



Problem Statement

The lack of durability of concrete repairs induces premature repair deterioration and endless "repair of concrete repairs". The deterioration of concrete repairs is mainly because of the high stresses induced by the differential volume changes between repair material and substrate concrete.

Goal

- To investigate the characteristics of stress and strain in the concrete repair subject to differential volume change.
- To develop a repair material, such as ECC, which can withstand the stresses due to the differential volume change.



Concrete repair.

Results

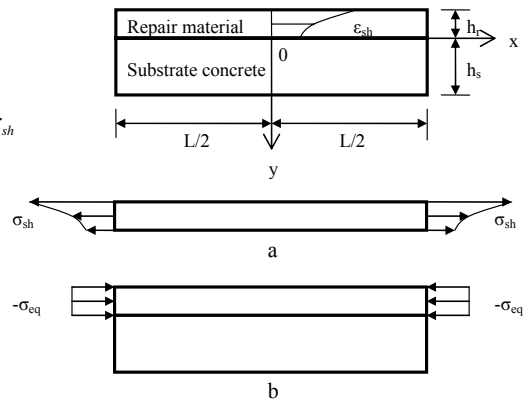
An analytical model:

- Calculate the stresses and strains in the layered concrete repairs subjected to differential volume change.

$$\sigma_{xx}^r = E_r \varepsilon_{xx}^r = \sigma_{eq} \frac{E_r \sin(\lambda h_r) (e^{\frac{\lambda L}{2}} + e^{-\frac{\lambda L}{2}}) + E_s \sin(\lambda h_s) \cos(\lambda y + \lambda h_r) (e^{\lambda x} + e^{-\lambda x})}{(E_r \sin(\lambda h_r) + E_s \sin(\lambda h_s)) (e^{\frac{\lambda L}{2}} + e^{-\frac{\lambda L}{2}})} + E_r \varepsilon_{sh}$$

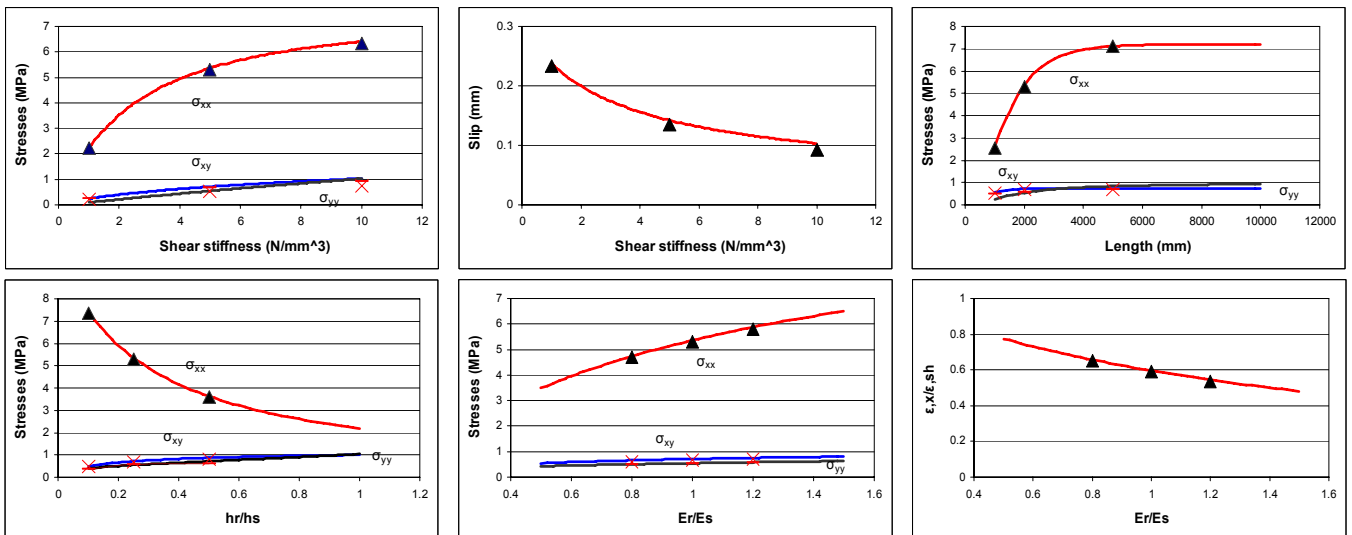
$$\sigma_{yy}^r = E_r \varepsilon_{yy}^r = \frac{\sigma_{eq} E_s \cos(\lambda h_s) ((e^{\lambda x} + e^{-\lambda x}) \sin(\lambda y + \lambda h_r) - \frac{2}{\lambda L} \sin(\lambda h_r) (e^{\frac{\lambda L}{2}} - e^{-\frac{\lambda L}{2}}))}{(E_r \sin(\lambda h_r) - E_s \cos(\lambda h_s)) (e^{\frac{\lambda L}{2}} + e^{-\frac{\lambda L}{2}})}$$

$$\sigma_{xy}^r = E_r \varepsilon_{xy}^r = - \frac{\sigma_{eq} E_s \sin(\lambda h_s) \sin(\lambda y + \lambda h_r) (e^{\lambda x} - e^{-\lambda x})}{(E_r \sin(\lambda h_r) + E_s \sin(\lambda h_s)) (e^{\frac{\lambda L}{2}} + e^{-\frac{\lambda L}{2}})}$$



Model development.

- Quantify the influence of related parameters.



29-11-2008

Durability of Concrete Repairs

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Subject

The lack of durability of concrete repairs induces premature repair deterioration and the endless “repair of concrete repairs”. The deterioration of concrete repairs is mainly caused by the differential volume change between repair material and substrate concrete. The differential volume change can induce high stresses in repair system and thus result in the failure of concrete repairs in the modes of repair material cracking or interface delamination.

Goals

The final goal of this project is to develop a repair material and method that can withstand the stresses due to differential volume change. It should lead to repairs that are durable without deterioration. Engineered cementitious composite (ECC) is one of the most promising repair materials and is currently being investigated in this project.

Research Question

- What are the main causes of the failure of concrete repairs?
- How to improve the bond properties of the interface between repair material and substrate concrete?
- How to mix ECC with locally available materials?

Strategy

The literature review reveals that the failure of concrete repairs mainly originates from the high stresses induced by the differential volume changes between repair material and substrate concrete. The characteristics of these stresses and strains will be experimentally and numerically studied. Another objective is to investigate the bond properties of the interface between repair material and substrate concrete from meso-scale to micro-scale.

An experimental work will be carried out on the mix design of ECC with locally available materials.

Expected Results

- A model, which can be used to calculate the stresses in the design of repair system.
- A model, which can predict the bond properties of the interface.
- A durable repair material, which can withstand the stresses due to the differential volume changes.

Preferred Partners Applications / Sponsors

Construction industry and Material producer

Prime Publication / Prototyping

- **Zhou, J., Ye, G., Schlangen, E., van Breugel, K. (2008)**, “Modeling of Stresses and Strains in Bonded Concrete Overlays Subject to Differential Volume Changes”, *Journal of Theoretical and Applied Fracture Mechanics*.
- **Zhou, J., Ye, G., Schlangen, E., van Breugel, K. (2007)**, “Simplified Model for Stresses and Strains in Bonded Concrete Overlays”, *Conference on Cracking in Engineered Structures*, Dalian, China.

Research Period

May 2006 – April 2010.