Repair of RC structures in cement plants - A case study

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A number of reinforced concrete structures in some cement plants were investigated and repaired using modern techniques. Appropriate repair method was used for rectifying the damage. Polymeric materials and systems used in repair enabled quick repairs to be carried out without major shutdown. The paper presents case studies of repairs to reinforced concrete structures in three different cement plants.

A large number of concrete structures are today in distress due to exposure to various types of aggressive environments. The distress is more pronounced in the marine environment, prevalent in the coastal belt of the country. At the same time, a number of industrial structures subject to aggressive chemical attack, are also showing signs of distress.

The present paper deals with some of the reinforced concrete structures in cement plants constructed in 1950s and 1960s in the central and southern parts of India. Within a span of 30 to 40 years, some of these structures showed signs of damage, mainly due to the aggressive environment. Detailed preliminary investigations carried out for different structures showed that many factors or a combination of factors were responsible for the distress in structures. These factors were :

(i) honeycombs in structural components

(ii) diffusion of gases

(iii) provision of random openings in slabs, exposing reinforcement

(iv) stagnation of water on the roof slab

(v) improper drainage of cooling water

(vi) lack of proper care of reinforcement at many places

(vii) accumulation of large layers of cement dust on the structure together with growth of bio-organisms and entrapment of moisture in the layers

Depending on the nature of damage, various standard tests were also carried out. Results of the tests, carried out both in the field and laboratory, were studied carefully. Depending upon the nature of distress, remedial measures were carried out.

Case study No. 1

Structural strengthening of the columns of primary lime stone crusher for a cement plant

Due to excessive vibrations which are transmitted to the main column foundation of lime stone crusher, a crack of approximately 5-mm width had developed throughout the periphery of column. This was at the level of construction joint between columns and beam haunches. The size of the column was 1.2 m x 2.4 m approximately, *Fig* 1.

After cleaning and widening of the cracked portion, mild steel nozzles of 12 mm diameter were placed with epoxy putty at 300 mm on centres all along the periphery. After 24 hours injection grouting was done with a low-viscosity, high molecular weight thermoset polymer grout with a pressure of 4 kg/cm^2. Honey combs and even hairline cracks could be filled upto full depth of concrete as viscosity of grout used was

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Fig 1 Strengthening of the column using epoxy resin

very low. It also helped in strengthening parent concrete of column foundation. The polymer also filled the gap between concrete and vertical reinforcement. This gap was created due to vibration from continued use of the crusher in spite of the distress.

Subsequently injection grouting was carried out once again with low viscosity epoxy resin system with a pressure of 6-8 kg/cm^2. By virtue of its low viscosity it could penetrate into cracks present in the concrete. As this system is non-shrinking and has good bond with concrete, the original strength of concrete could be restored.

Case study No. 2

Strengthening of DG set foundation bolt pockets at a cement plant

In a DG set foundation bolts were reported to be loose. Hair-line cracks were noticed in concrete foundation. At 15 out of 25 locations the anchorage in concrete was suspected to be lost due to this cracking. This would have caused vibrations of the DG set and subsequent damages to other parts of the DG set.

After removing dust particles and cleaning the pockets thoroughly, a low-viscosity, high-molecular weight thermoset

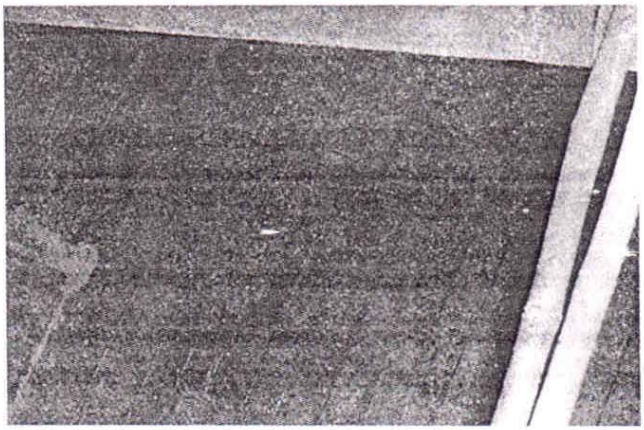

Fig 2 Repair of slag drier slab using anti-corrosive system

polymer grout was applied by brush repeatedly, so as to fill the gap by gravity. Two holes were then drilled in each pocket to remove entrapped air in the crack. Subsequently, two mild steel nipples were fixed with epoxy putty for injecting the above-mentioned thermoset polymer grout under pressure. In addition to this activity, ponding of the grout was made in each pocket to ensure filling of gap throughout the depth of crack.

Special heaters were arranged near the pockets to maintain higher temperature for quick polymerisation. An attempt was also made to inject an epoxy resin in each nozzle, but there was no access for the material as all gaps were sealed by the grout. The system was allowed to cure for 48 hours. After the repairs, DG set did not experience abnormal vibrations.

Case study No. 3

Repairs of various structures at a slag cement manufacturing plant

Slag drier slab repair

Due to excessive heat slag drier slab was getting damaged. In view of the critical nature of the unit, it was difficult to get a long shutdown. To repair this slab, shutdown was essential. So repair schedule was prepared in such a way that the work could be completed in just 3 days.

On the first day, scaffolding of about 15 m^2 area was completed in one hour. Subsequent activities such as chipping, bar cleaning, anti-corrosive coating of bars were carried out on the same day, *Fig* 2.

