

Materials & Repair Methodologies, Protection of Concrete Structures & Rebar Corrosion Protection

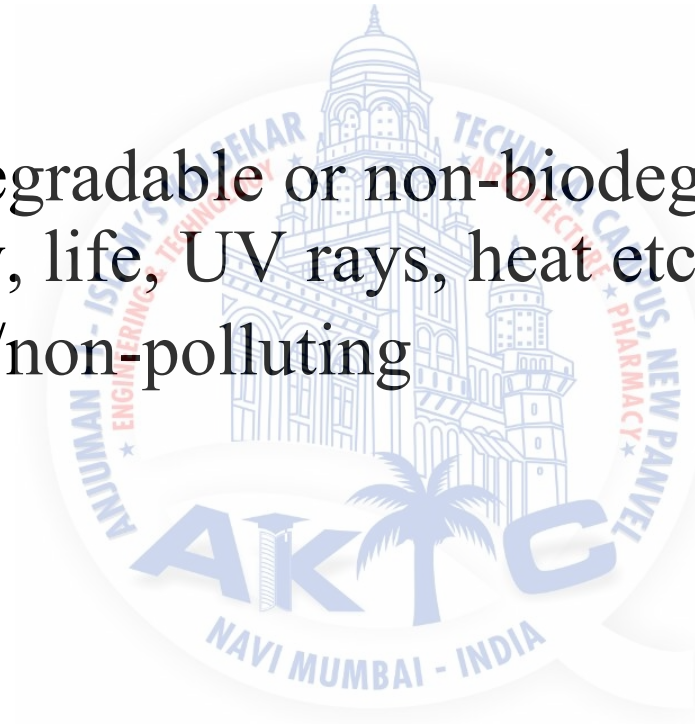


Repair materials and their properties

- Low shrinkage properties
- Requisite setting/hardening properties
- Workability
- Good bond strength with existing sub-strate
- Compatible coefficient of thermal expansion
- Compatible mechanical properties and strength to that of the sub-strate
- Should allow relative movement, if expected, particularly in case of sealing of cracks or dealing with expansion joints.
- Minimal or no curing requirement
- Alkaline character
- Low air and water permeability
- Aesthetics to match with surroundings

Repair materials and their properties

- Cost
- Durable, non degradable or non-biodegradable due to various forms of energy, life, UV rays, heat etc
- Non-hazardous/non-polluting



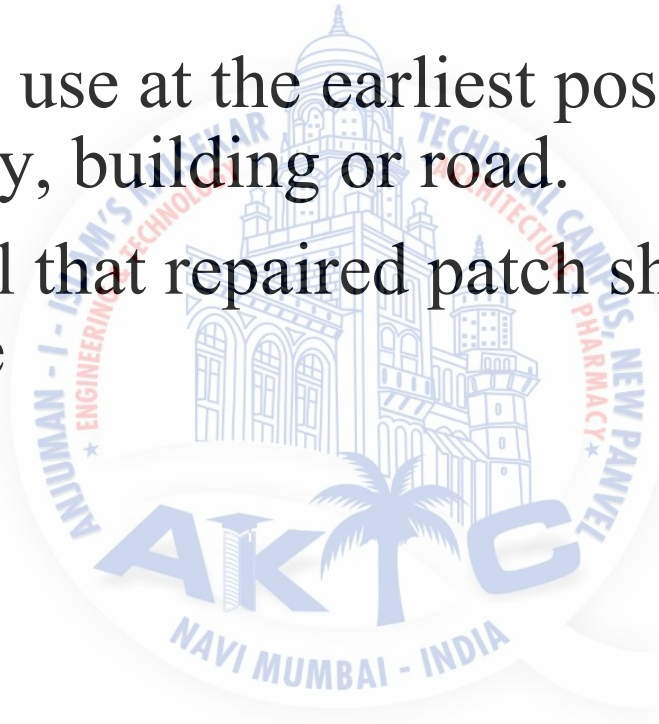
Low Shrinkage

- concrete/ mortar, is likely to get either delaminated due to de-bonding or develop shrinkage cracks on its surface due to shrinkage strains and stresses



