BETON™
CONSULTING ENGINEERS L.L.C.

Mr. Jason Barnes
Productions Team, Inc
PO Box 644
Mulberry, AR 72947

November 29, 2021

Sent by e-mail

Re: Results of 8% Green Canvas Shrinkage-Compensating Concrete

Further to our proposal dated May 20, 2021, Beton Consulting Engineers (Beton) has prepared this report to document the results of the laboratory test program as well as to provide analysis for implementation of the Green Canvas™ product.

Green Canvas™ is a type G expansive component, a blend of calcium dioxide and aluminum dioxide that produces calcium hydroxide platelet crystals when mixed with portland cement and water. By replacing a sufficient amount of cement with Green Canvas™ expansive component and providing proper restraint, strains caused by drying shrinkage can be offset. Thus, it is possible to minimize cracking and reduce the number of joints necessary. A testing program was developed to determine the appropriate amount of cement to replace with Green Canvas™ to produce a desired amount of expansion.

Production Testing

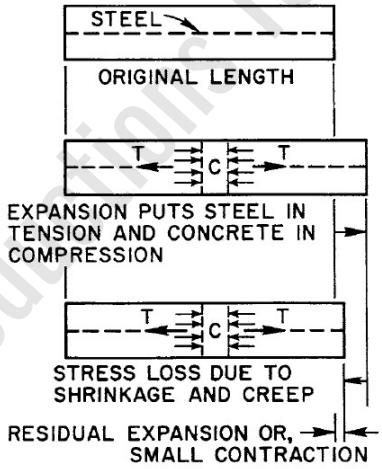

Figure 1: Basic Concept of shrinkage-compensating concrete (ACI 223R-21)

Mixture Proportions

The table below provides the proportions of the mixture investigated.

Table 1: Mixture Proportions

Mix	Cement (lb/yd3)	Green Canvas™ (lb/yd3)	Fine Aggregate (lb/yd3)	Coarse Aggregate (lb/yd3)	Water
8% Green Canvas	519	45	1430	1775	260

The mixture was batched at our Mendota Heights, MN laboratory. The mixture used mid-range water reducer and was non air-entrained.

Test Data

Restrained Expansion, ASTM C878

ASTM C878 is a test to determine the potential for expansion, under conditions of controlled restraint, of concrete made with shrinkage-compensating cement. The test method may be adapted to study expansion involving different degrees of restraint. The performance of 8% Green Canvas™ concrete (by weight of total cementitious material) was tested with ASTM C878 to determine the quantity of expansion. The expansion results are shown in Figure 2. The specimens were wet cured for the initial 7 days, then subjected to drying in 50% humidity thereafter.

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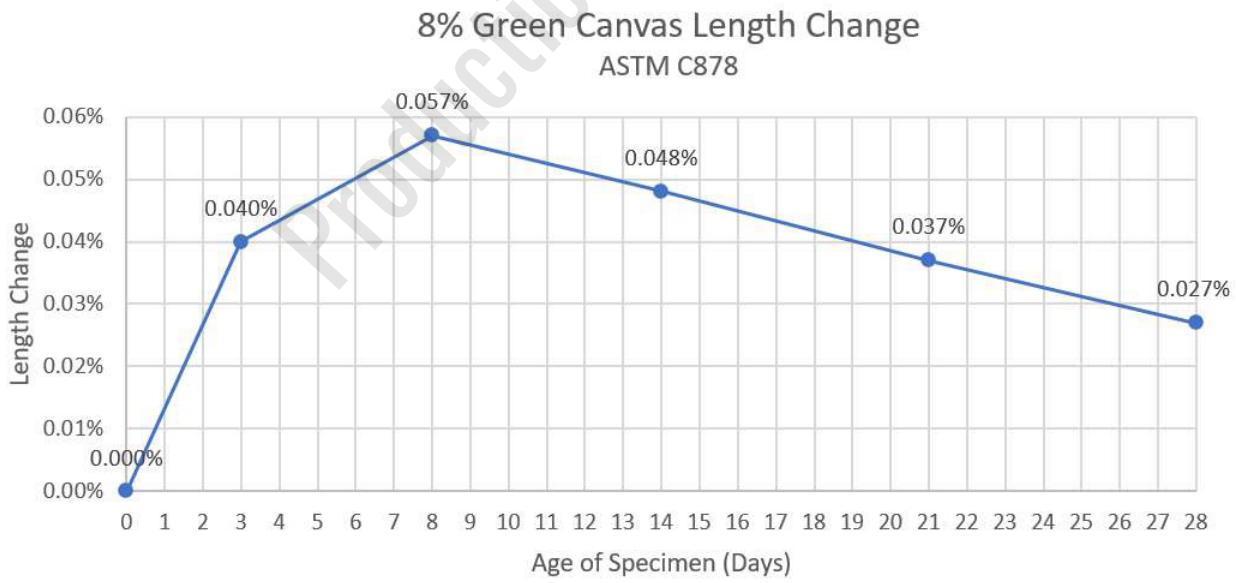

