

METHODS OF REPAIRING CONCRETE STRUCTURES

1. INTRODUCTION

- ◆ 3 Basic symptoms of distress in a concrete structure
- ◆ Cracking, Spalling and Disintegration
- ◆ Reasons for their development may be poor materials, poor design, poor construction practice, poor supervision or a combination

- ◆ repair of cracks usually does not involve strengthening
- ◆ repair of a structure showing spalling and disintegration, it is usual to find that there have been substantial losses of section and/or pronounced corrosion of the reinforcement

2. Repairing cracks

- ◆ In order to determine whether the cracks are active or dormant, periodic observations are done utilizing various types of telltales
 - ❖ by placing a mark at the end of the crack
 - ❖ a pin or a toothpick is lightly wedged into the crack and it falls out if there is any extension of the defect

- ❖ A strip of notched tape works similarly :
Movement is indicated by tearing of the tape
- ❖ The device using a typical vernier caliper is the most satisfactory of all.
Both extension and compression are indicated
- ❖ If more accurate readings are desired, extensometers can be used
- ❖ Where extreme accuracy is required resistance strain gauges can be glued across the crack

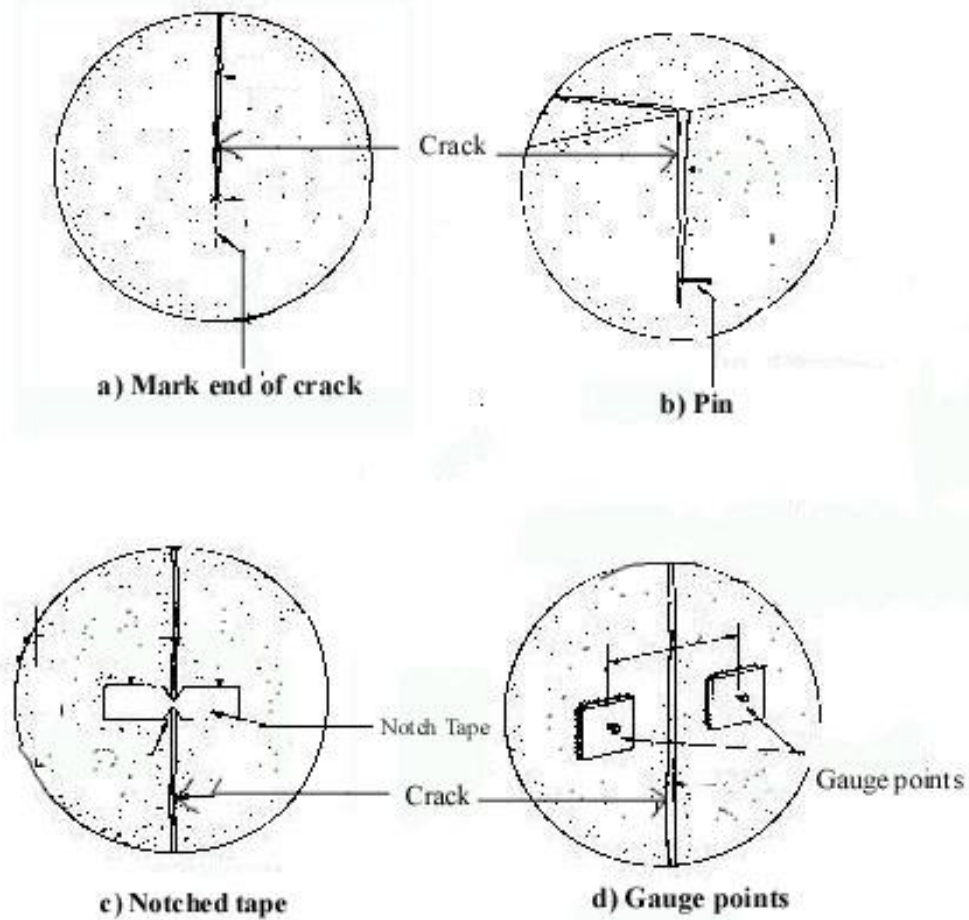


Fig. 1 Tell Tales

2.1 Types of cracks

- active cracks and dormant cracks
- the proper differentiation between active and dormant cracks is one of magnitude of movement, and the telltales are a measure of the difference

- If the magnitude of the movement, measured over a reasonable period of time (say 6 months or 1 year), is sufficient to displace or show significantly on the telltales, we can treat the crack as an active one.
- If the movements are smaller, the crack may be considered as dormant.