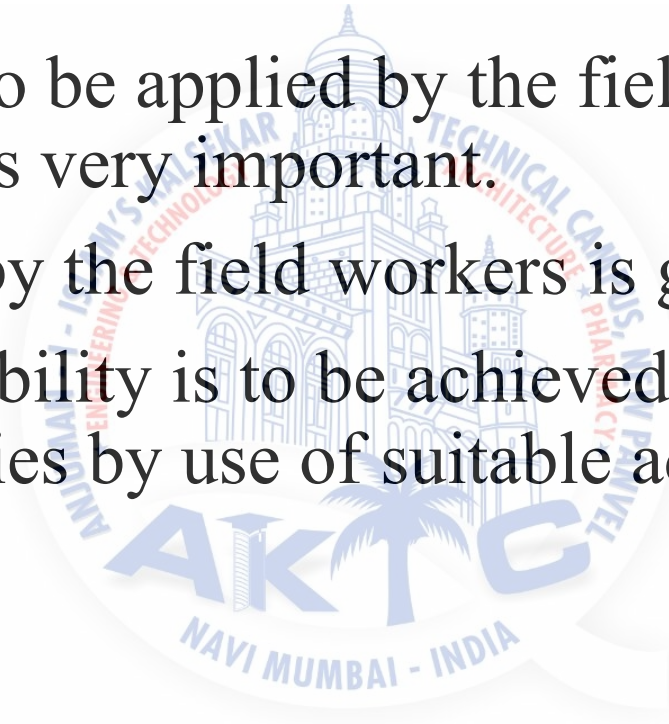
Requisite setting/hardening properties

- structure shall be put to use at the earliest possible to reduce the down time of plant, machinery, building or road.
- It is, therefore, essential that repaired patch shall harden in the minimum possible time



Workability

- The repair material is to be applied by the field workers and hence its acceptability by them is very important.
- The property desired by the field workers is good workability.
- Hence optimum workability is to be achieved without sacrificing the other desirable properties by use of suitable additives/admixtures.



Bond with the Substrate

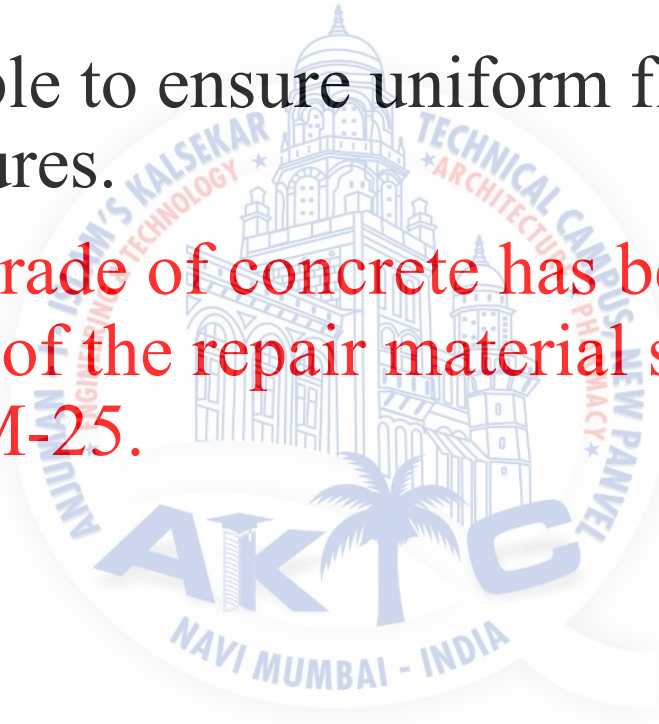
- The bond strength of repair patch with the substrate is essential to have a successful repair system
- If it is felt that the bond strength of the repair material with the base material is inadequate or less than the strength of the base material, then some other suitable means could be explored to improve bond strength between repair material and substrate.
 - Adhesive,
 - Surface interlocking system, and/or
 - Mechanical bonding

Compatible Coefficient of thermal Expansion:

