

**ADVANCED MATERIALS AND
TECHNIQUES FOR REPAIRING AND
STRENGTHENING OF CONCRETE
STRUCTURES**

- **Cement concrete is the most preferred construction material for most types of structures of present age.**
- **Drain to dam, tunnel to bridge every structure is built using concrete in many forms like plain CC, RCC, Pstd concrete, Fiber Reinforced concrete, High performance concrete, self compacted concrete etc.**
- **Making concrete and using it or moulding various shapes of structures seems to be quite simple and easy but producing a durable, strong and proper performing concrete need careful selection of quality materials, designed mix, proper mixing/placing/vibration followed by proper curing of set concrete**

C Collect and test proper ingredients.

O Optimise mixing proportions for strength and durability.

N Never compromise on Transportation time, pouring and compaction methods.

C Cure timely and adequately.

R Remove shuttering and centering after maturity not earlier.

E Examine concrete surface visually and identify defects if any.

T Test integrity if required.

E Ensure periodical inspection and maintenance for longer life.

- Any structure can not be considered safe and durable if even a small sign of distress appears. This may be a sign of beginning and major distresses may develop in future.
- RCC construction is wrongly considered as not needing any upkeep or maintenance hence no attention is paid to most of the structures after construction unless something happens, ACC, RCC/Pstd conc. or masonry structures need proper care and maintenance periodically & regularly. Retrofitting/strengthening or repairs become necessary in many cases where:-
 - The structure has developed distresses and damages occurred due to various reasons like corrosion, overloading, mechanical damages,
 - The structure has to be modified or updated for meeting out revised loading, revision of codal specifications like earthquake zones, change in use etc.

Various Rehabilitation Techniques/materials

- Guniting & shotcreting
- Pressure grouting
- Jacketing using cement based process like Ferrocement & Polypropylene Fibers (FORTA FERRO MAKE STRUCTURAL FIBERS Marketed by M/s JBA concrete solutions 135, Arjun Nagar Kotla Mubarakpur New Delhi & Manufactured by FORTA CORPN USA- These are the only structural grade fibers in market)
- Jacketing using FRP lining glass/carbon fibers mats wrapped in epoxy or polyester bedding and coverage
- Steel plate bonding
- Polymer concrete lining. And many more.

STRENGTHENING AND RETROFITTING BY FIBER WRAPPING (FRP) TREATMENT

- **Construction industry has faced an increasing need to reinstate, strengthen, rejuvenate and upgrade existing distressed/weak concrete structures due to various reasons like aging of structure or materials, insufficient capacity for revised conditions of loading, environment, instability of ground, flooding, thermal cycle affects, fire, and earthquake.**
- **These causes serious effects on structures like cracking, collapsing, deformations/deflections in members, permeability, degradation of facing treatments, spalling etc. resulting in loss of structural capacity.**
- **The traditional strengthening of RCC elements include concrete Jacketing, Shortereting/Guniting, steel plate bonding, microconcreting etc. which are quite cumbersome, time consuming, skilled Labour oriented and pose several problems including disturbance, in the working environment and requiring stopping of work in place these are to be adopted.**

- A system based on composite fiber wrapping with polymers provide a solution to most of the problems faced in traditional/conventional Rehabilitation techniques. Composite laminates are formed over the structure.
- The composite fiber wrapping is a very effective technique for increasing the strength of existing non distressed structures and also for distressed structures. The system has been found to be very effective for columns & beams both even in seismically deficient cases, key benefits and features of composite fiber wrapping system are:

S.No	Features	Benefit
1	Very high strength to thickness ratio	Increase in strength and load carrying capacity without much increase in weight
2	Enhancement in stiffness, shear and tensile strength	Increased load carrying capacity, better resistance to seismic forces and deflections.
3	Light weight & durable	Increase in dead load negligible
4	Chemical resistance good	Can resist acids and alkalies
5	Impervious	No effect of atmospheric gases
6	Flexible system	Can be applied on any shape or contour of substrate
7	Economical	Easy to install, saving of time & manpower
8	Thin section	Can be applied even in space constrained areas.

Materials used

- Glass fiber woven roving (GFRP) -360 gm/sqm
 - Isothalic polyester resin –general purpose polymer resin
 - Accelerator
 - Catalyst
 - Hardner
- added to initiate polymerization and hardening

How to do

Ratio between FRP to resin 1:2.5 by weight –the work should be done by a person who has experience in GFRP application:

- **Remove plaster fully from the structure**
- **Sand blasting is done over the RCC surface**
- **The required amount of polyester resin, catalyst and accelerator are mixed in a plastic container**
- **Apply resin over the RCC surface with the help of a paint/plastic chemical brush**
- **Glass woven roving is then wrapped for the full length of the structure**
- **Overlap at joints to be kept =50 to 80mm.**
- **The amount of resin applied should cover all openings in the glass fiber woven roving**
- **Apply one more layer of resin into the mesh with small amount of pressure with paint brush-entrapped bubbles of air will come out with pressing.**
- **If needed apply more resin mix to make sure that entire roving is covered.**

FRP Composite-Strengthening

The construction chemicals division of BASF has been at fore front in introducing latest technologies in the field of construction chemicals. MBrace FRP Composite Strengthening system is one such innovative system for rapid strengthening of concrete and masonry structures.

Fiber reinforced polymer (FRP) composite have been used for nearly 30 years in aerospace and manufacturing applications where low weight, High tensile strength, and non-corrosive structural properties are required.

The MBrace composite strengthening system, an externally bonded FRP reinforcement system for concrete and masonry structures, is field proven with advantages like high strength, High stiffness, lightweight, highly durable, Non-corrosive and low installation time. They can be installed in areas with limited access and easy to conceal. It forms around complex surface shapes. Its typical uses are to upgrade load bearing capacities of concrete and masonry structures restoring capacity of concrete structures lost due to deterioration and to design/construction errors and for correcting substitute missing reinforcing steel also for seismic retrofitting.

