

# *Innovative Techniques for the Repair and Strengthening of Concrete Structures*

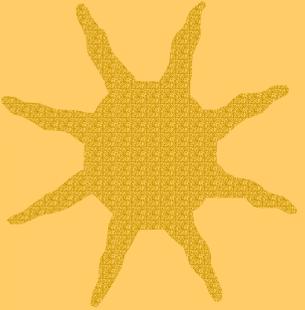
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by  
Alex Otenti



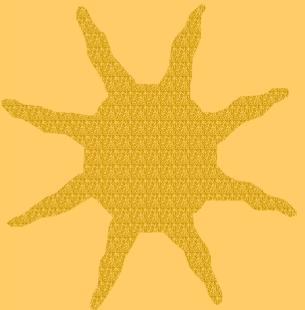
## *Outline*

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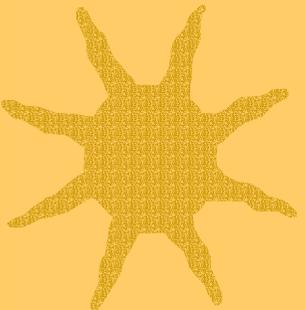
★ Concrete Behavior/Environmental Effects

★ Site Preparation



★ Repair Materials

★ Conclusion



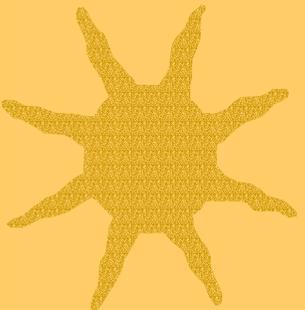
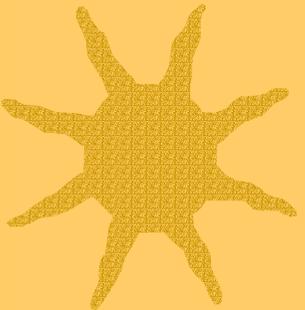
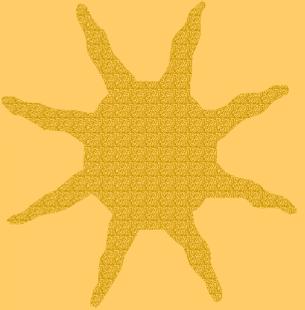


# *The Environment*

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## ★ Neutral Barrier Destruction

- Protective neutral barrier formed by cementitious mix
- Carbonization and chloride infusion
- Two methods penetration: diffusion and cracks



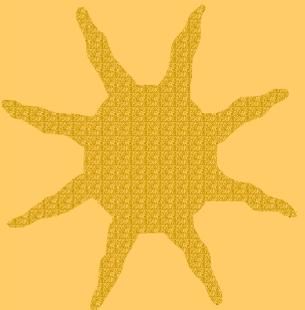
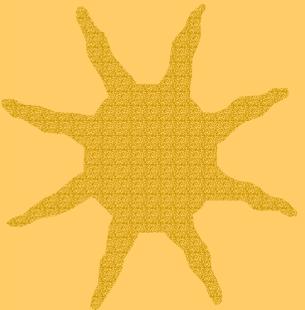
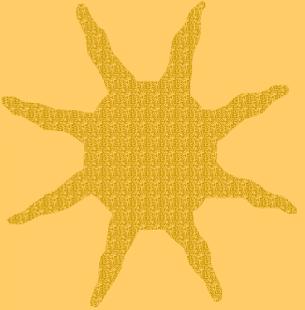


# *The Environment*

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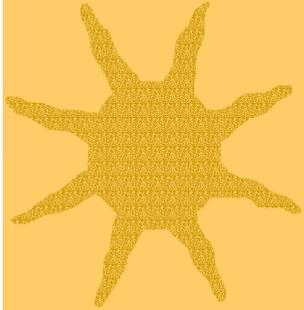
## ★ Shrinkage

- Caused by the loss of water in drying
- Independent of loading
- Causes strains to develop in the repair-concrete interface
- Can be solved by proper curing procedure