S. No.	Material	Co-efficient of thermal expansion in $10^{-6}/^{\circ}\text{C}$
1.	Stones	
	(i) Igneous rocks	8 to 10
	(ii) Lime stones	2.4 to 9
	(iii) Marbles	1.4 to 11
	(iv) Sand & sand stones	7 to 16
	(v) Slates	6 to 10
2.	Metals	
	(i) Aluminium	25
	(ii) Bronze	17.6
	(iii) Copper	17.3
	(iv) Lead	29
	(v) Steel and iron	11 to 13
3.	Bricks and brickwork	5 to 7
4.	Cement mortar and concrete	10 to 14
5.	General purpose non-shrink concentitious micro-concrete (Renderoc RG)	10 to 12
6.	Polymersmodifiedmortar/concrete	10-12
7.	Epoxy mortar/concrete	20-25

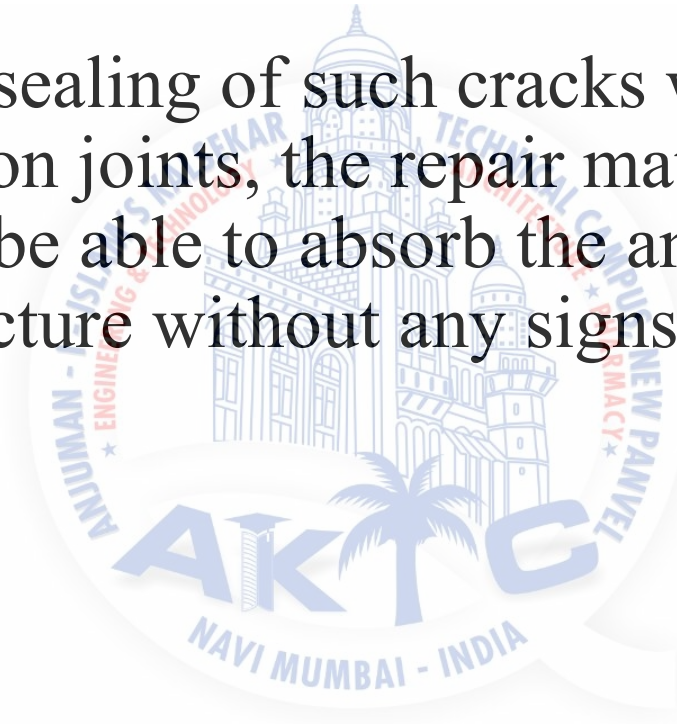
Compatible Mechanical Properties & Strength

- This property is desirable to ensure uniform flow of stresses and strains in loaded structures.
- For example, if M-20 grade of concrete has been used in original construction, the grade of the repair material shall neither be less than M-20 nor higher than M-25.



Relative movement, if expected

- Particularly in case of sealing of such cracks where movement is expected or at expansion joints, the repair material selected shall be resilient and elastic to be able to absorb the anticipated relative movements of the structure without any signs of distress or crack.



Minimal or no curing Requirement

- It is desirable that the repair material shall not have any curing requirement after the repair has been applied or even if it is required, it should be minimal to ensure that the repair patch hardens and attains the desired strength without much post-repair-care.

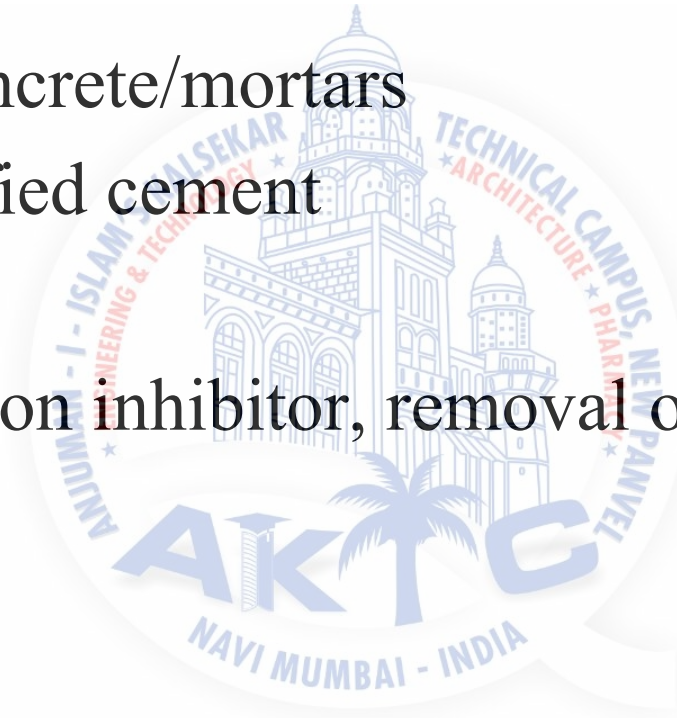


- Cost
- Alkalinity
- Low air & water permeability
- Aesthetics
- Non-Hazardous / Non –Polluting