Method of applications

There are three popular methods of application:

1- Fabrics

The MBrace system is “cast-in-place” from its two primary components: fiber and polymer. The fiber is delivered to the site in form of dry, flexible fabrics which are formed around the structure and saturated with uncured epoxy, the polymer component. As the epoxy cures, a rigid FRP composite is formed that shapes itself to the epoxy resin. This technique, known as wet lay-up, provides flexibility, constructability, and short installation times. The result: lower labor costs and less downtime. There are three types of fabrics available [as shown in figure 1], and selection is based on the right fiber for right purpose basis.

2- Laminates

MBrace® Laminates are pre-fabricated carbon fiber reinforced epoxy strips. The laminates are bonded to concrete using approved laminate epoxy adhesive. The 50/1.4 and 100/1.4 laminates are surface bonded to provide positive and negative bending [flexure] strength. Carbon fiber laminates can be applied to wooden and concrete beams, columns, slabs and walls. As permanent structural reinforcement we can order laminates by roll or in factory cut lengths. There are no minimum order requirements.

3- Near Surface Mounted

MBrace® CFK 10/1.4 is used for near surface mounted flexural and shear strengthening. The NSM method uses thin carbon fiber laminates & epoxies into shallow grooves that are saw cut into a concrete or masonry structure. The laminates provide additional reinforcement, strength and stiffness to the structure similar to adding steel reinforcement. However, unlike steel reinforcement, MBrace® 10/1.4 is non corrosive. This allows the bars to be installed in much shallower grooves since minimal cover is needed.

In India BASF has carried out applications on bridges and building for increasing load carrying capacities and the system is gaining fast acceptance due to one shop solution approach adopted by BASF which includes assistance on design, Material selection and application.

USE OF FERROCEMENT LINING WRAPPING TECHNIQUE FOR STRENGTHENING OF RCC & MASONRY

Jacketing & Laminating of RCC and Masonry Structures based on polymeric materials has been successfully adopted too number of structures in the past one decade. The technique of mechanically anchored, crack resistant, high bond ferrocement lining was first developed at SERC Roorkee in 1974 after a lot of experimental work in laboratory and in field. The developed technology was successfully rued out for restoring of wooden pyramid shaped roof structures at HANSOL (Ahemdabad belonging to sarabhai family), damaged roof and supporting structures of American embassy school New Delhi, Medical College Hospital Bldg at Rohtak, IFFCO office Bldgs Nehru place New Delhi, Delhi emporium basement structures etc. Very large numbers of basements, tanks have been repaired/retrofitted using this technique in the past 26 years. The long term monitoring results on many of the treated structures have been excellent. A PHD thesis by Dr. K.K. Singh at UOR carried out on similar lines confirmed the capability of ferrocement treatment. A house constructed in sector 15A of Noida in 1979 developed serious cracking in its wall and other supporting structure where red trap bond was used. The structure was treated with ferrocement jacketing 5 years ago and the structure is in excellent condition.

Let us first see what is ferrocement

Ferrocement is a cement based long lasting composite material a modified form of reinforced microconcrete in which the reinforcement is finely subdivided and dispersed uniformly in the matrix (throughout thickness and area) in order to achieve a closely spaced crack regime coupled with excellent corrosion resistance and high impermeability to ingress of water.

Matrix of the composite is a modified cement based microconcrete/mortar prepared using (a) ordinary Portland cement, (b) well graded zone II medium silt free sand, (c) specially formulated admixtures containing plasticizer, bond improving agent and pore sealer, (d) water.

Special type orbital vibrators are used for vibrating thin F.C. layers. These vibration devices were developed by author at SERC (R & G).

Durability

F.C. was developed in 1847 and was used for construction of boats and garden furniture at that time. During 1940-49 period it was used for structural & marine constructions which came up in form of many roofs, swimming pools and large size boats. Many structures treated using F.C. water proofing technique developed at SERC (R) are still in perfect performing condition. The domes, 5 No's, constructed using ferrocement at ashram road Ahemdabad by BM Instt & sarabhai group did not show even a single crack during 2001 Gujrat E.Q. Similarly boats built more than 100 years ago are still available in good shape in European museums after being in water for more than 75 years. These are the examples of durability.

Constituents of ferrocement

Cement, sand, water, woven wire hot dip galv. Mesh reinforcement–skeletal reinforcement, chemical admixtures,

Merits

- High strength in compression/tension/shock/impact/explosion
- Resistant to mild chemicals
- Can get good surface finish
- Crack arresting capacity very high due to dispersed reinforcement
- Lower in cost only 1/6th cost of FRP jacketing
- No problem during fire accidents as in case of FRP jacketing
- No environmental pollution as in case of FRP due to fumes
- Normal labor can do it after small duration training.

How it is carried out

Take case of a RCC column needing jacketing, steps are explained here:-

In case of old columns remove plaster in full, hack the surface and clean using wire brush. In case of very old columns it is advisable to remove ½”cc from cover portion.

Drill holes at designed locations clear them from all debris and wash the surface with water jet. Use polymer mortar and fix the anchor pins projecting=thickness jacketing-6mm.

Apply a layer of bond coat on the column surface and apply a plaster of 6 to 8mm thick mix cement-1 part medium coarse sand- 2 part Acrylic polymer@ 5% of cement, water C ratio-0.5-wait for 12 to 24 hrs depending on weather

Next day wrap a layer of hot dip galv mesh tightly and the with an overlap of 80 to 100mm-3mm vertical wires are used to separate the mesh layer from mortar plaster surface

Slurry Mix

Cement Part- 1

Acrylic/SBR based Admixture-0.1 part, water to make honey like slurry.