- ◆ Cracks can also be divided into solitary or isolated cracks and pattern cracks
- ◆ Generally, a solitary crack is due to a positive overstressing of the concrete either due to load or shrinkage
- ◆ Overload cracks are fairly easily identified because they follow the lines demonstrated in laboratory load tests

- ◆ In a long retaining wall or long channel, the regular formation of cracks indicates faults in the design rather than the construction, but an irregular distribution of solitary cracks may indicate poor construction as well as poor design
- ◆ Regular patterns of cracks may occur in the surfacing of concrete and in thin slabs. These are called pattern cracks

Methods of repairing cracks

1. Bonding with epoxies

- ◆ Cracks in concrete may be bonded by the injection of epoxy bonding compounds under pressure
- ◆ Usual practice is to
 - ❖ drill into the crack from the face of the concrete at several locations

- ❖ inject water or a solvent to flush out the defect
- ❖ allow the surface to dry
- ❖ surface-seal the cracks between the injection points
- ❖ inject the epoxy until it flows out of the adjacent sections of the crack or begins to bulge out the surface seals

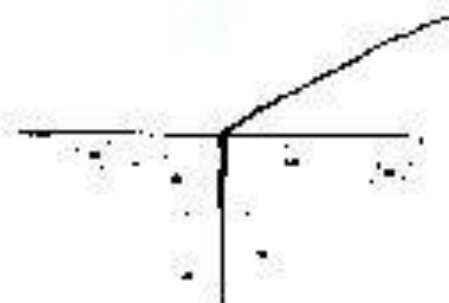
- ❖ Usually the epoxy is injected through holes of about $\frac{3}{4}$ inch in diameter and $\frac{3}{4}$ inch deep at 6 to 12 inches centers
- ❖ Smaller spacing is used for finer cracks
- ❖ The limitation of this method is that unless the crack is dormant or the cause of cracking is removed and thereby the crack is made dormant, it will probably reoccur, possibly somewhere else in the structure

- ❖ Also, this technique is not applicable if the defects are actively leaking to the extent that they cannot be dried out, or where the cracks are numerous

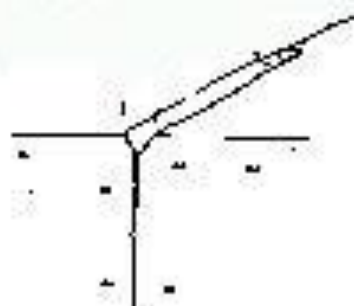
2. Routing and sealing

- This method involves enlarging the crack along its exposed face and filling and sealing it with a suitable material

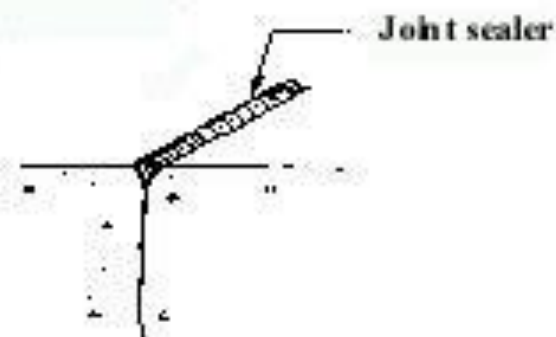
- ◆ The routing operation
- ◆ placing the sealant
- ◆ This is a method where thorough water tightness of the joint is not required and where appearance is not important



a) Original crack



b) Routing



c) Sealing

Fig. 2 Routing and sealing

3. **Stitching**

- ◆ Concrete can be stitched by iron or steel dogs
- ◆ A series of stitches of different lengths should be used
- ◆ bend bars into the shape of a broad flat bottomed letter U between 1 foot and 3 feet long and with ends about 6 inches long
- ◆ The stitching should be on the side, which is opening up first

