YEAR2010
The Young European Arena of Research

Reduction of Plastic Shrinkage Cracking in Concrete Pavements and Elimination of Maintenance Expenses

Peter Briatka
Faculty of Civil Engineering, Slovak University of Technology, Slovakia
briatka.p@gmail.com

Within very early age of concrete (plastic state) it undergoes the plastic shrinkage what imposes cracking of concrete directly above inserted steel reinforcement. Except of unsightly cracks it also enables ingress of water and deleterious substances and thus shorten durability of concrete and service life of a structure. In other words, if our goal is to ensure durability of pavement or bridge deck we must reduce cracking in concrete or perform frequent and expensive maintenance.

I. INTRODUCTION

There, behind the plastic shrinkage, stands generally one principle – loss of water forming voids in cement paste. The voids are partially filled with capillary solution what means existence of menisci at the air-liquid interface. Following Young-Laplace equation (1) we can calculate the capillary tension P_{CAP}. By loss of water system is reaching the critical point [2,3] – time when the concrete is most susceptible to cracking [4].

$$P_{CAP} = -\frac{2 \cdot g \cdot \cos q}{r_{CAP}} \tag{1}$$

2. ASSUMPTIONS & "CURING" CONCEPTS

First concept was based on adding several types of fine polymer fibers (PF) in various doses into changeless concrete mixtures. Added PF were expected to carry over the internal stresses arose within drying out [5].
According to second approach, the plastic shrinkage cracking should be eliminated by partial replacement of normal-weight aggregate (NWA) by saturated light-weight aggregate (LWA) [4] acting like internal reservoirs keeping cement paste saturated [6] and thus hindering cracking.

3. TESTING & EVALUATION METHODS

Testing of PF reinforced concrete was performed in accordance with [7]. An outcome variable called crack reducing ratio (CRR equation (2)) says how effectively fibers in the mixture act, where $w_{MOD,C}$ is an average crack width in sample with modified concrete and $w_{REF,C}$ is an average crack width in reference sample.

$$CRR = \left(1 - \frac{\overline{w}_{MOD,C}}{\overline{w}_{REF,C}}\right) \cdot 100\% \tag{2}$$

Testing of second approach was performed by non-contact laser measurements of settlement and water loss of cylinder mortar samples [8,9] with different doses of LWA. The X-Ray absorption was interpreted on the basis of relation between density of saturated cement paste and intensity of X-Ray detected on a sensor [4]. [9]

4. RESULTS & CONCLUSIONS

Analyzed data of PF concrete indicate that usage of fine PF may significantly reduce plastic shrinkage cracking (see Table 1) and thus prolong concrete durability. The most effective seem to be short monofilament fibers at dose of circa 60% of commonly recommended by their producers.

Table 1: Efficiency of fibers

Fiber Length(") – Dose (lbs)	CRR (%)
Plain (without fibers)	0,00
M0,5"-0,75	90,70
M0,5"-1,00	93,38
M0,75"-0,50	64,20
M0,75"-1,50	90,46
F1,0"-1,00	44,66
F1,0"-1,50	63,86

The X-Ray test confirmed theory of empty of different pores within water consumption. The evaporation and settlement data also proved anticipated behavior when higher dose of LWA causes higher overall evaporation and lower settlement resulting in reduction of cracking (increase of CRR, see Tabale 2).

Table 2: Efficiency of LWA

Mixture (dose of LWA)	CRR (%)
0,0%	0
6,0%	65
10,0%	89
18,0%	100

References

[1] Briatka, P. et al: Assessment of Influence of Spread reinforcement on Concrete Properties, in Beton Technologie Konstrukce Sanace 2/2009, Beton TKS, Praha, 2009, pp. 28-35.

[2] Lura, P. et al.: Influence of Shrinkage-Reducing Admixtures on Development of Plstic Shrinkage Cracks, ACI Materials Journal, March-April 2007, ACI, Farmington Hills, 2007, pp. 187-194.

[3] Radlinska, A. et al.: Shrinkage Mitigation Strategies in Cementitious Systems – A Closer Look at Differences in Seald and Unsealed Behavior, Purdue University, Submitted to TRB IN, USA, 2007.

[4] Henkensiefken, R. et al.: Plastic Shrinkage Cracking in Internally Cured Mixtures, Accepted for publication in Concrete International, February 2010, ACI, Farmington Hills, USA, 2010.

[5] Briatka, P. et al: Spread Reinforcement and Its Influence on Concrete Properties, In Proceedings of JUNIORSTAV Conference, February 2009, CVUT, Brno, 2009.

[6] Briatka, P. et al.: Fresh Concrete Curing – 1. Water Loss from Concrete, Structural Almanac 2010, Jaga group, Bratislava, 2009, pp. 31-35.

[7] ASTM C 1579-6

[8] ASTM C 192

[9] ASTM C 305-06