Mixed using a striurr

Mix cement: sand: Acrylic polymer: water

1 : 2 : 0.05 : 0.4

into a homogeneous mortar and apply this mortar over and into the mesh upto a cover of 6 to 7mm over the mesh level and tie one more layer and apply mortar. This is two layer systems, depending upon design no of layers and thickness is built up. The coverover 1st layer is provided between 6 to 8mm only. Use a orbital vibrator for compacting and removing entrapped air

Cure properly

Rehabilitation of corroded steel tanks, plastic tanks, RCC basements and OH tanks, canals, swimming pools, walls and roof of all types have been successfully carried out using ferroement in the past 3 decades in India and many other countries using SERC (R & G) know how on F.C. lining developed by the author.

STRUCTURAL GRADE POLYPROPYLENE FIBER REINFORCED CONCRETE FOR STRENGTHENING AND REPAIR/RETROFITTING OF CONC. & MASONRY STRUCTURES

WHEN USING POLYMER CONCRETE AND HIGH PERFORMANCE CONCRETE FOR JACKETING OR ADDING SECTIONS TO EXISTING RCC/MASONRY STRUCTURES ADDING OF VIRGIN POLYPROPYLENE FIBER REINFORCEMENT HAS BEEN FOUND TO PROVIDE ADDL STRENGTH AND DURABILITY. SPECIALLY DEVELOPED MIXES FOR OVERLAYING DECK CONCRETE OVER WEAK CONCRETE BRIDGES ALL OVER WORLD. This Technique has been developed by FORTA CORPN USA producing FORTA FERRO FIBERS. When these are added to repair concrete formulations reduces plastic and hardened shrinkage, improve impact strength and increase fatigue resistance and concrete toughness hence providing long term durability, structural enhancement and effective secondary/temperature crack control by incorporating a unique synergistic fiber system of long term of long length design. FORTA FERRO is a non corrosive non magnetic and 100% alkali proof. It is one of the most favored fibers for fiber shotcrete used for tunnel lining work.

Recommended dosage-0.2% to 2% of concrete (3 to 30 lbs per cubic yd added directly to concrete during mixing, easy to mix, specific gravity 0.91, tensile strength=620-758 Mpa), acid/alkali resistance excellent, water absorption- nil, length 54mm, compliance-ASTM C-1116

For repair of concrete structure the high strength concrete mix is designed as in normal way then depending on the type of application dosage of fiber approx 2kg/m³ to 9kg/m³ of concrete is adopted. This concrete is very effective in jacketing of concrete columns, foundations and strengthening of deterioration decks of bridges. Steel reinforcement is also added along with the fiber. The 4 c's are very important in selection of type of fibers:-

Configuration –fiber must be a synergistic combination of twisted-boundels non fibrillating monofilament and a polypropylene fiber system.

Chemistry –fiber shall be made of 100% virgin polypropylene

Contents - proper dosage of fibers added

Correct - length 2.25” or 54 mm

ASTM- C-1116is standard specification for fiber Reinf- concrete and shotcrete and FORTA FERRO is an approved product.

In India FORTA FERRO FIBER is available from M/S JBA concrete solutions 135, Arjun Nagar Kotla Mubarkpur New Delhi-3, Phone 011-41553830, Fax 24618346

HIGH PERFORMANCE CONCRETE (HPC)

Used for section adding and also jacketing of masonry & RCC structures

HPC can be achieved using conventional materials but it is important to exercise high degree of control over the production and casting process.

HPC has higher durability because of

Low permeability

Good abrasion resistance

Good resistance to many common chemicals

Good frost resistance due to low air entrainment. Hence has been found to be good in repair & rehab jobs of RCC slabs, floors and bridge decks.

Proper mechanical anchorage and bond between new and old concrete should be provided when taking up repair jobs.

MIX GENERALLY CONTAIN

Ordinary Portland cement 33 & 43 grade-No PPC

Good quality silt free fine aggregate-graded

Good quality graded crushed aggregate

Super plasticizer with slump retention capability or high range water reducing admixtures

Silica fume-5 to 15% by wt. of cement.

Polymers (acrylics/SBR)

APPLICATION OF CURING COMPOUNDS OVER HPC PROVIDES STILL BETTER RESULTS

When polymers are added to conventional cement concrete:

- It attains high early strength
- Tensile strength gets improved upto four to five times
- Compressive strength goes up upto four times
- It become farless porous hence better water tight & durable
- Gets improved fatigue strength (6) Polymer concrete finishing is better

POLYMER CONCRETE AND MORTARS

GENERALLY USED FOR REPAIR & RETROFITTING WORK:

MATERIALS USED

Ordinary Portland cement

Fine and coarse aggregate-good quality free from silt-No CA in Mortar

Super plasticizer-malmanie/naphthalene resin based

Polymer latex modified acrylic co-polymer

SAMPLE MIX FOR POLYMER CONCRETE:

CEMENT	- 380kg.
POLYMER	- 10% by wt. of cement.
WATER	- 115 L
WC RATIO	- 0.30
F. AGG	- 690 kg
CA	- 1170 kg
HRWA	- 1% by wt. of cement.
SLUMP	- 33mm.
STRENGTH	- 24 Hrs 250 kg/cm ² 28d-450 kg/cm ²

WATER ABSORPTION-0.16% at 7 days & 28 days.

The above mix is only for giving an idea about ingredients. The actual mix will depend upon type of cement, aggregate and polymer used.

MIX RECOMMENDED BY ACI FOR POLY. CONC.

CEMENT	-414 kg
SAND AGG. RATIO	-55 TO 65%
POLYMER CEMENT RATIO	-15%
WC RATIO	-25 TO 40%
AIR CONTENT	-<6

WHEN POLYMERS ARE ADDED TO CONVENTIONAL CEMENT CONCRETE:

1) It attains high early strength (2) Tensile strength gets improved upto four to five times (3) Compressive strength goes up upto four times (4) It becomes far less porous hence better water tight & durable (5) Gets improved fatigue strength (6) Polymer concrete finishing is better.