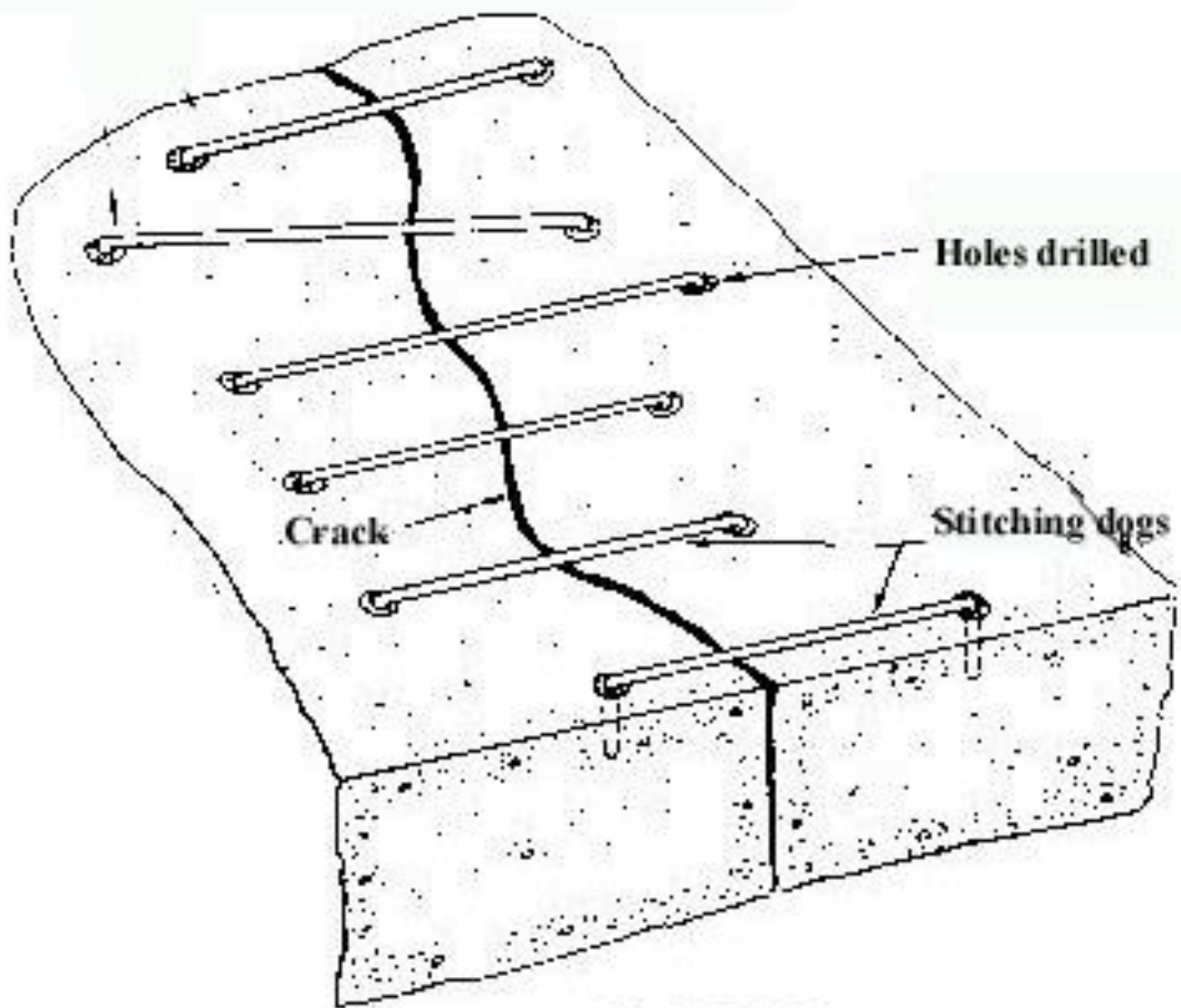
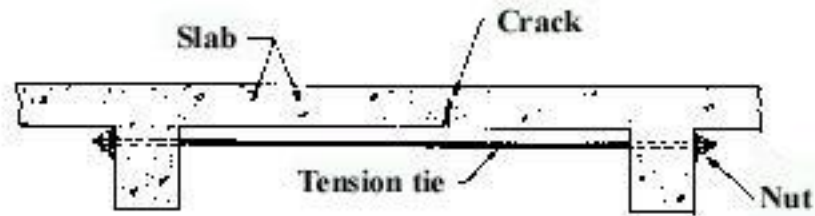


