4.2 Excessive Shrinkage (Includes FMs 4.3 and 4.4)

Description:

Concrete will shrink when it dries. In fresh concrete, the volume of water mixed with the cement and aggregates can be significant. As concrete dries, the excess water is removed - causing shrinkage in the HCP and leaving behind voids of various sizes. Cracks may result if the concrete is restrained. The extent of shrinkage depends on a combination of factors including the volume of water in the fresh concrete, the aggregate/cement paste ratio, the water to cement ratio and the concrete's strength and rigidity at the time of moisture loss. Coarse aggregate properties, especially its modulus of elasticity and content, are also important factors in concrete shrinkage. Therefore, to minimize drying shrinkage, concrete should be batched with the smallest volume of water needed for workability and the largest aggregate fraction practical. It should also be kept moist (wet cured) until it gains enough strength and rigidity to withstand the stresses of drying shrinkage. When these preventive steps are deficient, the concrete may crack and/or develop micro-cracks where cracks initiate due to stresses later in its life.

Concrete shrinkage may also be the result of autogenous process where water is consumed in the hydration process without external loss (formerly FM 4.3). Another shrinkage cause is carbonation shrinkage which is a by product of the carbonation process (formerly FM 4.4). These secondary processes result in limited shrinkage whose effect cannot be separated from the drying shrinkage.

Data to be collected and Analyzed:

1. Examine the concrete for shrinkage related cracks (review photos taken of area near SGR hole cut)
2. Observe microstructure of concrete for indications of early volume changes due to drying shrinkage.
3. Test for carbonation. Review Petrographic reports
4. Review curing specifications and records.

Verified Refuting Evidence:

a) Typical drying shrinkage cracks were not observed during visual inspections. A few hairline cracks observed around the opening appear to have been initiated during the delamination.(FM 4.2 Exhibit 1 to be provided later)

b) No shrinkage cracks were reported in Petrographic reports and none were any observed in cores obtained from the structure. (FM 4.2 Exhibit 2)

c) Observed carbonation levels were low. (FM 4.2 Exhibit 2)

d) Curing was found to be satisfactory. (FM 4.2 Exhibit 3)

Conclusion: Shrinkage during the early age, due to drying, autogenous shrinkage, or carbonation was not excessive and was not a contributor to the delamination.

Reviewed by: Dr. Avi Mor, 352-795-6486 , ext 1030 – PII CR3 Team Office

Verified Supporting Evidence:

Not Applicable

~~May identify additional perspective on this~~ issue as RCA related efforts proceeds

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