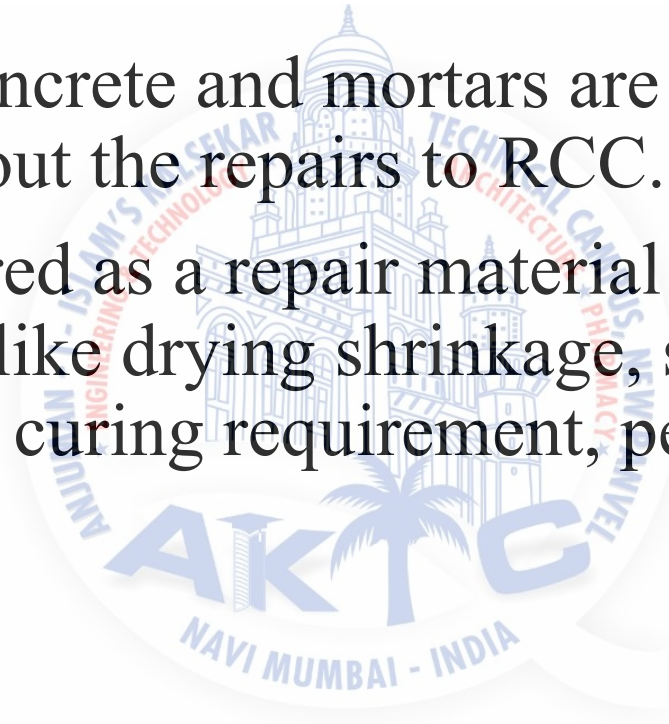
Materials for Repairs

- 1) Premixed Cement concrete/mortars
- 2) Polymers/latex modified cement
- 3) Epoxy resins
- 4) Chemicals for corrosion inhibitor, removal of rust



1) Premixed Cement concrete/mortars

- Though, the cement concrete and mortars are most natural repair materials for carrying out the repairs to RCC.
- Yet, they are not favored as a repair material due to its inherent undesirable properties like drying shrinkage, slow setting, low workability, prolonged curing requirement, permeability, etc.



Types of cements for Repair work

- **Rapid Hardening Portland Cements** gains strength more rapidly at early ages but has its ultimate strength comparable to OPCs. It is used where early strength is required.
- **Portland Slag Cements and Portland Pozzolana Cements:** Generally, such cements have low heat of hydration, better sulphate and chloride resistance and have low permeability.
- **These are more suited for use in marine structures and in structures having contact with soils and water containing high percentages of sulphates and acids.**

Types of cements for repair works

- **Shrinkage Compensating Expansive Cements** Shrinkage compensating expansive cements are used to minimize cracking caused by drying shrinkage in repair concrete in addition to its use in concrete structures.

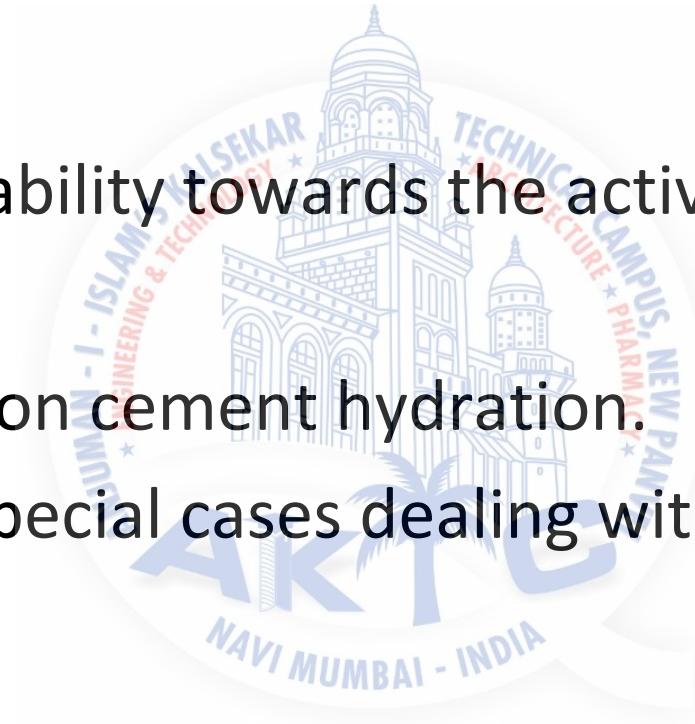


Polymer Modified Mortars and Concrete (PMM/PMC)

