Crack Prevention in Concrete Repair Materials

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Repair of existing pavements and structures will become even more important to ensuring the sustainability of infrastructure as funding sources becomes more scarce. There are a variety of cementitious repair materials available for concrete pavement and bridges. Each material has a unique chemistry and chemical reaction that causes hardening, giving different strength gains, durability, and cracking tendency. Cracking and debonding of these materials is a major source of repair failure and is primarily a function of the material early-age visco-elastic properties which are not very well known. The four most important repair material properties that contribute to cracking and debonding are tensile strength, elastic modulus, coefficient of thermal expansion, and stress relaxation. All of these properties will be measured for the repair materials selected for study.

This project will use for the first time a rigid cracking frame to measure the material early-age visco-elastic properties at varying and different constant temperatures. Rigid cracking frames were developed in Munich, Germany by R. Springenschmid to measure thermal stress development in portland cement concrete used in the Autobahn that had developed cracking at early ages. Cracking measure the stress by restraining the concrete volume change with two invar bars attached to crossheads that grip the concrete specimen as shown in Figure 1 (Whigham, 2005). Rigid cracking frames were used in calcium aluminate cements and found that they experienced self-generated shrinkage stresses at low temperatures, but expansive stresses at high temperatures. This helped explain why these materials needed to be heated to prevent cracking when used to line concrete sewer pipes (Ideker, 2008). A new rigid cracking frame is being developed at Kansas State University that uses a concrete specimen with a 4 in. x 4 in. cross section instead of the standard 6 in. x 6 in. cross section. This specimen size will be large enough to allow for realistic aggregate sizes but small enough to remove the concrete forms to measure drying shrinkage stresses. This new style of cracking frame will be fabricated and used to test the repair materials early-age properties.

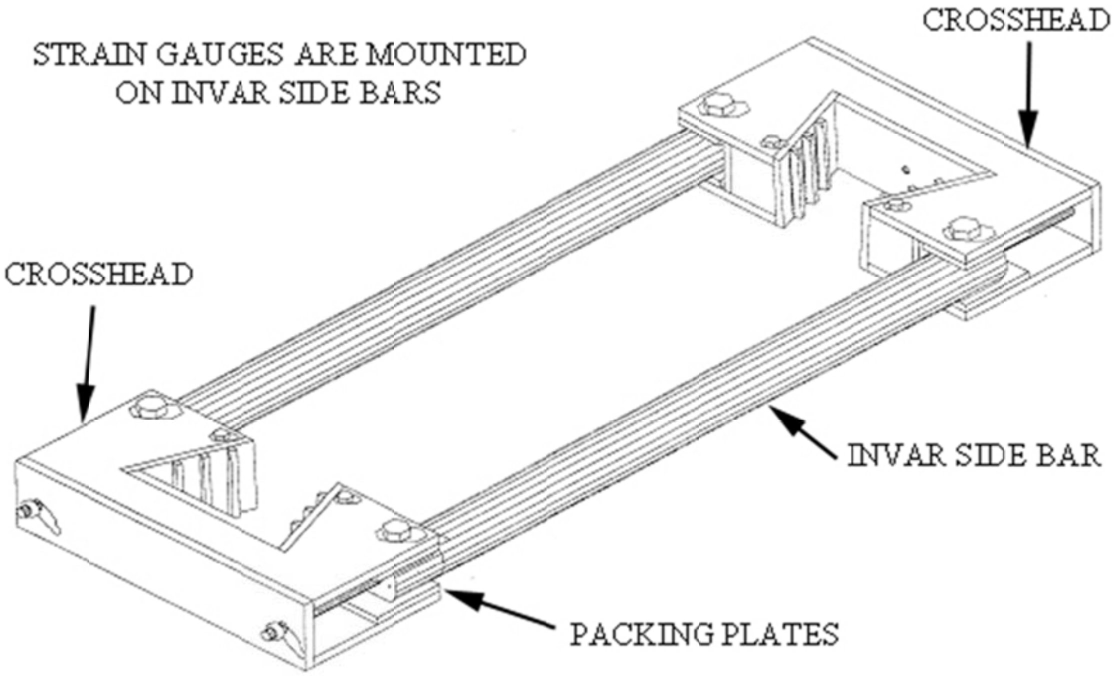

Figure 1 – Rigid Cracking Frame Setup (Whigham, 2005)

This project will study the early-age visco-elastic properties of three cementitious materials. A type III portland cement will be chosen for study as it is commonly used in pavement repair and will give a baseline value of early-age stresses for comparison to the other alternative cementitious materials. A magnesium phosphate will be selected because of the very high early strength and good chemical resistance. A geopolymer cement will also be used. Geopolymer cements use no 100% recycled solids such as slag cement or fly ash that is activated by a strong base such as sodium silicate or sodium hydroxide to react and rapidly harden. Because geopolymers gain strength rapidly and consist mainly of recycled materials, they have become popular in repair applications. Each of the three materials will be tested at a constant temperature of 72°F and 122°F, and a realistic pavement repair temperature during the summer. The stress development will be modeled to calculate the material stress relaxation at the different temperatures tested from the measured cracking frame stresses from setting through the first 4 days of curing.

This groundbreaking work in concrete repair will give preliminary data to present to DOTs and repair material.

References

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