

REPAIR METHODOLOGIES

NOTE: ALL STRUCTURAL REPAIRS TO BE CARRIED WITH PROPER TEMPORARY SUPPORTS TO TRANSFER THE LOAD FROM DISTRESSED MEMBER UNDER REPAIR.

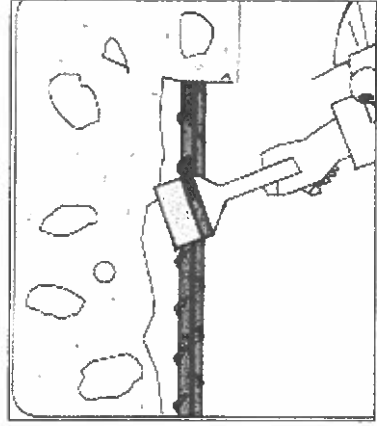
Annexure 4A:

Treatment for Exposed Reinforcement and Spalling of Concrete / Cracks in concrete members due to corroded reinforcement
(When new reinforcement is not required to be added).

When corrosion of reinforcement occurs, it exerts pressure on the concrete leading it to cracks in concrete. When the corrosion is severe, concrete portions break apart from the main member which is called spalling of concrete. Spalling of concrete will lead to complete exposure of reinforcement, which becomes susceptible to further corrosion. This makes the reinforcement ineffective and reduces the life of the concrete member.

Recommendation:

- Use light chipping hammers to remove concrete from the affected area. Clean the surface thoroughly and remove all dirt & loose dust and aggregate.
- Clean the exposed steel reinforcement with mechanical wire-brushing and by using a rust remover compound of reputed manufacturer such as Rusticide of Sunanda or similar.
- The reinforcement should then be protected against corrosion by applying two coats of epoxy based zinc primer such as FRIAZINC R of SIKA/ NITAZINC PRIMER of FOSROC or equivalent as per manufacturer's instructions.



- Apply an epoxy bonding agent to the existing concrete surface so that proper bonding of the existing concrete to the repair material can take place. The bonding agent has to be applied as per the manufacturer's instructions. Products such as SIKA HIBOND (SIKA) or equivalent can be used.
- Apply Polymer modified mortar (PMM) to repair the concrete member and bring it to its original shape and size. The PMM should be applied while the bonding agent is still tacky. Nitobond SBR (Fosroc) or Monobond of Krishna Conchem or equivalent additive can be used to make the mortar. Polymer modified mortar is to be prepared in ratio 1:5:15 (1 part by weight of polymer: 5 parts by weight of cement: 15 parts by weight of River sand) and mixed with approximate 3 litres of water. Alternately premixed polymer modified mortar such as SikaTop®-122 HS or equivalent may be used and mixed with water as per manufacturer's instructions.
- Cure the repaired concrete member adequately.

Note:

- 1) Speed and time for application of any chemical or PMM should be as per manufacturer's instructions.
- 2) It is not advisable to place PMM above 30 deg Celsius. Newly prepared surface should be protected from rainfall and other source of water. However it should be moist cured for 1 to 3 days under ambient temperature or as per manufacturer's instructions.

Annexure 4B

Injection Grouting for Dampness in RCC Wall or Slab in Contact with Water / Moisture (when both sides of the wall or slab are accessible)

RCC walls and slabs which are in contact with water or soil have a constant risk of deterioration due to ingress of water or moisture inside them. Very minor surface cracks will also lead to ingress of moisture, corrosion of reinforcement and delamination of concrete. This problem can often be identified by tapping of hammer when it is visually not evident.

Injection grouting using epoxy can be carried out to rectify this condition. Following steps are to be followed:

- Clean the cracks that have been contaminated by gently widening the cracks. Contaminants such as oil, grease, dirt, or fine particles of concrete prevent epoxy penetration and bonding, and reduce the effectiveness of repairs. Contamination should be removed by vacuuming or flushing with water.

