

TECH NOTE NO: 25
TITLE: Value Engineering for OMP Pavement Design
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Ref: Memo, 5-24-06, from D. Lange to R. Anderson

This Technical Note summarizes various recommendations that resulted from a value engineering meeting at OMP on May 17, 2006 [Attendees: Michael Vonic, David Rose, Ross Anderson, Jeff Roesler, David Lange]. These recommendations were originally submitted by the referenced memo. Our objective at the meeting was to review a broad scope of ideas that had potential to save costs of construction at OMP. Below are the key recommendations that Jeff Roesler and David Lange support (i.e. the “we” throughout the following paragraphs refers to Roesler/Lange) :

1. *Reduce required concrete strength*

The current OMP P-501 specification requires concrete strength of 700 psi flexural strength at 28d. We recommend that this clause be changed to 650 psi at 28d. The actual design strength required by the pavement design is 700 psi, but it is widely recognized that concrete gains strength with time, even after 28d. It is reasonable to specify 650 psi at 28d to achieve 700 psi at 90d. Attainment of 700 psi at 90d is adequate to fully meet the requirements of the pavement design. The reduction of strength in the specification has two benefits. First, the concrete mixtures will cost less because less cement will be required. Second, concrete with lower cementitious content will exhibit lower shrinkage, and will therefore reduce cracking potential.

2. *Remove prohibition of use of fly ash during winter months*

The current OMP P-501 specification prohibits the use of fly ash from October 15 to April 1, that is, the cold winter months. The reason for this clause is that fly ash concrete is more susceptible than normal concrete to slow strength gain in cold temperatures. However, in the OMP case, we are not particularly concerned about slow rates of strength gain because there is considerable time in the schedule before the new pavements are placed into service. Therefore, we recommend that fly ash be allowed all year. The benefit of this change will be lower materials costs and higher quality long-term properties made possible by use of mineral admixtures.

3. *Omit some (or all) dowels from design of joints in concrete pavement*

Our meeting included significant discussion of the issue of dowels in OMP pavements. We recognize that there are two schools of thought on this issue. On the one hand, some engineers prefer to specify dowels because they want the highest possible confidence that slab load transfer remains very high (LTE ~ 100%) throughout the life of the pavement. On the other hand, other engineers believe that high slab load transfer without doweling can be assured through a) use of smaller slabs sizes, b) enhancement of joint surface roughness, and c) avoidance of wide joint openings by minimizing concrete shrinkage. We consider the current slab size at OMP (18.75' x 20') to be relatively small for airport pavements. Furthermore, we think that joint surface roughness will be rough enough to provide high load transfer, particularly if larger (1.5" top size) aggregate is used. Finally, we think that adoption of strategies to achieve low concrete shrinkage can lead to small joint openings. We recognize that the location of dowels need not be an all-or-nothing decision, and that there is still considerable cost savings if dowels are omitted from only the outside lanes that receive low traffic. The main benefit of omitting dowels is cost savings (~ \$9 per lineal ft of joint). In addition, we think there is evidence of improved performance because dowels can lead to "binding" between slabs, and there is anecdotal evidence that such binding mechanisms can create sufficient stress to cause cracking that otherwise would not have occurred.

4. *Impose limits on concrete shrinkage*

The current OMP P-501 specification does not include a requirement to measure concrete shrinkage. However, we believe that drying shrinkage of concrete is a major aspect of pavement performance, one that is commonly overlooked by traditional design and construction practices. Our research has shown considerable variation in shrinkage of candidate concrete mixtures. It would be useful to impose a limit on concrete shrinkage in the P-501 specification as part of the qualification of proposed concrete mixture designs. This action would create a small additional cost, but we believe the benefit will be significant to a) increase awareness of how designers can control concrete shrinkage, and b) develop a database of concrete shrinkage data that will lead to use of materials with improved performance, and c) identify aggregates, cements, and mineral admixtures associated with shrinkage problems. We recommend that concrete mixtures be tested using ASTM P-157 "Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete" in an environment of 50% RH, 23°C, and 1d of moist curing at the time of the initial length measurement. Our research at UIUC (ref. CEAT Tech Note #23) suggests that an appropriate limit for shrinkage at 28d should be no greater than 0.045%. This limit would not have caused rejection of any of the mixtures in our test program, but should be effective for identifying truly problematic high shrinkage materials.

5. *Allow (encourage) use of larger coarse aggregates*

The current OMP P-501 specification limits maximum size of coarse aggregates to 1” top size. We observe that the FAA P-501 specification allows the use of larger coarse aggregates up to a 2.5” top size. Limits on coarse aggregates top size is generally motivated by concern about freeze-thaw (i.e. D-cracking) problems. However, we believe that there are sources available for larger coarse aggregates that will meet IDOT’s 40-year life category for freeze-thaw resistance. There are several benefits to the use of larger coarse aggregates. First, larger coarse aggregates will create rougher joint surfaces, thus improving slab load transfer when dowels are not used. Second, mixtures with larger coarse aggregates can often be designed to have lower paste content, thus reducing the concrete drying shrinkage. Third, we believe there may be some cost savings by use of larger coarse aggregates.

6. *Relax specification limits on fly ash content*

The current OMP P-501 specification limits fly ash to 15% for Class C and 6% for Class F. These values were probably motivated by concern about slow strength gain that can be associated with higher fly ash content. However, we believe these values are overly conservative for the construction at OMP, and the bias against high values of fly ash stands in the way of cost savings. We recommend that the limit be raised to 25%, a level that has been successfully used in practice. Since the OMP P-501 specification includes a strength requirement at 28d, it can be argued that any limit on fly ash content is unnecessary to protect against truly problematic concrete mixtures, however the 25% value seems wise to avoid use of unusually high fly ash mixtures for which there is little experience and knowledge of long-term durability. Use of fly ash as a mineral admixture in concrete provide benefits of improved performance and lower cost. Another common and useful mineral admixture – ground granulated blast furnace slag (GGBFS) – is not currently mentioned in the OMP P-501 specification, but we believe it can be used to advantage and would fall under the same limits as fly ash as a mineral admixture.

7. *Remove unnecessary clause for fly ash additions*

The current OMP P-501 specification includes a provision that addresses substitution ratios for fly ash in concrete mixtures. The specification says that fly ash should be substituted for cement at a ratio of 1.5:1 or 1.2:1. Such clauses are peculiar since we do not have a prescriptive specification for mixture proportions, and as such should be omitted for improved clarity.