Next day, application of bond coat and polymer-modified mortar in layer-by-layer was carried out. Since the depth of repair is 40 mm the activity involving application of polymer-modified mortar took two days. A quick-setting mortar was developed for this purpose.

The plant was operational from the fourth day. However, the scaffolding top was covered by AC sheet so that newly applied mortar was not exposed to direct heat: Polymer-modified mortar was cured with water for two days.

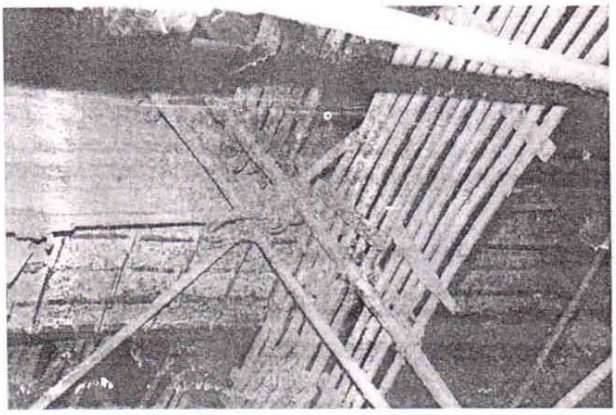

Fig 3 Corrosion of reinforcements in one of the main columns (lapol grate area)

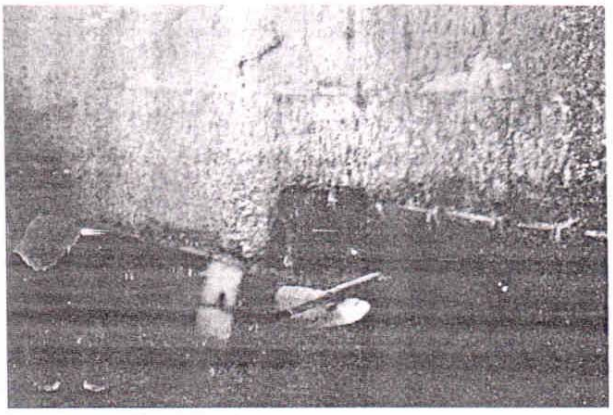

Fig 5 Application of repair mortar

Lapol grate area

Tie beams and main column at 20-22 m level were damaged due to heat and periodical wetting and drying process, *Fig* 3.

After completing about 30 m^2 scaffolding upto 22m level, all beams were repaired with polymer-modified mortar. Main columns at 20-22 m level were badly damaged. Concrete in cover portion had completely come off. For repair of these columns the method of low-viscosity monomer injection was adopted to strengthen sub-base of parent concrete column. Subsequently, casting was done with polymer modified concrete (1:2:4) using 10 percent polymer latex. Before casting, expanded wire mesh had been fixed as an additional reinforcement, *Figs* 4 and 5.

Beam repaired with epoxy mortar

The bottom profile of a beam had been modified as it was obstructing the movement of a conveyor belt. Due to this modification the bottom reinforcement was exposed and, load carrying capacity of the beam was reduced. The beam was repaired with an expanded wire mesh of thickness 2.5 mm and an epoxy mortar to regain its original strength with minimum shutdown time.

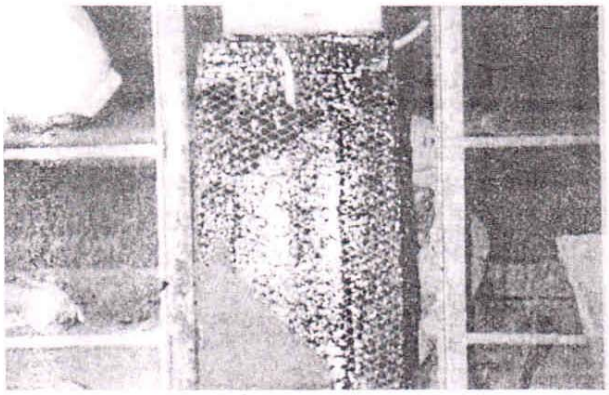

Fig 4 View of expanded wire mesh as additional reinforcement

Dry slag conveyor tunnel top (Recasting)

Owing to the impact of a gantry hitting the slag conveyor tunnel top, the 200-mm thick tunnel top was punctured. An area of about 5m^2 was affected by the impact. Here also, enforcing shutdown was quite difficult. The work was therefore properly planned and completed within the stipulated 72-hour shutdown period. The work consisted of cleaning affected area, placement of formwork and centering, and use of rapid-hardening concrete, involving the use of bonding agent and accelerators.

Primary crusher

Retaining wall behind the crusher in which limestone boulders were stored was badly damaged due to impact of big boulders of lime stone. There was difficulty in getting shutdown as there was only two-hour stoppage in between shifts. Then two-hour stoppages were utilised for repair works. Erection of scaffolding and other activities like chipping and application of an anticorrosive agent were completed in 3 stoppages of 2 hour each.

The cover portion of the wall was also damaged badly. Repair was done using polymer-modified concrete. Before casting of concrete, expanded wire mesh was fixed as additional reinforcement. Simultaneously, mild steel nipples were placed for epoxy injection.

As soon as curing period for the polymer was over, the work of laying 5-mm thick epoxy mortar lining was carried out. Subsequently, after curing of epoxy mortar, epoxy grout was injected through mild steel nozzles which were placed earlier.

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