- Seal the cracks on both faces of the wall or slab by using an epoxy or cementitious mortar. Products such as Sikadur®-41 Normal of Sika or equivalent can be used with mixing done as per manufacturer's instructions.
- On the face which is less vulnerable to penetration of moisture, mark points for grouting in the wall/slab at a spacing decided based on the condition of the effected member and as per grout manufacturer's instructions. The selected points should be on the crack locations if the problem is present only at cracks. If the concrete member is hollow in general, then a grid in both horizontal and vertical directions has to be used. A grid spacing of 150mm c/c to 300 mm c/c can be used depending on the condition of the member.
- Now, drill holes of 12 mm dia at the predetermined points
- Fix PVC/MS nozzles in the grouting holes using a suitable putty & allow to set
- Inject **Moisture Insensitive Epoxy Resin Grout** of a reputed manufacturer such as Sikadur-53 (UF) or similar. The grout has to be prepared as per the manufacturer's instructions.
- Allow to cure as per manufacturer's instructions
- Cut the projecting nozzles and seal the grouting holes. The same mortar used for sealing the cracks before grouting can be used.
- If any face of the wall/slab is in constant contact with water or moisture (such as water tank walls or slabs) and the waterproofing is not proper, then the waterproofing will have to be rectified/redone to prevent reoccurrence of deterioration of the RCC member
- Finish both the concrete surface appropriately. If required, premixed PMM such as SikaTop®-122 HS equivalent may be used and mixed with water as per manufacturer's instructions.

Annexure 4C
Leakage from Terrace Slab due to Damage in Waterproofing

At some places it was observed that leakage is occurring in the slabs through the terrace slab. This is happening due to deterioration in waterproofing.

Recommendation:

1. Fresh brickbat coba waterproofing should be carried out for the building. A specialized waterproofing contractor should be appointed to carry out the waterproofing work. However prior to carrying out the waterproofing, the design of the terrace slab must be checked to make sure that it has sufficient load carrying capacity to take the weight of the brickbat coba.

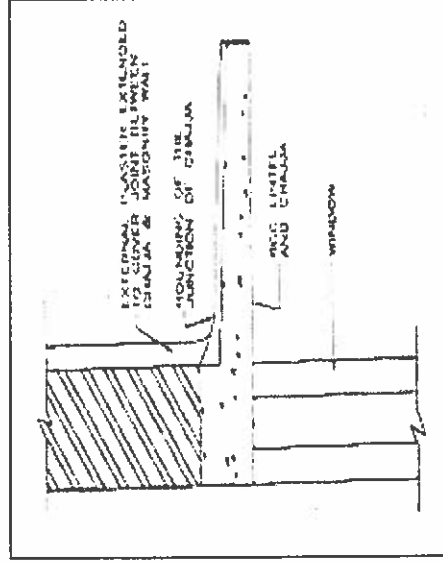
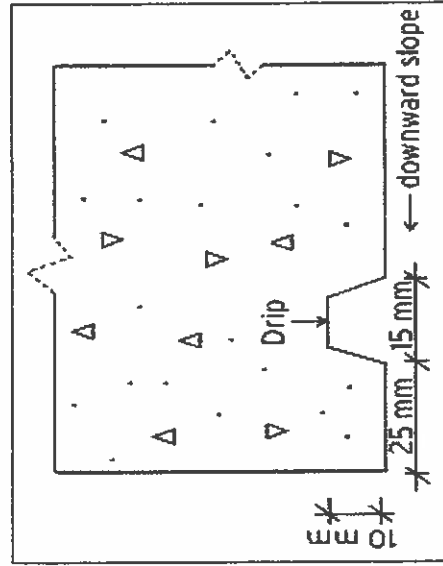
2. The new waterproofing should be laid such that the slope is towards the down take pipes so that water can easily exit the terrace without any stagnation.
3. In case complete new waterproofing is not opted for at this stage, chemical waterproofing membrane or bitumen sheets should be overlaid on the current surface. Products such as Dr. Fixit's new coat or other similar products can be used as per manufacturer's instructions.
4. Even if chemical waterproofing or bitumen sheets are opted for, it will be required that the slope of the terrace be towards the outlet drains. Wherever this is not the case currently, a layer of cement slurry can be used to correct the direction of slope prior to using the chemical waterproofing or bitumen sheets.