MIX FOR POLYMER MORTAR DEVELOPED AT SERC(G)

OPC → 100 Parts

SILT FREE ZONE II SAND → 250 Parts

ACRYLIC POLYMER → 15 Parts

WATER → 35 Parts

This mortar was tried out in several projects and has found to be strong, durable and economic in patch, repairs, crack sealing etc.

POLYMER MORTAR

For concrete repairs

POLYMER MORTAR two component polymer modified powder to be mixed with water on site to produce a highly consistent, high strength cement mortar. It is specially designed for locations where high compressive strengths are required, and high resistance to chloride and carbon-di-oxide is required.

FEATURES & BENEFITS:

High strength

Can be applied by hand like conventional mortars

Excellent bond to concrete substrate

Contains no chloride admixture

Extremely low permeability provides maximum protection against carbon dioxide and chlorides

Shrinkage compensated

AREAS OF APPLICATION:

Reinstatement of spalled concrete to R.C.C. members like beams, columns, wall, slab etc.

MEHTOD OF APPLICATION:

- For normal application use 3.25 to 3.5litres of drinking water per25 kg. Bag of **POLYMER MORTAR**. First add polymer into water and mix for 2 minutes. Then add powder slowly and mix for 3 minutes till homogenous mix is obtained. Mixing must be done with forced action mixer
- Clean the surface and remove any dust, loose material, oil paint, grease etc.
- Expose fully any corroded steel in the repair area and remove all scale and corrosion deposits mechanically or ideally by grit blasting
- Apply **ZINC PRIMER** over the cleaned re-bars &allow to dry before continuing
- The substrate should be primed by applying one coat of cement based bonding material acrylic based or **SBR** based.
- Apply the mix **POLYMER MORTAR** to the prepared substrate by a trowel when primer becomes tacky. **POLYMER MORTAR** can be applied upto 50mm thickness in section of 10-15 mm in each layer.
- Cure the prepared surface mildly with water for 3-4 days. Do not cure later.

PRECAUTIONS & LIMITATIONS:

- For a repair thickness more than 15mm, bond coat after each layer is recommended before applying the next layer.
- Minimum thickness to be 10 mm
- For cold conditions upto 30oC must be added, to help **POLYMER MORTAR** quickly gain strength.

PRECAUTIONS & LIMITATIONS:

For a repair thickness more than 15mm, bond coat after each layer is recommended before applying the next layer.

Minimum thickness to be 10 mm

For cold conditions upto 30°C must be added, to help **POLYMER MORTAR** quickly gain strength.

Compressive strength	120kg/cm ² at 1 day 450 kg/cm ² at 28 days
Flexural strength	80 kg/cm ² at 1 day
%water absorption after 24 hrs	0.45
Chloride content	Nil
Depth of carbonation, mm (accelerated carbonation test) 2 hours	Nil
4 hours	Nil
Setting time (initial set)	3 hours 15 mins at 30 °C
(Final set)	4 hours 30 mins at 30 °C

GROUTING AS A STRUCTURAL REPAIR & STRENGTHENING TECHNIQUE

Grouting is a process which can be used by engineers in maintenance, repair and strengthening operations for monumental/historical bldgs., honeycombed concrete structures, ground strengthening, construction/maintenance & leak proofing of hydro projects/transportation system tunnels, bridge structures etc. Grout consists of a high strength binding material in a liquid form which could be poured or pumped into cracks, behind concrete linings (as in case of concrete tunnels where contact grouting is needed for anchoring concrete lining to rock surfaces behind) voids or interstices of another material and will set as a coherent mass which fills the entire space maintaining its original volume hardened grout must be (a) strong (b) durable (c) able to protect reinforcement. Properties of fresh grout are also important because of an accessibility of grout region for visual inspection hence attention on specification should be placed on:-

(a) flow behaviour (b) bleeding prior to set (c) strength of hardened grout.

Nature of voids/cracks to be grouted must be considered while deciding the specification and deciding:-

Which grouting material will be suitable?

What should be grouting pressure?

Which type of equipment to be used?

Distance between grouting holes and nipple or packer positions and depth of bore.

GROUTING METHOD

Pressure grout 1

Manual

By gravity flow- Hydrostatic head is created

- Self flow grouts need very small head, these are self levelling and self compacting hence easy to use – but will work only in open conditions and can not be used for grouting of cracks.
- 3. Pressure grouting – most used technique in rehabilitation and strengthening jobs.
- 4. Under vacuum

TYPES OF GROUTS

Two types of grouts composition are available for use:-

Cementious grouts:- Improved Flow behaviour through addition of chemical admixtures and stabilizers. Good injectability and rheological properties. Easy to use, less wastage, cost effective.

Chemical grout s:- Polymeric materials like epoxies, Polyurethane etc. Have high injectability without standing mechanical and bonding properties, low shrinkage on setting, better heat and chemical resistance. Expensive on an average 6 times or more expensive than cementious grout ; should not be used over wet surfaces. Procedures and mix proportions specified by manufactures of epoxies must be followed. Injectable epoxies are different in grade.

EQUIPMENT FOR GROUTING

For cement grout:-

Drilling machine with concrete drilling diamond bits & cleaning brushes

Mixer-colloidal type or hand blender type- A storage unit for grout for large jobs

Grout pump hand operated or pneumatic operated for larger jobs.

For Epoxy grouting:-

Drilling machine as above

Hand blender type mixing unit-SPL mixing units are now available

Pumping unit-hand operated units similar to grease guns used for automobile greasing. But these are sophisticated.

Health hazards

None in cement grouting, but in epoxy grouting for cleaning for cleaning of tools and hands solvents like acetones, toluene etc. are used which generate toxic fumes. Proper ventilation, gloves and goggles etc must be used. It is always better to engage an experienced firm for taking up epoxy grouting and even for cement grouting.