Figure 2: Restrained Expansion of 8% Green Canvas™

The test results demonstrate that much of the Green Canvas™ expansion happens within the first 3 days of wet curing. One issue encountered with the ASTM C878 test method, was that the specimens are not allowed to expand until the concrete has gained sufficient strength to be demolded. Therefore, the

expansion that happens during the initial hours of the test cannot be captured. To account for the initial expansion, the rate of expansion during the first 3 days was assumed for the first 6 hours.

When designing shrinkage-compensating concrete, the amount of expansion should be adequate to overcome the stresses that will be induced by subsequent drying shrinkage. The net result of the expansion and shrinkage should be zero. To determine the desired amount of expansion, the amount of restraint in the slab and the estimated amount of shrinkage must be calculated. The internal reinforcement, adjacent elements, and subgrade friction all provide restraint. The predicted amount of shrinkage can be obtained from ASTM C157 results. However, engineering judgement can be used based on the concrete mixture materials and proportions.

Conclusions

Green Canvas™ would be an ideal product to design slabs on ground with extended joint spacing. ACI 223R-21 states the shrinkage-compensating concrete can permit lengths up to 500 feet between expansion joints. ACI 223R-21, Guide for the use of Shrinkage-Compensating Concrete, provides design information. First, the anticipated final drying shrinkage of the slab would need to be calculated. Next, the percentage of reinforcement is used to calculate the minimum amount of expansion to compensate for the anticipated shrinkage. ACI 360R-10 suggests a minimum ratio of reinforcement area to gross concrete area of 0.0015, located in the upper 1/3 of the slab, should be used in each direction that shrinkage compensation is desired. The maximum ratio of reinforcement should be approximately 0.006. Figure 3 may be used to determine the minimum amount of expansion required. It is also permissible to adjust the reinforcement percentage based on expected shrinkage and expansion. Suggested details are provided in ACI 223R-21 for locations that require additional consideration such as isolation joints, columns, footings, and door openings.

Production Part

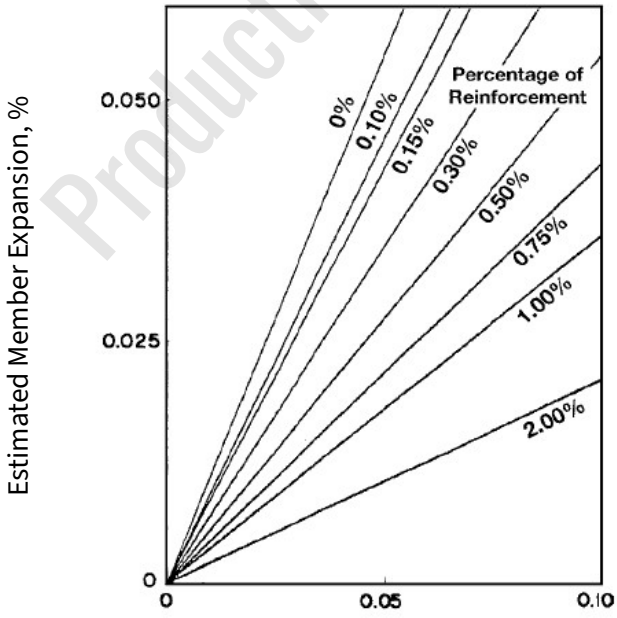

Figure 3: Member expansion as a function of ASTM C878 specimen expansion (ACI 223R-21)

We trust that this letter is self-explanatory. I look forward to additional discussions and thank you for the opportunity to be of service.

Sincerely,

Beton Consulting Engineers, LLC

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