Fig. 3 Stitching

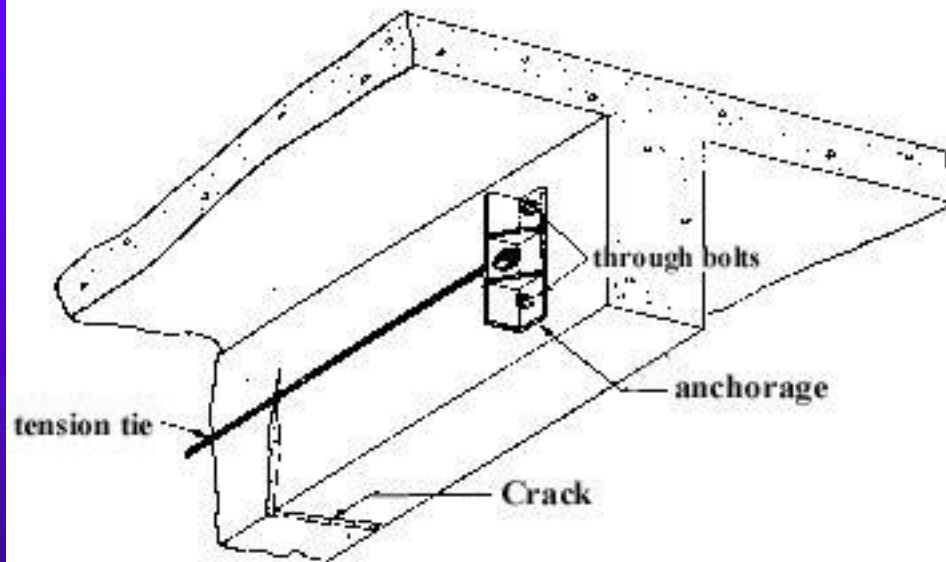
- ◆ if necessary, strengthen adjacent areas of the construction to take the additional stress
- ◆ the stitching dogs should be of variable length and/or orientation and so located that the tension transmitted across the crack does not devolve on a single plane of the section, but is spread out over an area
- ◆ In order to resist shear along the crack, it is necessary to use diagonal stitching
- ◆ The lengths of dogs are random so that the anchor points do not form a plane of weakness

4. External stressing

- ◆ cracks can be closed by inducing a compressive force, sufficient to overcome the tension and to provide a residual compression
- ◆ The principle is very similar to stitching, except that the stitches are tensioned; rather than plain bar dogs which apply no closing force to the crack



a) to correct cracking in beams



b) to correct cracking in slabs

Fig. 4 External stressing

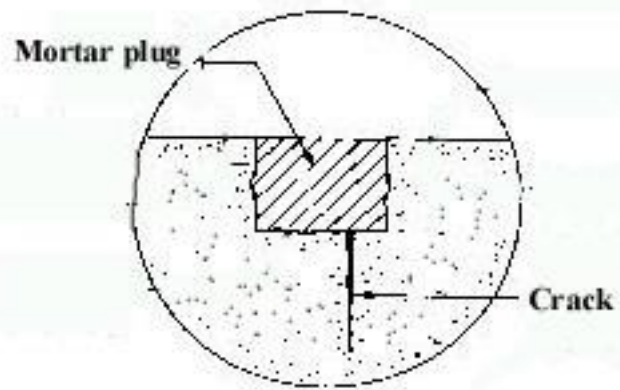
5. Grouting

- ❖ same manner as the injection of an epoxy
- ❖ cleaning the concrete along the crack
- ❖ installing built-up seats at intervals along the crack
- ❖ sealing the crack between the seats with a cement paint or grout
- ❖ flushing the crack to clean it and test the seal; and then grouting the whole

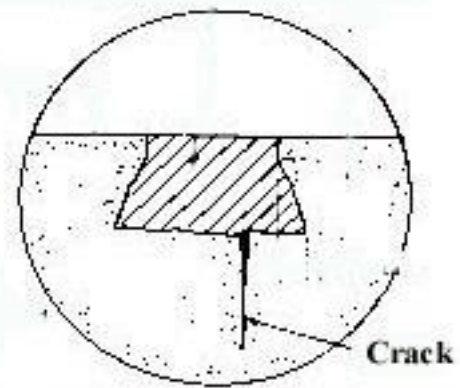
6. Blanketing

- ◆ similar to routing and sealing
- ◆ applicable for sealing active as well as dormant cracks
- ◆ Preparing the chase is the first step
- ◆ Usually the chase is cut square
- ◆ The bottom should be chipped as smooth to facilitate breaking the bond between sealant and concrete