Injection grouting should also be carried out at locations where the slab is allowing the water to seep through as it indicates presence of voids at such locations as follows:-

- Mark points for grouting in the wall/beam/slab at a spacing decided based on the condition of the effected member. The selected points should be on the crack locations if the problem is present only at cracks. If the concrete member is hollow in general, then a grid in both horizontal and vertical directions has to be used. A grid spacing of 150mm c/c to 300 mm c/c can be used depending on the condition of the member.
- Now, drill holes of 12 mm dia at the predetermined points
- Fix PVC/MS nozzles in the grouting holes using a suitable putty & allow to set
- Inject Cementitious grout material such as Monopol of Krishna Conchem or similar mixed with reinforcement corrosion inhibitor such as EPCO-KP-100 of Krishna Conchem or similar. The grout has to be prepared as per the manufacturer's instructions.
- Allow to cure for 24 hrs.
- Cut the projecting nozzles and seal the grouting holes using epoxy or cementitious mortar such as Sika WR Putty or equivalent.
- After application of grout material the surface should be finished using PMM. Premixed PMM such as SikaTop® -122 HS/ Molith of Krishna Conchem or equivalent may be used and mixed with water as per manufacturer's instructions.

Chajja are exposed to the external weather including rainfall and if the construction is not proper, water seepage and dampness can occur in these elements. The water seepage from chajja can also affect the adjacent RCC members and masonry walls.

- Clean the top of the chajja and remove any extra mortar or spalled concrete to get an even surface
- If there are any cracks on the top or bottom surface, these can be repaired using polymer modified mortar. Premixed PMM such as SikaTop®-122 HS or equivalent to be used and mixed with water as per manufacturer's instructions.
- Use cement mortar with 1:3 ratio to make a slope of 1 in 100 to drain off the water effectively. If suitable slope is existing, then the same can be retained.
- A dripcourse should be provided on the bottom face at the end of the chajja that the water does not travel back and is effectively thrown off the building. Refer below image for the details.
- The junction of the chajja and the wall / beam should be rounded off. This can be done by using polymer modified mortar. Premixed PMM such as SikaTop®-122 HS or equivalent to be used and mixed with water as per manufacturer's instructions.



Annexure 4E

Repair Honeycombs or Hollowness in RCC Members (Beams / Columns / Slabs / Walls)

Honeycombing occurs either due to excessive bleeding of cement slurry or insufficient compaction at time of concreting. Injection grouting can be carried out to rectify this condition. Following steps are to be followed:

- Seal the surface honeycombing using premixed PMM such as SikaTop®-122 HS/ Molith of Krishna Conchem or equivalent. PMM has to be mixed with water as per manufacturer's instructions.
- Mark points for grouting in the wall/beam at a spacing decided based on the condition of the effected member. The selected points should be on the crack locations if the problem is present only at cracks. If the concrete member is hollow in general, then a grid in both horizontal and vertical directions has to be used. A grid spacing of 150mm c/c to 300 mm c/c can be used depending on the condition of the member.
- Now, drill holes of 12 mm dia at the predetermined points
- Fix PVC/MS nozzles in the grouting holes using a suitable putty & allow to set
- Inject Cementitious grout material such as Monopol of Krishna Conchem or similar mixed with reinforcement corrosion inhibitor such as EPCO-KP-100 of Krishna Conchem or similar. The grout has to be prepared as per the manufacturer's instructions.
- Allow to cure for 24 hrs.
- Cut the projecting nozzles and seal the grouting holes using epoxy or cementitious mortar such as Sika WR Putty or equivalent.
- After application of grout material the surface should be finished using PMM again if required. Premixed PMM such as SikaTop®-122 HS or equivalent may be used and mixed with water as per manufacturer's instructions.