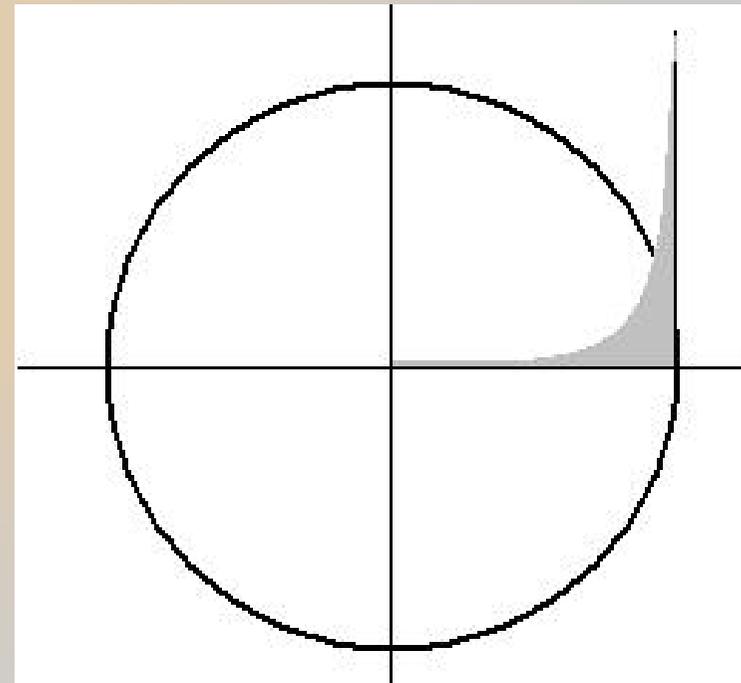
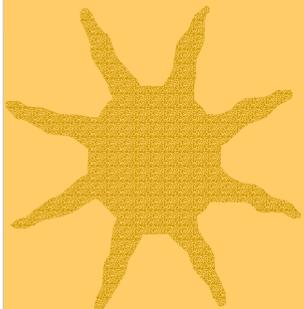
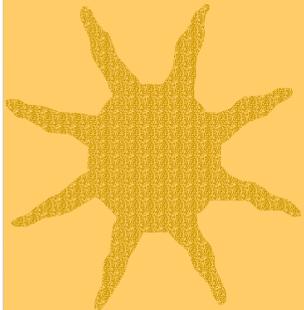


# *The Environment*



## ★ Critical layer concept

- Weather effects are worse on the outer layer of the concrete than at the core



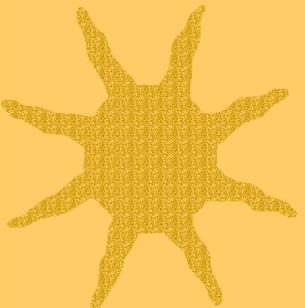
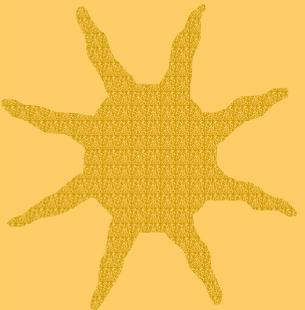
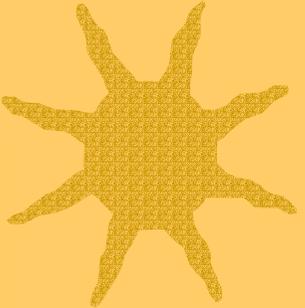


# *The Environment*

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## ★ Creep

- Causes tension in the repair material
- Modeling creep effects is difficult because the mechanisms of creep are not well understood



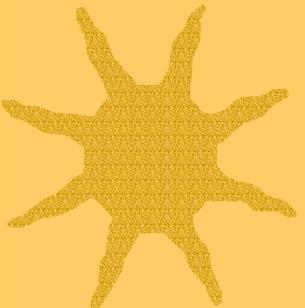
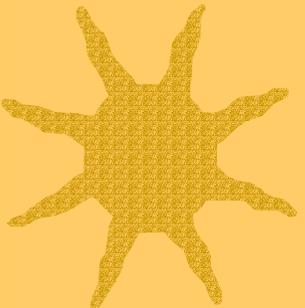
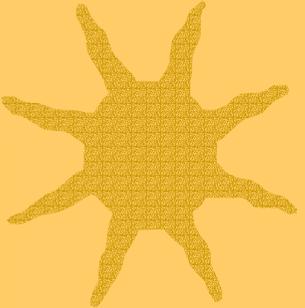


# *Site Preparation*

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## ★ Industry Practice

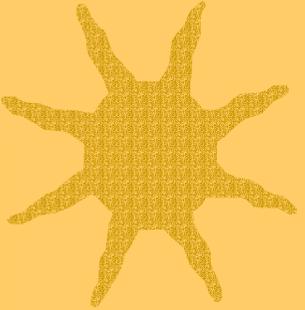
- Remove loose concrete
- Clean reinforcement by sandblasting
  - Acid washing is being tested
- Apply corrosion inhibitors
- Apply repair material





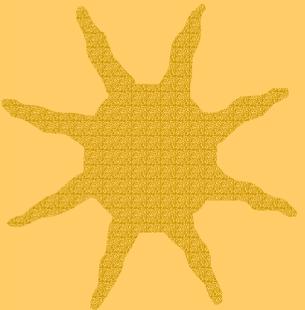
## *Preparing the Site*

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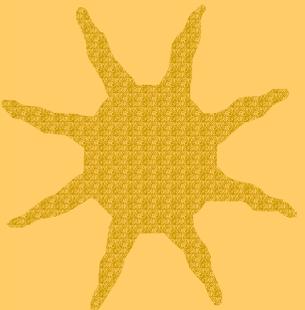
### ★ The advantages of some corrosion (< 4%)