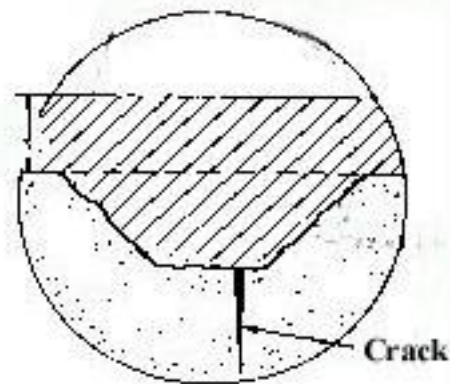
- ◆ The sides of the chase should be prepared to provide a good bond with the sealant material
- ◆ The first consideration in the selection of sealant materials is the amount of movement anticipated
- ◆ and the extremes of temperature at which such movements will occur
- ◆ elastic sealants
- ◆ mastic sealants
- ◆ mortar-plugged joints



a) Squarecut chase



b) Undercut chase



c) Beveled chase

Fig. 5 Types of chase

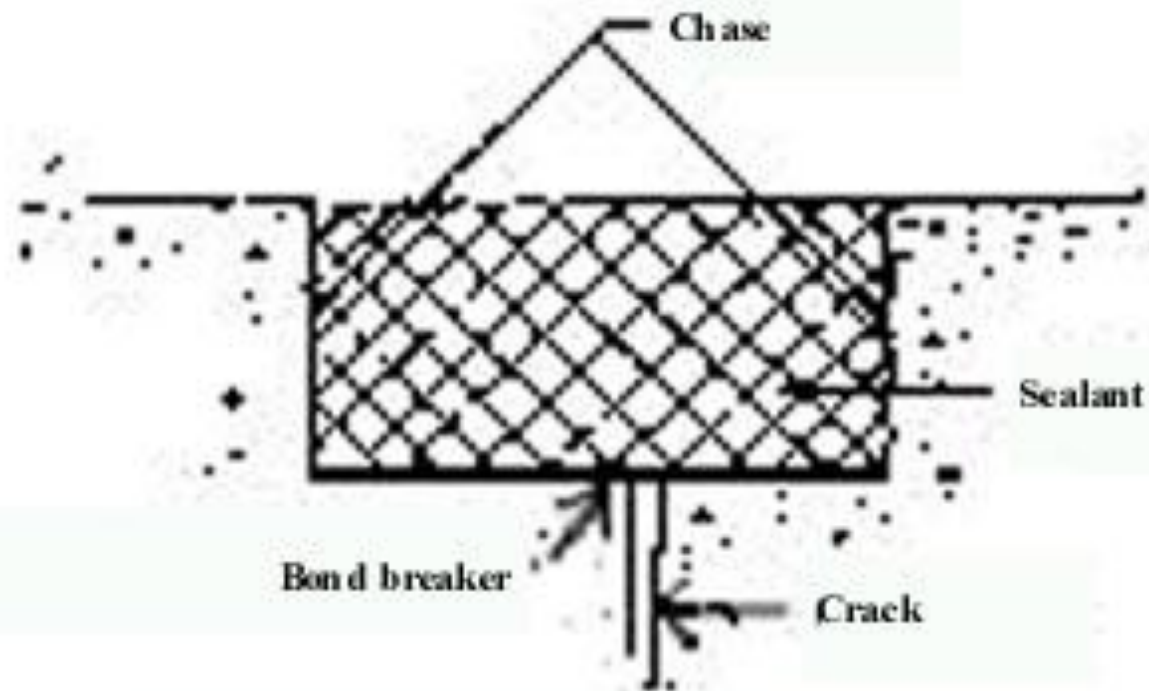


Fig. 6 Sealed chase

7. Use of overlays

- ◆ Sealing of an active crack by use of an overlay requires that the overlay be extensible and not flexible alone
- ◆ Accordingly, an overlay which is flexible but not extensible, ie. can be bent but cannot be stretched, will not seal a crack that is active

- ◆ Gravel is typically used for roofs
- ◆ concrete or brick are used where fill is to be placed against the overlay
- ◆ An asphalt block pavement also works well where the area is subjected to heavy traffic

Repairing spalling and disintegration

- ◆ In the repair of a structure showing spalling and disintegration, it is usual to find that there have been substantial losses of section and/or pronounced corrosion of the reinforcement
- ◆ Both are matters of concern from a structural viewpoint, and repair generally involves some urgency and some requirement for restoration of lost strength

