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Some aspects of methods for measuring consistence*

by Sándor Popovics, Dipl.Ing., Ph.D.

Contribution by J. M. Plowman, B.Sc., Ph.D., A.C.G.I., D.I.C., A.M.I.C.E., A.M.I.C.E.I.
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Dr Popovics has made an interesting case for a simple method by which a required change in workability may be translated in practical terms into a change in water content. He has used some of my early results in his Figure 4, assuming that arbitrary axes may be taken as relative water content = 1.0 at a time of 2 min. I have continued this line of thought with some results recently published.⁽¹⁾ These results are for two gradings and three mix proportions, each

covering a wide range of water content. Besides measurements of the time required to compact these mixes when vibrated in 4 in. cubes, tests of slump, compacting factor and "slope" were also made. The compaction time and "slope" results curves have been replotted in Figures I and II for the two mixes. Unfortunately they do not bear out Dr Popovics's assertion that the relation between time and relative water content is a straight line. This may be due to the

*Pages 15 to 20 of *Magazine* No. 50.

Figure I

Figure II

Figure III: Apparatus for measuring consistence by a penetration test.

assumption of an arbitrary datum at 2 min. Perhaps Dr Popovics would care to examine these additional results and comment.

Contribution by K. Komlos, Dipl.Ing., C.Sc.
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At our Institute we have recently developed a simple penetration method for measuring the consistence of concrete mixes.⁽²⁾ A steel mould for $20 \times 20 \times 20$ cm test cubes is mounted on a vibration table with a frequency of 3,000 c/min and an amplitude of 0.4 mm. The mould is filled with one layer of the concrete mix and the table vibrated until the mix is fully compacted; after compaction, the surface is smoothed flat. Then the frame of the apparatus is fastened to the steel mould and the penetration rod is inserted through an opening in the upper part of the frame (Figure III). At the start of the test the lower end of the rod touches the surface of the compacted concrete. Then the vibration table is switched on and the time (penetration time) required for the collar of the rod to touch the tube in the upper part of the frame is recorded.

When using this penetration test to predict consistence, we have applied the "K-procedure" developed by Dr Popovics. We have found that in our case we may use the fundamental equations of this procedure:

$$w_2 = Kw_1 \dots \dots \dots (1)$$

and

$$K = (y_2/y_1)^{1/i} \dots \dots \dots (2)$$

only, as with the compacting factor test, "i" should not be considered constant for every concrete composition. As the analysis of our test results shows, i is a function of cement content (we have used concrete mixes with 240, 300, 350 and 400 kg cement per m³ of

the prepared concrete mix) as in the equation

$$i = \frac{155}{c} \dots \dots \dots (3)$$

where c is the cement content of concrete in kg/m³.

The range of applicability of equation 3 is for penetration times between 10 and 40 s.

Reply by the author

I certainly appreciate Dr Plowman's calling my attention to a series of test results that were not discussed in my paper. In order to evaluate the test results that Dr Plowman referred to with respect to the K-procedure, we re-plotted them. Figure IV presents the re-plotted results taken from Figures 3 and 4 and Figure V presents the results taken from Figures 5 and 6 of Dr Plowman's published paper.⁽¹⁾ It can be seen that the test results fit a straight line with a reasonable approximation in both Figures.

The water contents related to two minutes of vibration, that is, the 100% relative water contents for each test series, were assumed as follows: for the results in Figure 3, 7%; Figure 4, 8.2%; Figure 5, 6.6% and Figure 6, 8.7%. These estimated water contents are a little higher than the corresponding values of the fitting curves used by Dr Plowman but the differences are so small that curves fitting equally well can be constructed which pass through the water contents assumed above.

Finally, the K-procedure does not state that the results of every method of measuring consistence must provide a straight line in the system applied in, say, Figure IV. However, the better the test results approximate to such a straight line, the better is the approximation of the "assumption of independence" and

Figure IV: Relation between duration of vibration for full compaction and relative water content. Data from Plowman⁽¹⁾.

Figure V: Relation between the results of the "slope" test and relative water content. Data from Plowman⁽¹⁾.

that of the K -procedure. Accordingly, Figures IV and V indicate that the K -procedure is applicable to both the "time of vibration" and the "slope" methods.

Mr Komlos's comment, namely that the value of i for his penetration test is not independent of the cement content, is also in accordance with earlier experiences of the author. It was found, for instance, that the i value for the standard German penetration test performed according to DIN 1048 can be expressed as the following function of the cement content⁽³⁾

$$i = 0.01c_0 + 3$$

where c_0 is the cement content of the concrete in kg/m^3 . It should be noted, however, that in my formulae the value of i increases with the increase of the

cement content, while the trend is reversed in the formula presented by Mr Komlos. It would be interesting to speculate on the reason for this discrepancy, but it seems that only further research along this line can bring a satisfactory answer.

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