Have we progressed beyond workability?

The great surge in technology since World War II has had especially profound effects in the field of concrete construction. Engineering has made great progress in introducing new ideas and in simplifying expediting, and lowering the cost of the preparation of structural plans and of the construction itself. Architects have made much more frequent, stringent and varied demands on architectural concrete. New construction techniques, such as lift slab, pumped concrete, precasting, slip-form, and prestressing, have come into popular use. And concrete in general has been used much more widely.

Performance control

All of these factors have placed much greater demands on control of concrete performance. In some ways the technologies of concrete materials, mix design, and field control have not kept pace with these demands. One of the areas in which control has lagged the most has been that of workability. The key to this may be the lack of a reliable field test for assessing the workability of a given mix.

One must go back one step further, however, and ask just what is meant by workability. This seemingly obvious term implies an entire concept upon which agreement is not as wide-spread as is commonly believed. The characteristic which is probably meant when most people refer to workability is the ease with which the concrete can be mixed, transported and placed. Ease of course is an inexact term, subjective enough to defy quantitative measurement. In addition this definition is too comprehensive to allow a single accurate criterion for measurement. A low-slump concrete, for example, might be difficult to transport and yet be relatively easy to place. To carry this one step further, a concrete might be difficult to transport by pumping but quite easy to transport by buggy, or vice versa.

Definitions

In recent years a considerable amount of study and discussion has been devoted to this subject. One paper has defined workability in terms of stability, coherence, fluidity and mobility. Another employs the terms of compactability, mobility and stability. Still another adds to these the relatively new factor of finishability.

Mobility is another word which keeps cropping up in many learned definitions of workability. Rheology (the science treating of the deformation and flow of matter) has developed a quite explicit definition of mobility. Unfortunately the type of mobility obviously applicable to workability differs sufficiently from the established theological meaning that the scientific definition is rendered useless.

Another definition

Another definition of workability is “that property of concrete which determines the amount of useful internal work necessary to produce full compaction.” The latter definition has the advantage of narrowing the problem down to one measurement, in terms of energy, which is capable of being objectively gauged. This definition unfortunately relies entirely on a technique which actually measures one aspect of consistency; at best this is only one of several physical characteristics of concrete bearing on the common interpretation of the word workability.

Therein lies the root of the problem of defining workability: any inclusive definition is almost certain to list several plastic concrete characteristics, and the list compiled by one man is highly unlikely to match that of another. To complicate matters further, most of the characteristics do not lend themselves to reliable quantitative measurement.

Slump test

Despite considerable evidence against the practice many specifications still rely on the slump test as an indication of workability. It has been said that the only thing a slump test really measures is the number of inches concrete will slump after a slump cone is lifted. Perhaps this is too sweeping. On a given job and with a given mix design, slump can be a valuable watchdog on variations occurring in the field, for example, variations in water content, absorption characteristics of aggregates, or gradation. But as a means of specifying or assessing workability the slump test is virtually useless.

Reasons for use

The slump test will be difficult to unseat, however. First, it has great acceptance among architects, engineers and contractors. Second, it is easy and economical; almost anyone can learn to conduct a slump test in a few minutes with just a low-cost slump cone and a bullet-nose rod. (You don’t really even need the special rod; just pick up any handy piece of rebar laying around.) Third, the results come out in nice, easy-to-understand inches. And finally there can be a relation between workability and slump. When a con-

tractor calls for a few more gallons of water in the concrete to improve the workability, the slump does go up.

No substitute

What's to take its place? No matter what is said about ASTM not intending the slump test to be a measure of workability, or about its shortcomings in that respect, it will probably continue to be used until a definition is agreed upon and practical tests are introduced that will accurately and simply measure the component characteristics that comprise the quality which we call workability.

Uzomaka approach

The list of component characteristics should cover all the facets of workability; when all are specified and controlled, all aspects of workability should be satisfactory. Of course, when only certain characteristics are needed, it would be possible to specify controls over only those aspects of workability. One such approach to the problem has been forwarded by O. J. Uzomaka.* He proposes an analogy with the science of soil mechanics, basing this on the theory that the concrete characteristics included in the term consistency are sufficient to describe the important factors bearing on the physical properties of a concrete mix called into play during the placing of plastic concrete.

The three terms he uses to describe consistency are: (1) compactability, the ease and amount of void reduction achievable; (2) spreadability, the ease with which concrete spreads when subjected to vibration; and (3) stability, the ability of concrete to remain homogeneous (resist segregation and bleeding) while it is being transported and placed. Tests are available to measure these characteristics: Glanville's (1) compacting-factor test; the Vebe test for spreadability; and Hughes' (2) test for segregation and the Ritchie (3) test for bleeding capacity.

Drawbacks

This approach may well be an advantageous way of specifying concrete workability, but it has some drawbacks. For one thing, the tests involved are numerous and not nearly so simple as the slump test. In any case a great deal of additional work is needed to relate the three factors to specific field needs.

Until a simple technique is developed and established to specify and test workability, it appears advisable to handle this aspect of concrete construction by using a performance specification. With an adequate description of what type of workability is needed, the ready-mix producer is well qualified to produce concrete which can be transported, placed and finished with relative ease and which will also develop the required hardened concrete properties.

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