applications complete filling of the cavity may be difficult. In those cases a final step of dry packing the remaining cavity works well.

➤ **Surface Repair of Overhead Location (Beam)**

There are many techniques available to restore damaged or deteriorated concrete structures. Each surface repair techniques offer advantages and limitations depending upon the conditions of the repair project. Form a pump technique is relatively new method which has been developed as a viable alternative to Shotcrete (gunite), hand placement and grouted preplaced aggregate techniques.

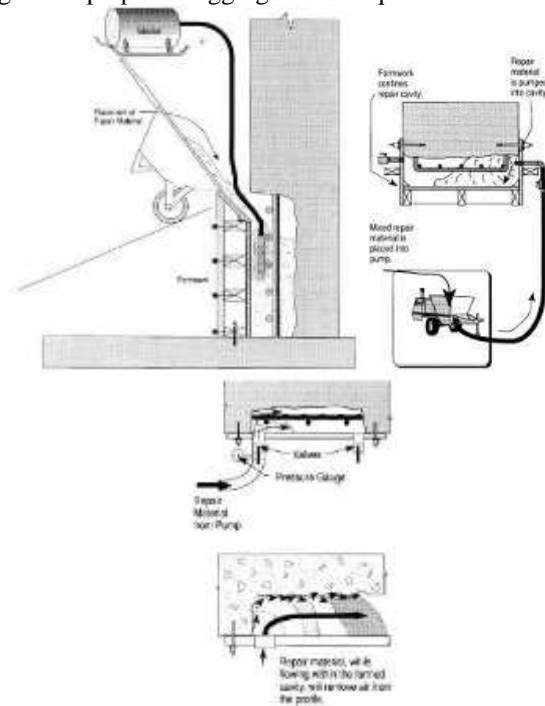


Fig. (c) Surface Repair of Vertical & Overhead Location

Advantages of Form And Pump Technique:

- The use of almost any type of repair material- from fine grained mortar to course grained cement concrete.
- Placement is not limited by depth of repair, or by size or density of reinforcements.
- The pressurization process provides full encapsulation of exposed reinforcing steel.
- The formwork protects the repair material during curing process.

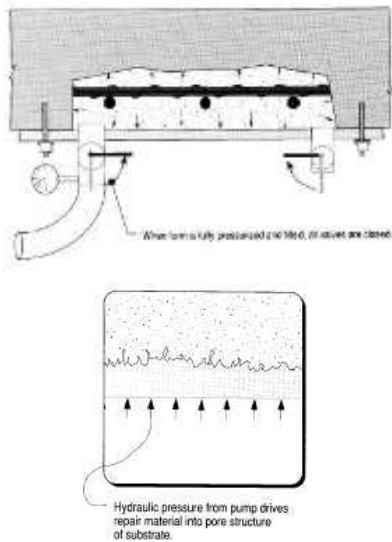


Fig. (d) Form and Pump Technique

Placement of the Materials

The sequence of material placement into the formed cavity depends upon the geometrics involved. Vertical surfaces start at the lowest point, filling in a manner that prevents air entrapment. Arrangements for ports for pump line attachments are usually in grid form. When the flow is without the intrusion of air, the pump is shut off temporarily; the port closed off and pump line connected to the adjacent port which has seen flow. The sequence is carried out until the cavity is filled. Once the cavity is filled, the full line pressure is available to pressurize the formed cavity.

Selection of Materials

Constructability requirements for materials used in form and pump method are limited only by their ability to be pumped and flow characteristics. The materials in-place properties like low drying shrinkage, compatibility, thermal and elastic properties. Drying shrinkage can cause cracking, delimitation, inability to carry loads and low durability. Pumpability and flowability can be brought into the materials by additives and admixtures. Prepacked repair materials which are designed for pumping and incorporating shrinkage compensating additives are appropriate for many applications.

Conclusion

- Periodic maintenance of structures is essential.

- Each and every problem should be properly analyzed and then the appropriate repair methods undertaken.
- Primary design of the building reflects its performance in long run.
- Each repair technique is suitable only for the particular application for which it is meant for.
- Form and Pump technique which has become the alternative for grouting, gunning nowadays is also cost effective in large scale operations
- Cost should not be significant planning factor in rehabilitation though it is a deciding factor.

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