Sealing procedure for water bearing cracks or moving joints has been included in this text in the end.

Steps

- Marking of location where grout is to be injected
- Widening of cracks
- Fixing of nozzles at 200mm to 300mm c/c at an angular position to the crack.
- Holes are drilled, entry points are enlarged, nozzles fixed and enlarged area around nozzles is sealed using fast setting polymer mortar-wait for 24 to 36 hrs depending upon pressure and climate. Pressure inject water in case of cement grouts and air under pressure in case of epoxies. This is a very imp step. Providing proper vent system for removing trapped air is a must.
- Mix the material in specified proportions and inject
- Wait for 24 hrs and cut the nozzles/packers at surface level and seal with epoxy/polymer mortar

EPOXY INJECTION GROUT

EPOXY INJECTION GROUT is a 2 component water insensitive, low viscous epoxy based injection grout, ideal for repairs of cracks in concrete, cement based renders and underwater structures.

FEATURES & BENEFITS:

Water insensitive and hence ideal for moisture laden cracks.

Excellent flow ability which is required for injection grouting

Has a good chemical resistance

Also very good for applications into cracks/voids of underwater structures

Seals voids/cracks in concrete effectively works in the negative side of water pressure

AREAS APPLICATION:

For repairs, rehabilitation of underwater structural members

To fill up cracks in roof slab, RCC walls and other structural members

METHOD OF APPLICATION:

The cracks where the grouting is to be done are identified and marked

Holes are drilled at regular intervals for fixing of nozzles

Nozzles are fixed into the drilled holes. Leave for a day before grouting

EPOXY INJECTION GROUT is injected using a low pressure injection grouting system

Ensure that mixing is homogenous before application

PRECAUTIONS & LIMITATIONS:

Use mixed materials within pot life period

Handle **EPOXY INJECTION GROUT** with gloves

All tools and tackles should be cleaned with (Epoxy Solvent) before its pot life period has expired.

Any contact with skin should be washed with plenty of water and soap, splashes in the eyes should be washed with plenty of water and immediate medical advice should be taken.

SEALING FOR THE WATER BEARING CRACKS OR MOVING JOINTS IN CONCRETE STRUCTURES

The construction engineers come across many situations when the concrete structure has developed cracks and water has seeped inside. Also there are situations when the same crack starts behaving as a moving/dynamic crack by relieving the internal stress in the structure. Some times the construction joints/cold joints also start leaking due to the movement of the structure due to development of some stresses. It becomes challenging to stop such leakage, as the water proofing system employed has to resist not only the water pressure from the negative side (Exit side of water) but also the flexibility required for absorbing the stresses due to the dynamic nature of the crack/joint. The author faced similar situation while working as a consultant for Tala hydropower project in Bhutan where extensive leakage was detected in the tunnels.

Very good systems are now available which are initiated with the injection of 2 components water activated PU-injection Foam into the crack, which stops the ingress of water and immediately thereafter is followed by injecting a flexible 2 components polyurethane – injection resin which not only seals off the water but also remains permeability flexible.

The water activated hydrophobic MDI based polyurethane foam system only reacts when it comes in contact with water, expands and converts into stiff closed cell, waterproof polyurethane foam. It is free of solvents and fibers; it is resistant to hydrolysis and is suitable for use in drinking water areas (KTW-test). The system I consist of a resin and a special catalyst, supplied separately, to allow on-site adjustments of gel. KB-Pur in I is a similar system marketed by chowgul koster India const chemical Ltd.

TECHNICAL DATA OF KB-PUR IN II

Mix ratio (by volume)	
Comp. A	:2
Comp. B	:1
Mix ratio (by weight)	
Comp. A	:5
Comp. B	:3
Pot life (30°C/86°F, 1 mixture))	:20 min
Shore-hardness D/DIN 53505	:25-35
Elongation	:10%
Application temperature	:above +5 °C/41 °F
Sp.gravity (of mixture)	:1.1kg/l
Viscosity (25 °C)	
Comp. A	130 mpa.s
Comp. B	200 mpa.s
Color	
Comp. A	:Yellow green
Comp. B	:Dark brown

Application procedure

Mark and drill the holes on either side of the crack/joints in staggering manner and at a distance of 30cm c/c on each side and at 45 degree angle, clean the hole and fix the packers and tighten it.

For dry joints **KB-PUR IN II PU** resin can be directly injected. But if the water is oozing out then resin **IPU** is injected first to stop the water by foaming.

Add the **KB-PUR IN I** component A and B mix thoroughly with a slow speed mixer until a homogenous mixture is obtained (avoid mixing humid air into the resin).

Inject the material with conventional single component pumps with low pressure.

Always start at the bottom and continue upwards, if in doubt, go back and inject the same packer once again. **As soon as the KB-PUR IN I comes in contact with water, it reacts and forms foam by 30 times volume expansion.** Water will be replaced by the grid closed cell foam and can no longer pass through the crack.

Mix both the component of **KB-PUR IN II** and inject through another pump into the same port injected with **KB-PUR IN I**. **KB-PUR IN II** will replace the foam and occupy the entire depth of the crack.

In a classic example of box push tunnel sub-way constructed at Virar railway station below the busiest western railways, the butt joint between the pre-cast tunnels started leaking and the problem was aggravated due to the vibrations from the traffic. The joints were treated vertically, horizontally and overhead by **kostar KB-PUR** injection system.

The joints were treated under water pressure with the **KB-PUR IN I**- foam forming material and then with **KB-PUR IN II**- flexible PU resin.