Annexure 4F

Undulation in top of concrete slabs / Corrosion of reinforcement in slabs

Where it is observed that there is undulation in flooring tiles or crack in tiles, it indicates that there is a possibility of tensile stress being developed in the slab concrete due to corrosion of reinforcement. Sometimes unevenness or crack in tiles may also occur due to poor workmanship during installation of tiles.

Corrosion of slab reinforcement occurs due to seepage of water through joints (sandha) of tiles, if joints were not grouted properly during laying of tiles or if the joints have opened up with normal wear and tear.

Recommendation:

1. Tiles to be removed carefully and stacked, bed mortar to be removed and slab surface to be totally cleaned with wire brush.
2. RCC slab to be tapped and checked for hollow sound. If slab is found hollow or if there is any sign of corrosion of reinforcement such as presence of cracks or swelling of concrete, then slab to be propped and supported.
3. Top cover of concrete to be removed and rusted reinforcement should be exposed. The exposed reinforcement to be cleaned of concrete and rust.
4. A bond of Polymer modified cement (PMC) slurry is to be applied all over the surface of concrete and reinforcement before covering it with repair material.
5. This is to be covered in layers with polymer PMM 1:2:5 modified with 5% SBR by weight of concrete.
6. Flooring to be re-laid as per standard specifications making sure that all joints are grouted properly.

Annexure 4G

Cracks in masonry walls/plaster

However cracks on the external walls will lead to seepage of water into the walls and can also allow water to go to the concrete members which is not desirable. Moreover the aesthetics of the buildings is affected due to the cracks in the wall.

Masonry walls also serve an important purpose in resisting the seismic forces during an earthquake and if cracks are present in the walls, they are not as effective in taking the seismic forces.

Cracks in masonry walls are to be treated as per the procedure below:

- Cracks in the body of the masonry will have to be opened up and V-grooves should be created (of minimum width 5mm) with the help of grinder.
- Clean the groove to remove all loose particles and wash with water. The surface must be free from dust, oil, grease, loose particles,

- Shrink free crack filler material such as Dr. Fixit Crack-X Powder / Paste or equivalent can be used to repair the cracks. The crack filling material has to be prepared as per the manufacturer's instructions by mixing adequate water. The crack filling material shall be pushed into the crack with a spatula or a putty knife. The surface can then be leveled off. Allow it to dry in ambient conditions for 1-2 days before application of plaster & paint.
- Manufacturer's instructions related to ambient conditions should also be followed.

Annexure 4H

Separation cracks in between masonry walls & concrete columns/beams

Separation cracks have been observed at beam-wall and column-wall junctions. These cracks manifest themselves at changes in material, changes in geometry such as openings for windows or doors and adjacent to corners.

At junctions of masonry walls with column or beam, chicken mesh should be used during plastering to prevent any shrinkage cracks due to change in material. However when this is not done, separation cracks begin to appear.

Separation cracks should be filled using Polymer Modified Mortar (PMM). The manufacturer's instructions should be followed for the application of PMM and its curing. Premixed PMM such as SikaTop®-122 HS or equivalent to be used and mixed with water as per manufacturer's instructions.

Annexure 4I

Dampness in masonry walls near plinth level

Dampness is observed in the bottom portion of the masonry walls at the ground level. This dampness occurs due to capillary action where water from the ground is pulled by the masonry walls.