- Polymers reduce the **rate of water evaporation**, allowing the crystal structure to keep growing and building strength during these critical early curing stages.
- **Improve workability** making the mortar more fluid and easier to handle and apply.
- **Improved adhesion**. Polymer modifiers act as an adhesive to enable the modified mortar overlay to stick to a variety of surfaces.
- **Improved strength and durability.**
- **Higher early strengths.**
- **Reduced shrinkage**

General Requirements of a Polymers

- Water Solubility
- Very high chemical stability towards the active cat-ions.
- Low air entrainment.
- No adverse influence on cement hydration.
- Thermal stability: In special cases dealing with higher temperatures



Mix Proportioning

- Usually mortar are 1:2 to 1:3 (Cement- fine aggregate ratio)
- 5 to 10 % by weight.

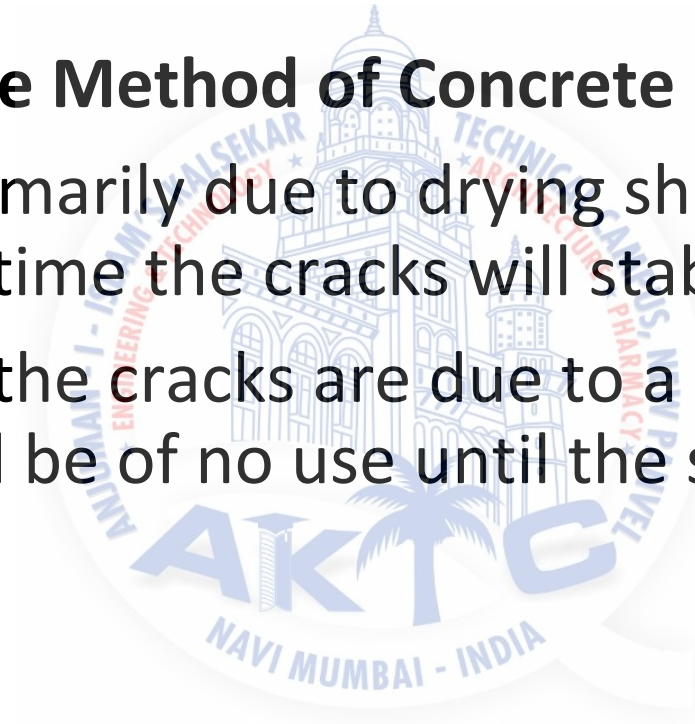


Applications of PMM/PMC

- **Structural repairs to RCC.**
- Ultra Rapid Hardening Polymer used for **urgent construction and repair works.**
- **Polymer Ferrocements:** For the purpose of improving the flexural behaviour and durability
- Anti Washout Underwater Concrete.
- Protective Anti Corrosive and Water Proofing Coatings
- **Structural Adhesives and grauts**

Crack repair techniques

- **How to Select Suitable Method of Concrete Crack Repair?**
- if the cracking was primarily due to drying shrinkage, then it is likely that after a period of time the cracks will stabilize
- On the other hand, if the cracks are due to a continuing foundation settlement, repair will be of no use until the settlement problem is corrected.



Methods of Concrete Crack Repair

- **Epoxy injection**
- Epoxy injection method is used for cracks as narrow as 0.05.
- consists of establishing entry and venting ports at close intervals along the cracks, sealing the crack on exposed surfaces, and injecting the epoxy under pressure.
- This will not work if cracks have water leakage or if root cause of the crack are not replaced.

What If the cause of the cracks cannot be removed ?

- Two options are available
- 1) Rout and seal the crack.
- **treating it as a joint, or, establish a joint** that will accommodate the movement and then inject the crack with epoxy.
- Wet cracks can be injected using moisture tolerant materials