FREE FLOW CEMENTIOUS GROUT 5M

High strength, non shrink, free flow grout for foundation grouting and structural strengthening

SELF FLOW & COMPACTING GROUT 5M is a ready to use, non-shrink, free flow cementious grout, that is specially formulated for critical grouting operations where high strength binders, select grade fillers and fluidity are required. It comprises of hydraulic setting binders, select grade fillers and expansion control additives that need only addition of the required quantity of water at site. The grout has high bending property hence is suitable for use in structural repair work and encasing of steel sections. It has zero shrinkage also

SPECIFICATION: meets requirements of corps of engineer's spec.

CRD-C-621-83 & ASTM-C-1107

FEATURES & BENEFITS:

Non-shrink with controlled positive expansion hence suitable for jacketing technique

High flowability and excellent pourability for easy field use

No bleeding and segregation at high fluid consistency

High strength for excellent load (dynamic and static) bearing capacity

High early strength –quick turn around

Free of chlorides and additives that may lead to corrosion

High drill resistance property

Self compacting

AREAS OF APPLICATION:

Heavy machinery and equipment foundations

Turbine-generator bearing plates

Structural columns in pre-cast anchorage

Bridge bearing pad

Boiler foundation

Cavities, gaps and recesses

Crane rail construction

Structural strengthening of RCC/masonry structures by enhancement process

METHOD OF APPLICATION:

Wet the inside of the mechanically powered padded/drum type grout mixer with water, before starting to mix the first the first batch of grout. According to the grout consistency required, the water addition for 50 kgs. Standard pack of grout at 27oC should be approximately 6.5-7.5 liters for flowable consistency and 6.0-6.6 liters for dry/trowelable consistency

Ensure that the mixer is damp but free of standing water.

Add approx. 85-90% of measured water (as per water to powder ratio depending upon required consistency) into the mixer and then slowly add the contents of grout (dry pack)

Mix or 1-2 minutes and add remaining approx. 15-10% of measured water (as per water to powder ratio depending upon required consistency)

Allow to mix for additional 2-3 minutes until a smooth. Uniform homogenous mix is achieved.

Pour the prepared mix into the required area, taking care that it is poured from one end only, with a watertight shuttering in place.

PRECAUTIONS & LIMITATIONS:

For large pours, the grouting operation shall be done in steps, with a high head or by a grouting pump, to avoid air entrapment.

Do not add extra water in any circumstances.

Pour the mix only from one end under the gravity of 6 to 8 inches head.

TECHNICAL INFORMATION:

Yield	2,200± 50 kg./m ³
Bulk density (tapped)	1.4 gm/cc
Compressive strength (IS:4031-1988)	24 hrs, more than 250 kg/cm ² 7 days, more than 450 kg/cm ² 28 days, more than 550 kg/cm ²

Compressive strength is related to water powder ratio (0.13-0.15)

Flow-table flow (without vibrations): more than 260mm when water powder ratio greater than 0.15

Restrained expansion (after 28 days): +0.15 to + 0.4%

Setting time (IS:4031-1988 part 5)

Initial set: >300 mins

Final set: <600 mins

FREE FLOW CEMENTIOUS GROUT 10 M

Rest of the details for 5m grout are applicable to 10m also

TECHNICAL INFORMATION:

Yield	2,200± 50 kg./m ³
Bulk density (tapped)	1.4 gm/cc
Compressive strength (IS:4031-1988)	24 hrs, more than 350 kg/cm ² 7 days, more than 550 kg/cm ² 28 days, more than 650 kg/cm ²

Compressive strength is related to water powder ratio (0.14-0.16)

Flow-table flow (without vibrations): more than 260mm when water powder ratio greater than 0.15

Restrained expansion (after 28 days): +0.15 to + 0.4%

Setting time (IS:4031-1988 part 5)

Initial set: >300 mins

Final set: <600 mins

PRESSURE GROUTING EQUIPMENT

GROUT PUMPS

Wide range of high performance pumps, with grout outputs of up to 200 liters per minute and grout pressures of up to 100 bar. The pumps will meet the most demanding requirements across a wide range of applications and permit a variety of materials including cement, bentonite, Fly ash (PFA), sand and chemicals to be pumped quickly and efficiently.

Pneumatic grout pump

Pneumatic operated single diaphragm grout pump. The unit is powered by a single ended pneumatic cylinder, which deflects a heavy – duty rubber diaphragm. Routine maintenance and general servicing of the unit is extremely simple and can be carried out under site conditions.

The small size of the unit makes it ideal for use in areas of confined working space, i.e. tunneling and sewer refurbishment.

Single and double piston pump

- Choice of output range
- Single or double acting pump
- Low maintenance costs
- High performance

Single and double diaphragm pumps

- High output performance
- Heavy duty diaphragms
- Low maintenance costs

GROUT MIXERS

In the application of grout it is essential that the mix constituents are quickly and thoroughly mixed. This will ensure that the design properties of the mix are not affected and that the grout is delivered quickly and efficiently to the point of application. In particular, cement and chemical based grouts should be supplied to the point of application in a consistent condition

PADDLE MIXERS

Pneumatic, hydraulic or electric options

Choice of three capacities

Low maintenance costs

Consistent batch mixing action

HAND-OPERATED GROUT MIXER

Lightweight construction

Minimum maintenance

Requires no additional services

The hand – operated grout mixer has been designed to provide rapid and thorough mixing of liquids and solids used in grout mixes and applications.

With a drum capacity of 90 liters, the mixture is suitable for use with grouts including cement, fine sand, Fly ash (PFA) and chemicals.

The internal baffle plates and gearing of the unit are designed to ensure that minimal effort is required to produce a suitable mix.