- Increases pull-out strength
- Increases bond strength
- Rate of rust is less than uncorroded paper



### ★ Disadvantages

- Reduces flexural strength by as much as 25%



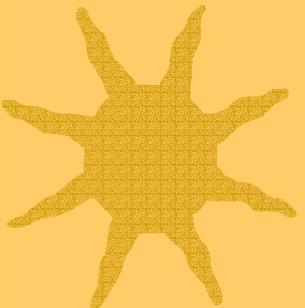
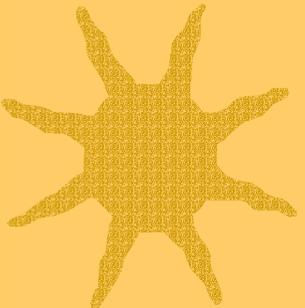
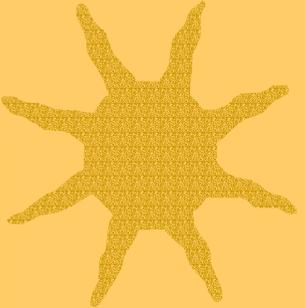


# *Preparing the Site*

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## ★ Inhibitors

- Corrosion is an electrochemical process
- Three kinds: anodic, cathodic, and mixed
  - Anodic: accepts electrons, active process
  - Cathodic: accepts protons, passive process
  - Mixed: combination of both



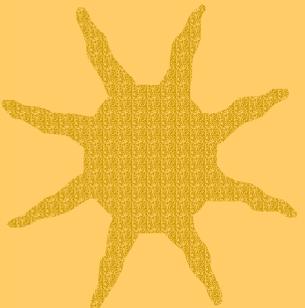
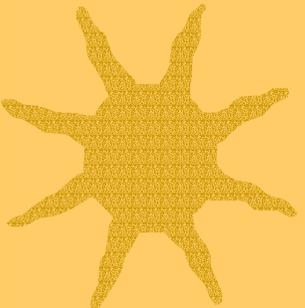
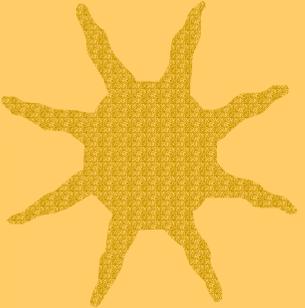


# *Materials*

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## ★ Polymer-Resin Concrete

- Reduces permeability
- Cures faster than traditional concrete
- Shrinkage values close to levels of concrete
- Polymers bridge microcracks
- Low modulus of elasticity



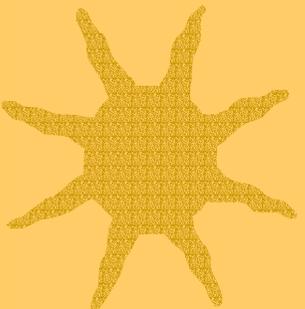
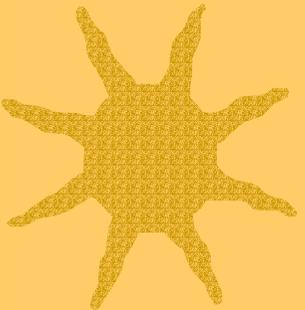
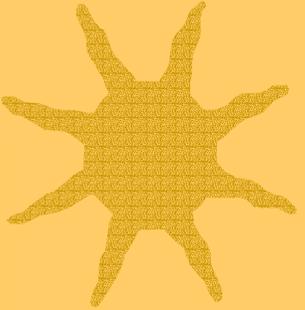


# *Materials*

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## ★ Magnesium-Phosphate

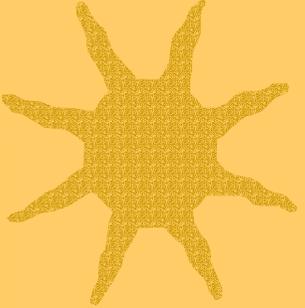
- Can achieve the same strength as 28-day concrete in less than 24 hours
- Metallic fibers added to increase ductility
- Cures exothermally
  - Thick sections get hotter and cure faster than thin sections



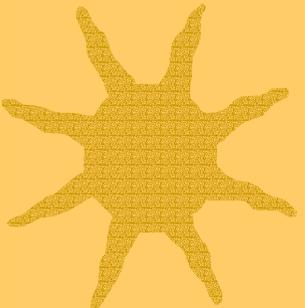


## *Conclusions*

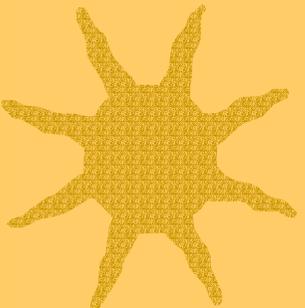
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★ Original idea was to fit best material to each situation



★ No studies investigate the “big picture”  
– Articles are extremely focused on the intricacies of specific materials



★ Polymer concrete seems to be the best general material