Deterioration of Bond Between Repair Material and Concrete Due to Thermal Incompatibility

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Case Studies of Failures in Repair Techniques Used by MDOT in Mississippi

When a composite material (concrete-repair material composite) is subjected to a temperature change, thermal stresses are created due to a mismatch in thermal expansion coefficients (CTE). The difference in the thermal coefficient of expansion between concrete and epoxy formulations can be altered by controlling the amount of aggregate to binder ratio, where filler/epoxy ratio was varied in an attempt to vary (CTE) of repair materials. This considerable difference in coefficient of thermal expansion between epoxies and Portland cement does require careful consideration.

Spalling of repair material from concrete

Failure in repair material due to the size of repaired area

Improper use of repair technique

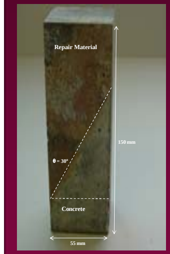
Abrasion of repair material

Cracking of repair material

Repair of joint failure due to continuous dynamic impact of traffic

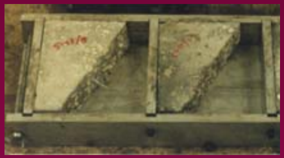
Slant Shear Test

The slant shear test highlighted by B. S. 6319 No. 4 was used to evaluate the bond strength between selected repair materials and parent concrete.



Test Specimen

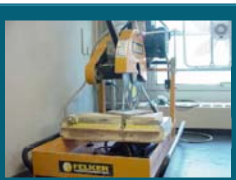
Fractured Concrete Specimen



Trapezoidal Half Plaques Placed in Mold

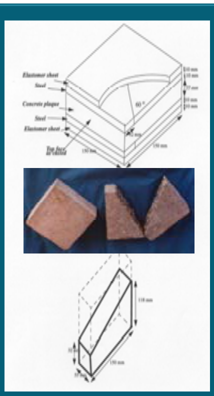
Slant Shear Test

- The test program required the splitting of the plaques in two halves along 30° angle
- Before splitting the plaques, the plaques were grooved by a cutting wheel to a depth of about 5 mm to ensure a perfect half split
- Concrete plaques were assembled with a trapezoidal steel plate and an elastomeric pad
- A steel rod was located on the top of the plaque to help guiding and promoting the crack along the desired angle
- Compression loading was then applied slowly at constant rate until plaque was fractured



A groove was made on every concrete plaque at an angle of 30 degrees

Concrete Compression machine was used to split concrete plaques



Assembly for splitting concrete plaques at controlled angle

Slant Shear Sample Preparation

Repairing of the split Plaque

- The trapezoidal half plaques were placed at the base of the 150*150*55 mm aluminum molds
- Mix the repairing material thoroughly using a hand mixing a drill
- Each empty half of the molds was filled with the repairing material in 3 layers
- Required plaques were then left to cure.

Typical repaired concrete plaque

Typical test specimens from resin based repair materials

Preparation of Test Specimens from composite Plaques for the Slant Shear Bond:

- After the recommended curing period, each plaque was sawn into three segments in accordance with BS 6319: No. 4:1994 as shown in figure
- The sawn prisms of 55*55*150mm are the repair material- concrete composite specimens

Preparation of test specimen

Typical test specimens from cement based repair materials

Slant Shear Testing Procedure

Testing The Repaired Samples:

The following characteristics of the thermal cycles were used:

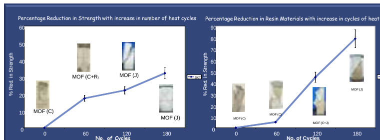
- The chamber temperature was lowered from room temperature to 65F ° in a period of 5 minutes
- The temperature was held constant for 4 hours at 65F °
- The temperature was raised to 120F ° in a period of 5 hours at a constant rate 11F °/ hour
- The temperature was then constant for 7 hours at 120F °
- The temperature is then dropped to 65F ° in hours at same rate 11F °/ hour
- The temperature is then kept constant at 65F ° for 3 hours

Oven with specimens inside

0 60 120

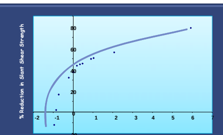
Failure Mode of concrete prisms repairs with resinous repair material RS5 and subjected to 0, 120, and 180 thermal cycles

Sample Results



a b

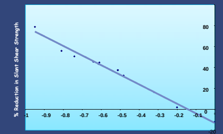
Effect of thermal cycling on slant shear strength of prisms repaired with (a) cement- based repair material (CM5) and (b) resin-based repair material (RS5)



Effect of repair material coefficient of thermal expansion on reduction of slant shear strength of repaired prisms subjected to 180 thermal cycles

i ii iii iv

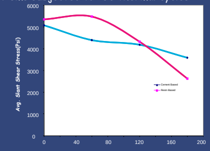
Modes of Failure



Effect of repair material Young's modulus on reduction of slant shear strength of repaired prisms subjected to 180 thermal cycles

Description of Modes of Failure

I. Diagonal failure at the joint at a significantly lower load than the control, with no concrete failure
II. Diagonal failure at the joint at a load only a little lowers than the control with little or no concrete failure
III. Diagonal failure in the concrete parallel to the joint but about 5 mm away from it at a similar load to the control
IV. "Double - pyramid" failure of the same type as that of plain concrete specimens; the failure load may be equal to or superior to that of the controls



Effect of thermal cycling on average slant shear strength of concrete prisms repaired with resinous and cementitious materials