COLLOIDAL MIXERS

Pneumatic, hydraulic or electric options

Rapid mixing action

Choice of 3 capacities

MICRO CONCRETE

Flow able mortar for RCC member jacketing

Used for jacketing of columns, foundations and adding section to slabs & patch repair jobs

MICRO CONCRETE ready to use dry powder which requires only addition of clean water at site to produce a free flowing non shrink repair micro concrete. This is a cementitious material, with additives, specially designed for repairs to damaged reinforced concrete elements, particularly where area is restricted and where vibration of the placed material is difficult or impossible. Mix for micro concrete need to be worked out. The max agg size is 5mm and down graded. Polymers and super plasticizers are used in preparing micro concrete.

FEATURES & BENEFITS:

Can be pumped or poured into restricted locations

Flowable mortar hence does not require compaction

Gaseous expansion system compensates for shrinkage and settlement in the plastic state.

High ultimate strength and low permeability of cured repaired section

Contains no chloride admixture

Rapid strength gain to facilitate early reinstatement

AREAS OF APPLICATION:

Repair to damaged reinforced concrete elements like beams, columns, wall etc., where access is restricted and compaction is not possible.

METHOD OF APPLICATION:

Clean surface and remove any dust, loose material, oil, paint, grease etc.,
Expose fully any corroded steel in the repair area and remove all scale and corrosion deposits. Shot blasting is highly recommended

Apply **EPOXY ZINC PRIMER** over the cleaned re-bars and allow to dry before continuing

Saturate the substrate with water to prevent absorption of water from mixed **MICRO CONCRETE**

The substrate should be primed by applying one coat of **EPOXY BONDING AGENT**.

Mix **MICRO CONCRETE** with water (3.75 to 4 liters per 25 kg bag) till homogenous mix is obtained, at 30oC

Mixing should be done thoroughly with a forced action mixer of adequate capacity, atleast for 5 minutes

Pour or pump the mixed **MICRO CONCRETE** into a watertight shuttering in the repaired area, when primer becomes tacky

Cure repaired surface for minimum 7 days.

PRECAUTIONS & LIMITATIONS:

MICRO CONCRETE can be applied in sections upto 100mm deep.
For thickness more than 100mm addition of pre-calculated aggregates is recommended
Strictly follow water power ratio as specified

TECHNICAL INFORMATION:

Compressive strength	100 kg/cm ² at 1 day 300 kg/cm ² at 3 days 400 kg/cm ² at 7 days 500 kg/cm ² at 28 days
Flexural strength	5 kg/cm ² at 28 days
% absorption after 24 hrs	0.45
Chloride content	Nil
Depth of carbonation, mm (accelerated carbonation test)	
2 hrs	Nil
4 hrs	Nil
Coefficient of thermal expansion	11 x 10 per °C

EPOXY ZINC PRIMER

For cathodic protection to re – bars and steel surface

EPOXY ZINC PRIMER is recommended for coating to steel reinforcement or steel surface as an anti corrosion primer. The product actively resist corrosion within the contains at the repair location and avoids the generation of incident anodes in the immediately adjacent locations. **EPOXY ZINC PRIMER** is supplied as two component system based on metallic zinc and epoxy resin which on mixing gives a grey coloured liquid

FEATURES & BENEFITS:

Active zinc rich system combats corrosion by electro chemicals means

Two component product, easily brush or spray applied

Time saving touch dry after 15 to 45 minutes

Excellent as primer on steel surface for further epoxy or polyurethane based coatings.

AREAS OF APPLICATION:

For coating re-bars and steel surfaces

METHOD OF APPLICATION:

Expose fully any corroded steel in the repair area and remove all loose scale and corrosion deposits. Care should be taken to clean the back side surface of steel bars. Grit/sand blasting is recommended for this purpose.

The application of **EPOXY ZINC PRIMER** must take place as soon as possible to a dry steel surface after completion of the preparation work but always within three hours.

Apply one full coat of **EPOXY ZINC PRIMER** by a suitable brush, making sure that the backs of exposed steel reinforcement bars are properly coated.

Apply one additional full coat, in case of any discontinuity in the first coat, after drying of first coat.

The primed surface should not be left exposed to a longer time. The application of concrete repair material should proceed as soon as the **EPOXY ZINC PRIMER** is fully dry.

PRECAUTIONS & LIMITATIONS:

EPOXY ZINC PRIMER should not be applied when the temperature is below 10oC or is above 40oC

Epoxy zinc primer is “flammable”. Keep away from source of ignition

Flash point :16oC

In case of fire extinguish with CO2 or foam

EPOXY REPAIR MORTAR

For RCC members & floors

EPOXY REPAIR MORTAR is a 3component epoxy mortar for all types of floor repairs, where quick turnaround is required. **EPOXY REPAIR MORTAR** has good chemical and abrasion resistance hence ideal for industrial units, automobiles unite, textile units etc.

FEATURES & BENEFITS:

Easily applied as a universal repair mortar in all industries.

Has excellent load bearing, abrasion resistance and chemical resistance properties

Can also be used for small repairs of floors

Gives a non slip surface

Excellent early strength, hence floor can be used quickly

Chemical resistance are as under:

Water	Excellent
Steam	Good
30 % caustic soda	Excellent
Liquid ammonia	Excellent
50 % sulphuric acid	Fair
15 % sulphuric acid	Excellent
Conc. hydrochloric acid	Poor
15 % hydrochloric acid	Excellent
10 % nitric acid	Good
40 % phosphoric acid	Excellent
Xylene	Excellent
Methanol	Poor
50 % ethanol	Good
Chlorobenzene	fair
Carbon tetrachloride	Fair
Fruit juice	Excellent

AREAS & APPLICATION:

For repair in chemical industry, heavy industry, ramps, loading and unloading bays, paint shops, battery rooms, food processing plants etc.

METHOD OF APPLICATION:

Surface preparation:

Surface has to be sound and dry free from laitance, grease, oil and any other contamination.

The above can be achieved by wire brushing or grit blasting application of primer:

Mix the hardener into the **BASE** component of **EPOXY EP** (primer) thoroughly.

Using a slow speed drill for at least 3min to get a homogenous mix.