1. Jacketing

- ◆ primarily applicable to the repair of deteriorated columns, piers and piles
- ◆ Jacketing consists of restoring or increasing the section of an existing member, principally a compression member, by encasement in new concrete
- ◆ The form for the jacket should be provided with spacers to assure clearance between it and the existing concrete surface

- ◆ The form may be temporary or permanent and may consist of timber, wrought iron, precast concrete or gauge metal, depending on the purpose and exposure
- ◆ Timber, Wrought iron Gauge metal and other temporary forms can be used under certain conditions
- ◆ Filling up the forms can be done by pumping the grout, by using fresh concrete, by dewatering the form and placing the concrete in the dry

- ◆ The use of a grout having a cement-sand ratio by volume, between 1:2 and 1:3 , is recommended
- ◆ The richer grout is preferred for thinner sections and the leaner mixture for heavier sections
- ◆ The forms should be filled to overflowing, the grout allowed to settle for about 20 minutes, and the forms refilled to overflowing
- ◆ The outside of the forms should be vibrated during placing of the grout

2. Guniting

- ◆ Guniting is also known as shotcrete or pneumatically applied mortar
- ◆ It is particularly useful for restoring surfaces spalled due to corrosion of reinforcement
- ◆ Guniting is a mixture of Portland cement, sand and water, shot into the place by compressed air

- ◆ Sand and cement are mixed dry in a mixing chamber, and the dry mixture is then transferred by air pressure along a pipe or hose to a nozzle, where it is forcibly projected on to the surface to be coated
- ◆ Water is added to the mixture by passing it through a spray injected at the nozzle
- ◆ The flow of water at the nozzle can be controlled to give a mix of desired stiffness, which will adhere to the surface against which it is projected

3. **Prepacked concrete**

- ◆ This method is particularly useful for carrying out the repair under water and elsewhere where accessibility is a problem
- ◆ Prepacked concrete is made by filling forms with coarse aggregate and then filling the voids of the aggregate by pumping in a sand-cement grout

- ◆ Prepacked concrete is used for refacing of structures, jacketing, filling of cavities in and under structures, and underpinning and enlarging piers, abutments, retaining walls and footings
- ◆ Placing of grout should be a smooth, uninterrupted operation

4. Drypack

- ◆ Drypacking is the hand placement of a very dry mortar and the subsequent tamping of the mortar into place, producing an intimate contact between the new and existing works
- ◆ Because of the low water-cement ratio of the material, there is little shrinkage, and the patch remains tight. The usual mortar mix is 1:2.5 to 1:3

5. Replacement of concrete

- ◆ This method consists of replacing the defective concrete with new concrete of conventional proportions, placed in a conventional manner
- ◆ This method is a satisfactory and economical solution where the repair occurs in depth (at least beyond the reinforcement), and where the area to be repaired is accessible
- ◆ This method is particularly indicated where a water-tight construction is required and where the deterioration extends completely through the original concrete section

- ◆ **Overlays**

- ◆ In addition to seal cracks, an overlay may also be used to restore a spalled or disintegrated surface
- ◆ Overlays used include mortar, bituminous compounds, and epoxies
- ◆ They should be bonded to the existing concrete surface

Conclusions

- ◆ When repairing cracks, do not fill the crack with new concrete or mortar
- ◆ A brittle overlay should not be used to seal an active crack
- ◆ The restraints causing the cracks should be relieved, or otherwise the repair must be capable of accommodating future movements

- ◆ Cracks should not be surface-sealed over corroded reinforcement, without encasing the bars
- ◆ The methods adopted for repairing spalling and disintegration must be capable of restoring the lost strength

References

- [1] **Champion, S.** *Failure and Repair of Concrete Structures*. John Wiley & Sons Inc. New York, 1961
- [2] **Sidney.M.Johnson.** *Deterioration, Maintenance and Repair of Structures*. Mc Graw-Hill Book Company. New York, 1965.
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- [5] **Jagadish, R.** *Structural Failures - Case
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A photograph of a traditional tropical house with a brown tiled roof and white walls. The house features a covered porch with wooden pillars and a railing. The interior is lit up, and a chair is visible on the porch. The house is surrounded by lush greenery, including several tall palm trees and a well-maintained lawn. The text "Thank You" is overlaid in large, bold, orange letters with a white outline, centered in the foreground.

Thank You