Injection grouting can be carried out to rectify this condition. Following steps are to be followed:

- Draw a line along the wall, 300 mm from the ground level & parallel to the window sill
- Mark points for grouting along the wall at a spacing of 300 mm c/c

- Now, drill holes of 12 mm dia at an angle of 45° at the predetermined points
- Fix PVC/MS nozzles in the grouting holes using a suitable putty & allow to set
- Inject Dr. Fixit Damp free (or equivalent) using a grouting pump as prescribed in the product data sheet of the manufacturer.
- Cut the projecting nozzles and seal the grouting holes using epoxy or cementitious mortar such as Sika WR Putty or equivalent.
- Allow to cure for 24 hrs. & seal the grouting hole appropriately

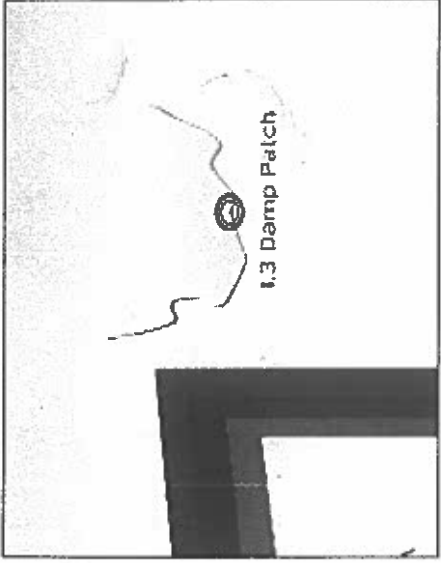
Annexure 4J

Dampness in masonry walls near window openings

- Water seepage into masonry wall and plaster can occur through cracks around door/window joints. This leads to damage in the paint and plaster on the walls.
- A flexible acrylic based crack filling material can be used to fill cracks around door/window openings.

Annexure 4K

Damp Patches in Masonry Wall



To repair damp patches in masonry walls, following procedures is adopted:

1. Wires brush the surface to remove existing paint and putty so as to expose the plastered wall.
2. If there are any cracks observed in the plaster or masonry wall, the same needs to be repaired first.
3. Shrink free crack filler material such as Dr. Fixit Crack-X Powder / Paste or equivalent can be used to repair the cracks. The crack filling material has to be prepared as per the manufacturer's instructions by mixing adequate water. The crack filling material shall be pushed into the crack with a spatula or a putty knife. The surface can then be leveled off. Allow it to dry in ambient conditions for 1-2 days before application of plaster & paint.
4. Brush apply two coats of damp proof coating such as SmartCare Damp Block 2K of Asian Paints or equivalent over the plastered wall as per manufacturer's instructions.
5. Time duration between two coats should be about 6 hrs.
6. Air cure for 24 hours, before applying paint

Annexure 4L
Leakage from Toilet Plumbing Lines

It was observed that water seepage is occurring from toilet plumbing pipes at certain locations. This may be due to:

- damage in plumbing pipes

- poor workmanship leading to gaps at pipe junctions
- choking of pipes restricting free movement of water

This water seepage is going into the masonry walls and concrete members. Where the seepage is occurring in the concrete members, it will lead to corrosion of reinforcement which will lead to reduction in strength of the rebar as well as development of cracks in concrete.

Recommendation: All such locations where plumbing lines are leaking should be identified and the plumbing lines should be checked for damage, blockages or gaps in connections.

Based on the findings, suitable steps should be taken to prevent any further leakage into the concrete members and walls.

Annexure 4M

Termite Infestation/White ants

The termites originate from the ground and move in mud tubes. Termites live in the soil and invade buildings in search of their favourite food i.e. wood and paper (anything containing cellulose). They are known to be hidden invaders. Generally during new construction anti termite treatment is done, but the treatment lasts only for 10 years. So termite problems generally arise in old buildings.

Recommendation:

1. Eliminate moisture problems in and around the structure by identifying the cause of moisture such as cracks in plaster, masonry wall or concrete members. Presence of water can also occur due to leaking plumbing lines or damaged terrace waterproofing and external plaster in walls.
2. Keep proper ventilation in both the attic and the crawl space areas.
3. Use chemical such as Rentokil to kill the white ants.
4. Generally it's better to do anti termite treatment along the plinth level soil along with the rooms where the infestation is observed. This is because termites live in soil and find their way to the structure from the plinth level only.