Apply a thin coat of **EPOXY EP** on the prepared surface at 200/300gms/m² depending upon the absorption and roughness of the surface. Recoat over areas where characteristic dry patches are seen on drying. It can be brush or roller applied

First mix thoroughly hardener into the base.

Then add filler slowly and mix with paddle attached to a heavy duty, low speed drilling machine to get a homogenous mix of the screed.

Overlay **REPAIR MORTAR** over the primer when it is tacky. It is based to work in lanes of 2 to 3 feet width for effective leveling & trowelling

Use steel trowel to finish. Over coating can be taken up after 24 hrs of application of **REPAIR MORTAR**

Achieve 3mm thickness per 10kg over an area marked to 1.5m² on a leveled surface.

PRECAUTIONS & LIMITATIONS:

Material should be used/laid before pot life i.e. 60mins. at 30°C

Part mixing of material is not recommended and will not give desired results.

No dilution of the product is recommended

When being applied on steel surfaces, they should be sand or grit blasted and primed with **EPOXY EP**

Coverage's & Quantity required to be ascertained before mixing

All tools should be cleaned before the pot life period

Should be applied with gloves and avoid contact with skin/eyes

Any splashes in the eyes have to be immediately washed with plenty of water and medical advice is taken.

TECHNICAL INFORMATION:

Pot life	60 min at 30 °C
Foot traffic	24 hrs after application
Full strength/chem. Resist	7 days
Comp. strength	50 N/mm ² at 7 days
Coverage	1.5 m ² /10kg pack at 3mm 1.0 m ² /10 kg at 5mm
Shelf life	12 months is unopened bag stored below 30 °C
Application	3 to 8 mm

CURING COMPOUND

Wax based membrane for repaired concrete surface

CURING COMPOUND is a white pigmented synthetic emulsion used for concrete curing. On drying, it forms a temporary membrane, which allows the concrete to retain sufficient water for optimum curing. This economical and efficient curing membrane eliminates the need for keeping concrete continuously wet for minimum 28 days. The white pigment reflects the light and heat of sun and minimizes the chance of cracking of the surfaces.

Specification: complies to ASTM-C-309-89, type -2, white pigmented.

FEATURES & BENEFITS

Water based product. No objectionable fumes

Quickly and easily applied by brush or spray application

Forms an efficient barrier of moisture for optimum curing of concrete

Eliminates the requirement of water in traditional concrete curing method

Keeps concrete cool by reflecting light and heat and minimize the chance of surface cracking

Breaks down by natural weathering to allow subsequent finishing application over the cured concrete

Suitable for interior and exterior application

AREAS OF APPLICATION:

Vertical and horizontal surface

Highways

Dry shake hardened floors

Industrial floors

Towers

Canals

Hospitals

Runways

Bridge decks

Ramps and walls

Dams

Retaining walls

METHOD OF APPLICATION:

CURING COMPOUND should be applied uniformly at the proper coverage rate by brush or spray on the fresh concrete after the surface has become free from bleeding water and final trowelling is over. Cast-in-situ and precast concrete (vertical application areas) should be coated with **CURING COMPOUND** as soon as the shuttering is removed.

PRECAUTIONS & LIMITATIONS:

Ensure complete removal of membrane from the surface before applying any treatment/painting over it

Ensure protection of membrane when applied on horizontal surfaces

TECHNICAL INFORMATION:

Appearance	White colour liquid
Specific gravity at 30° C	0.95 ±0.02 C
Viscosity at 30° C	2 – 4 poise
Application temp.	5° C to 45° C
Drying time	Approx. 2 hrs at 30° C
Flash point	Nil
Coverage	3 – 5 m ² / lit depending on the concrete surface

EPOXY BONDING AGENT

EPOXY BONDING AGENT is 2 pack solvent free epoxy based bonding agent. The unique formulation gives excellent bonding properties to freshly mixed concrete/mortars, glazed bricks/tiles, etc. to old sound concrete.

FEATURES & BENEFITS:

Easily applied as a bonding agent for old to new concrete/mortar

Excellent adhesive strength

Bond strength exceeds the tensile strength of concrete

Has very low shrinkage property

AREAS OF APPLICATION:

As a bonding agent for bonding old concrete to new concrete/mortar

To extend or repair structural concrete

Can be used as a bonding agent for glazed brick/tiles, steel & structural members

METHOD OF APPLICATION:

The surface for application must be cleaned and made free from dirt, grease, oil, and loose particles before application of **EPOXY BONDING AGENT**. Any laitance etc. must be thoroughly removed by mechanical means.

Mixing & application:

The hardener part should be poured into the base. The two parts must be thoroughly mixed with a low speed mixer (150 to 200 rpm for about 3 to 4 minutes) to a uniform colour of the mixed material. Mixed material should be brushed applied on the prepared surface. Overlay of concrete / mortar has to be placed on **EPOXY BONDING AGENT** when it is tacky. If **EPOXY BONDING AGENT** has dried, apply a 2nd coat before placing the new concrete/mortar.

PRECAUTIONS & LIMITATIONS:

EPOXY BONDING AGENT should be applied with gloves and avoid contact with skin or eyes.

Any splashed into the eyes or skin have to be immediately washed only with clean water and medical advice should be taken.

TECHNICAL INFORMATION:

Appearance	Grey colour viscious liquid
Mix proportion	1:0.8 (base : hardener)
Specific gravity	1.01 ±0.02
Pot life	1 hour at 30° C
Compressive strength	500 kg per cm sq. in 7 days
Coverage	2.3 sq mtr/kg depending on the substrate
Shell life	12 months in unopened condition and if stored properly in a dry and cool place
Flexural strength	350 kg /cm sq in 7 days
Tensile strength	200 kg /cm sq in 7 days
Shear strength	200 kg / cm sq
Application temp.	15° C to 35° C