

An Overview of Soil Stabilizing and Concrete Repairing Materials for RC Structures

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Abstract- This review paper is an attempt to explore and highlight the materials for defects of RC structures and for soil stabilization. It covers the different type of defects and the materials which can be used for repair and soil stabilization. This paper focuses on use of stabilizing and some special repairing materials for improved performance and durability of structures.

Index Terms- RC Structure, Defects, Repairing Materials, Stabilizing Materials.

1. INTRODUCTION

RC structures are prone to many defects. These defects arise from either soil settlement or deterioration of concrete or poor design/construction practice or combination of all such factors. There are many types of repairing and stabilizing materials are available in market. Those materials help to regain the aesthetic and structural aspect of RC structure. The selection of repair material is one of the most important tasks for ensuring durable repair. Though the detailed investigation and determination of the cause of distress is essential for a good repair system, the understanding of utilization of repair material under service condition is also needed. In this review paper, we have tried to discuss some materials related to repairing.

2. MATERIALS

Repair materials can be classified in to two major types:

- (1) Soil stabilizing materials, which deals with Soil settlement,
- (2) Concrete Repair Materials

2.1. Soil stabilizing material

Soil stabilization means to improve soil properties by various techniques and materials. Techniques or method means physical way of changing the soil properties i.e Ground improvement. Ground improvement can be achieved by blending and mixing other materials, mainly chemicals, with soil. The ultimate goal to adopt the technique / material improves engineering properties of the soil and makes it stable against the loads.

Following are the various soil stabilization materials:

- (3) Cement
- (4) Lime
- (5) Bitumen
- (6) Fly-ash
- (7) Chemical additives

2.1.1. Cement

When the soil is stabilized with cement, it is known as soil cement. The siliceous content of soil reacts chemically with cement and results into the cementing action during hydration reaction. The important factors affecting the soil-cement are nature of soil content, conditions of mixing, compaction, curing and admixtures used [1].

The appropriate amounts of cement needed for different types of soils may be as per Table-1:

Table 1. Type of Soil & Cement content [1]

Type of Soil	Cement content required
Soil with high Gravel content	5% to 10%
Sandy Soil	7% to 12%
Silty Soil	12% to 15%
Clayey Soil	12% to 20%

2.1.2. Lime

Slaked lime, also called calcium hydroxide, is very effective in treating soil which is highly plastic in nature, i.e Clay. Lime is either used alone or in combination with cement, bitumen or fly ash. The properties of Sandy soils also can also be improved

with these combinations. Such Soil stabilization process is also called Lime treatment of soils. Lime is very useful for stabilizing the road bases and the subgrade.

Lime provides pozzolanic action. Plasticity index of highly plastic soils are reduced by the addition of lime with soil.

Table 2. Type of Soil & Lime content^[1]

Type of Soil	Lime content required
Coarse grained soils	2% to 8%
Plastic Soils	5% to 8%
Fly Ash is added as an admixture – 8% 20% of weight of Soil	

2.1.3 Bitumen

Bitumen is a visco-elastic material. Without increasing the rigidness in the soil, it ensures zero cracking in the soil. If solvent is added in bitumen to make it liquid then, it might have adverse effect on soil properties. Bituminous materials when added to a soil, it imparts both cohesion and reduced water absorption. Depending upon the above actions and the nature of soils, bitumen stabilization is classified in following four types:

- Sand bitumen stabilization
- Soil Bitumen stabilization
- Water proofed mechanical stabilization, and
- Oiled earth^[1]

Apart from above four, now there is a new type called Foamed Bitumen.

2.1.4 Fly-ash

Fly ash reduces the volumetric expansion of a plastic soil by a physical cementing mechanism. Fly Ash can be of Class C or Class F. Fly Ash of Class C can be used with blending with any other material. This is due to its self-cementitious property. Class F type of Fly Ash is used along with Lime, Cement or any such binding agents. Whether the Fly Ash is self-cementitious or not is decided by its compressive strength.

Table 3. Type of Soil & Lime content^[6]

Fly Ash – Degree of Self Cementing	Compressive Strength
Strongly Self Cementing	> 3400 kPa
Moderately Self Cementing	700-3400 kPa
Poor (Non) Self Cementing	< 700 kPa

2.1.5 Chemical additives

Chemical stabilization includes the use of chemicals to help in compaction of soils, as binders and water repellents, and as a means of modifying the behaviour of clay. It also includes deep mixing and grouting. Chemical stabilization can aid in dust control on roads and highways, particularly unpaved roads, in water erosion control, and in fixation and leaching control of waste and recycled materials^[2].