Annexure 4N

Vegetation Growth in Building

Vegetation growth or moss growth that we see in the building is generally due to the dampness in particular area of building. Mostly it occurs near pipes or in groves of chajja, where water is generally present. This trees root infiltrate in concrete and reaches up to reinforcement, because of this seepage of water occurs in concrete and reaches reinforcement and causes corrosion of steel. Due to corrosion, steel exerts tension in concrete, while concrete is weak in tension so cracks tends to appear in concrete which in turn leads to spalling of concrete.

Recommendation:

1. Removing live plants from the structure can cause additional damage because it may also tear off surrounding building materials that have been weakened. To kill the roots, a “cut-and-paint” technique – where the plant is cut and the cut surface is then painted with an herbicide – is usually recommended.
2. Moss and lower order plants can be effectively removed with an appropriate biocide and a soft bristle brush, being sure to wet the surface prior to cleaning and to work from the bottom up to minimize streaking.
3. “Glyphosate” which is marketed as a weed killer and seems to be less toxic yet effective can also be used. Initially a 1:1 solution of Glyphosate, in water can be sprayed over the affected areas. After couple of weeks, a 3% solution of sodium arsenate can be injected in the stem the plant.

(Note: Sodium arsenate is highly toxic and hence should be used by an experienced handler.)

Annexure 4O

Repair for hairline/wide concrete cracks in floor/slab

Cracks in industrial floors may arise due to many reasons such as shrinkage, improper compaction of sub base during construction or due to impact from heavy parts or machines.

Procedure for repairing such concrete floor cracks is as follows:-

- Clean out the floor crack with a vacuum, remove any loose dust, cement or aggregates.
- Create a V groove along the crack so that the repair mortar can be filled in the crack properly.

- Use high strength and high abrasion resistant epoxy mortar system to fill the crack. Products such as Sikadur®-41 Normal or equivalent can be used.
- The crack filling procedure as specified by the manufacturer has to be adopted.

Annexure 4P:

Treatment for corrosion of steel members/plates:

Wherever corrosion is observed in the steel members, it must be treated on priority as corrosion will eat away the steel section and reduce its load carrying capacity. Corrosion in steel members can be at various stages, and based on the extent of corrosion seen at the site, some structures will require a replacement of members, whereas for most other structures treatment to remove corrosion will be sufficient.

Procedure to remove corrosion from structural steel is described below:

- Remove all pieces of rust and paint from the metal surface with a wire brush/emery paper and roughen the surface.
- Dust the metal with a dry cloth to remove metal dust from the surface.
- Apply Red oxide primer to the rusted metal surface and allow the paint to dry completely.
- Follow by two coats of Enamel paint.

Where bolts are found to be corroded, the bolts should be replaced as described below:

The corroded bolts must be removed and replaced. The replacement should be done using bolts of the same diameter and grade as the original drawings.

Removing the corroded bolts can be difficult, especially if the threads have become rusted or rust has degraded the metal head, making them hard to grip with a wrench or screwdriver. However if treatment is not carried out, the extent of corrosion will increase and it will become further difficult to remove and replace the bolts.

There are several options for helping to remove rusted fasteners, including:

Lubrication: Industrial lubricants can often reach a fastener's threads, which may be difficult for tools to grasp. Applying lubricant to the bolt, then tapping its head with a hammer, can help the lubricant penetrate the fitting and loosen the bolt sufficiently to be removed.

Cutting: If a fastener has rusted too severely, cutting it out may be the only alternative. A cut-off wheel can be used to remove the rusted fastener.

Torching: Using a moderate to low heat torch is another viable method for removing a rusted bolt.

Annexure 4Q:

Retrofitting for strengthening the existing corroded web plate:

- Carry out corrosion removal treatment for the existing web plate as per the instruction provided in the Annexure 4A.
- Add a plate on top of the existing web plate and carry out fillet weld on all four edges (Two side edges to be welded to the flange & top/ bottom edges to be welded to the existing web plate).
- During repair works, top layer of concrete grade slab to be broken to check the condition of plate embedded in concrete. If it is found to be corroded, the new plate to be continued below for strengthening.
- Refer the Image below for details.

