Comments on Admixtures and Aggregates: Key Elements in "Athletic Concrete" Revisited by William S. Phelan in Concrete International, September 2004

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The author is commended on writing on the subject of concrete mixture optimization that takes into account aggregate optimization. We agree with the author that optimizing aggregate grading to achieve a high packing density provides several benefits to concrete. The mixture will require less cement paste to fill in the voids, and provide the "excess paste" that coat the aggregates and facilitates workability. A concrete with the least amount of cement paste will achieve low shrinkage and curling and will generally cost less. *In addition to the least amount of cement paste, if the concrete has a low w/cm the resulting concrete will be durable, and strong as well.*

While we agree with this core idea discussed by the author, we do differ in certain areas. In Table 2 the mixture design of an elevated airport roadway is reproduced. This concrete mixture contains more than 700 lbs/yd^3 of cementitious material content and a total paste content (volume of cementitious plus water plus air) of almost 37%. Optimizing aggregate grading can reduce the void content of the aggregate skeleton to 18% or even lower. In this case why is it necessary to provide a paste volume so much more in excess of that required amount to fill in the voids? In a different section the author mentions that athletic concrete generally has a paste content of 25% to 36%. *In general it appears to us that using a paste content greater than 30% defeats the purpose of optimizing the aggregate grading to minimize the void content.* Preferably the paste should be less than 30% say about 25%. In air entrained concrete, air is part of the paste and so the paste contents of air entrained concrete should be closer to 30%.

We have seen many specifications that specify aggregate grading requirements striving to achieve a maximum packing density but continue to include minimum cement content requirements. *This is an inherent conflict in a specification where the benefits of optimizing the aggregate grading is not fully realized as a paste content much in excess of that required for filling the voids and providing the necessary workability is forced by the specification.* Needless to say thermal cracking, shrinkage and curling will also be higher due to the high amount of minimum cement content specified. The design professional who includes an aggregate grading requirement in specifications should determine whether this is feasible in the local area. He/she should have an understanding of the number of aggregate sizes available in the market and uncontrollable production factors that impact the final aggregate grading in the mixture. For instance, it is not practically feasible to control an aggregate grading on a particular sieve size to within 2%.

The author also provides examples of several concrete mixture designs for various applications. While these serve as good examples; we hope that these are not reflected as prescriptive mixture proportions for "athletic concrete" in future specifications. Local materials and production practices vary and it is always necessary to ensure that specifications are written to accommodate local practice. Further, it is our opinion that issues such as aggregate grading are not items that should be in specifications. These items are attributes to be used by the concrete producer to achieve certain performance characteristics. The intended performance characteristics should be measurable and enforceable items addressed in the specification.

In summary we reiterate our support to trying to reduce the paste content to optimize concrete mixture proportions. At NRMCA we are engaged in research on that issue and are currently looking at various options to help achieve that goal including the use of the popular 8 to 18% retained of the combined aggregate grading.