2.2. Concrete repair materials

There are two inherent weaknesses of Concrete, it is porous and it cracks. Selection of concrete repair materials is based on evaluation of cause of defect, type of damage, types of materials to be used for repair and the local condition. For some defects, the best repair material is concrete itself - but of high quality. Concrete repairing material must be compatible with the concrete being repaired. Thus high bond strength and durable materials are preferred. Varieties of materials are available for repair of concrete structures. The choice of such materials is based on performance and cost.

These repair materials are based on any one or combination of more than one of the following:

- (1) Portland Cement Mortar / Concrete
- (2) Low Viscosity Polymers
- (3) Very Rapid Setting Cement
- (4) Special Concrete for overlays

The properties affecting selection of repair materials:

- (1) Bond with concrete
- (2) Strength development of material with concrete (compressive, flexural and tensile)
- (3) Co-efficient of thermal expansion of the material
- (4) Co-efficient of permeability of the material
- (5) Stress development at interface whether on shrinkage, temperature change, alternative cycles of wetting and drying
- (6) Corrosion resistance property of the material
- (7) Durability of such concrete repair material
- (8) Appearance of finished surface
- (9) Speed of concrete repair

Following are some of the repairs materials which are selected keeping durability aspect into consideration:

- (1) “Waterproof” concrete admixture
- (2) High Performance Fibre Reinforced Cementitious Composites
- (3) CFRP fabrics

2.2.1 “Waterproof” concrete admixture

Waterproofing property of concrete increases its durability, which is the most important aspect of any repair material of RC structures.

Waterproof concrete has low permeability and reduced capillary water absorption properties. Therefore, it is more suitable to be used in water-resisting construction below ground. When it is difficult to use membrane technology because of surface irregularities, such concrete decreases overall repair time as well as cost.

The waterproofing admixture provides added reduction in drying shrinkage to mitigate the development of cracks and thus eliminates use of other materials along with concrete. Some waterproofing admixtures enhanced resistance to cracking, reduction of permeability and capillary absorption and develop well [3].

Such concrete is most useful for hydraulic and water retaining structures, maintenance of which is very challenging.

2.2.2 High Performance Fibre Reinforced Cementitious Composites (HPFRCC) [4]

In developing countries like India, there is tremendous load on road infrastructure. Conditions of roads and bridges are rapidly deteriorating because of population increase and material aging. Thus again, durability aspect comes into discussion.

In the paper durability aspect and the required property needs for different techniques of repair materials are reviewed.

A HPFRCC, known as Engineered Cementitious Composite (ECC), has characteristic of undergoing tensile strain-hardening after first crack. This large ductility of certain HPFRCCs make them excellent repair materials. It can be shown that high tensile strain capacity is most required property for durable materials and this property can be achieved by ECC economically.

The following properties are highly desirable of a repair material:

- a) Low cracking potential ϵ
- b) Low Young's modulus E
- c) Tight crack width w and
- d) Low permeability k in cracked state

ECC fulfills all above requirement as a repair material.

2.2.3 CFRP fabrics

Carbon Fiber Reinforced Polymers (CFRP) can be used on non-structural masonry elements which can be converted in to structural elements at the time of rehabilitation. This will improve performance of building at the time of earthquake and thereby increasing durability – life of building.

Based on various research data and tests, we can say that masonry infills can be converted into the structural wall successfully by strengthening non-structural elements with the help of CFRP sheets and strips connected to of the frame members. The technique is applicable on RC infills also. It strengthens the building and will upgrade it seismically. Use of CFRP eliminates possibility of delamination of masonry/concrete surface. Use of CFRP also rectifies the improper lapping of longitudinal bars at the time of original construction. The only demerit of the technique is that during the rehabilitation work, building needs to be evacuated for several months [5].

3. CONCLUSIONS

- (1) When the Defects in RC structure are detected, it is important to find out the characteristics of defects. Investigation of defects can lead us to causes of defect.
- (2) The defects should be healed with suitable material by relative method to repair them.
- (3) Selection of materials and methods is most important task and after defining them the application of them to repair the defects.
- (4) Several repair materials and techniques are available. Select most suitable one based on factors governing the condition.
- (5) Out of many required properties of building materials, durability is the most desired one.
- (6) Low permeability is the other most desired properties.
- (7) The recent research has opened gates for many new combinations of materials as well as techniques which can improve the performance of one the most versatile engineering materials – Concrete.

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(A.1)

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