Determination of the Consistency of Concrete By the Compacting Ratio Method

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The bulk density of a loosely charged concrete is dependent on its consistency. The relation of the volume of a loosely charged batch of concrete to the solid volume of this batch (for example after complete compaction) represents as "compacting ratio" a simple measure of the consistency.

For this procedure only a prismatic container and any tool for compaction (vibrator or tamper) are necessary. By this method the consistency of concrete with any maximum size of aggregate can be measured in the range from pulpy to stiff, and the compacting ratio extends from about 1.05 to about 1.50.

•THE determination of the consistency of concrete on construction sites requires a simple and sturdy device. Such an apparatus should reveal even slight changes in consistency and should be applicable to a large variety of concrete mixtures within wide limits of consistency. Since the existing methods for measuring consistency do not satisfy completely all these requirements, a new method has been developed, which is the subject of this paper. The procedure is based on the assumption that the denseness of a sample of uncompacted fresh concrete is controlled by its consistency. The acceptance of this method as a new German standard is under consideration.

The volume of a loosely charged batch of concrete, defined by the solid volume of cement and aggregate, is known to increase for concrete of stiffer consistency. A value for the consistency of the concrete will therefore be obtained by filling a definite prismatic container in always the same way with bulked (loose) concrete and by relating the volume of this loosely charged concrete to its solid volume determined by calculation, using the bulk specific gravity of the ingredients, or simpler by complete compaction (1, 2).

By always taking the same prismatic container, the volume of the bulked concrete and that of the completely compacted concrete is proportional to the height of the respective filling. Therefore, it is sufficient to relate only the height of the bulked filling, which is constant, to the height of the completely compacted filling. For concrete with aggregates up to 1½ in. maximum size, a sheet-steel container 16 in. high with an 8-in.-square cross section is used in practice. Also a cylindrical container of corresponding size will be suitable.

DETERMINATION OF THE COMPACTING RATIO

This procedure is shown in Figure 1. The following special devices are necessary (Fig. 2): a sheet-steel container 16 in. high with an 8-in.-square cross section, trapezoid-shaped trowel 4 by 6.5 in., straightedge, and foot rule. For testing the concrete, a quantity of at least 1 cu ft should be taken from different places of the mix and thoroughly mixed by hand. (By this method segregation will be avoided and parties that have already been precompacted during transport of the concrete to the testing device

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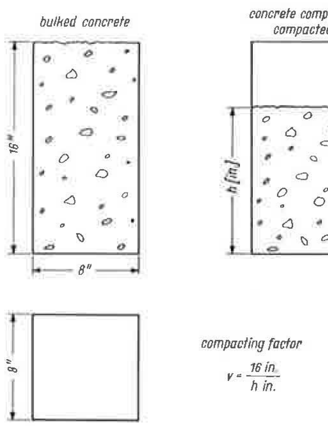

Figure 1. Determination of compacting ratio v by means of a container 16 in. high with an 8-in.-square cross section.

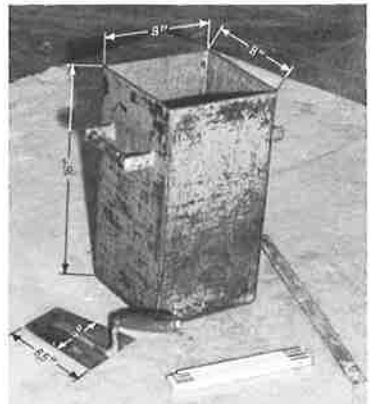

Figure 2. Equipment for determination of compacting ratio: steel-sheet container 16 by 8 by 8 in.; trowel 4 by 6.5 in.; straightedge; and foot rule.

will be loosened again.) As shown in Figure 3, the concrete is slowly dumped from a longitudinal edge of the fully loaded trowel into the container over its border. This is continued by turns over each of the four borders until the 16-in.-high container is slightly overfilled; then it is smoothly struck off (height of the filling 16 in.). Afterwards the dumped concrete is continuously compacted in some way, at best by an internal vibrator (Fig. 4), until there is no further sinking. After having leveled the surface, the height h (average) of the completely compacted filling (h = 16 in.) is

Figure 3. Filling of the container by slowly dumping concrete from trowel over borders of container.

Figure 4. Complete compaction of loosely charged concrete by a vibrator centrally inserted into the container (also possible by intensive tamping).

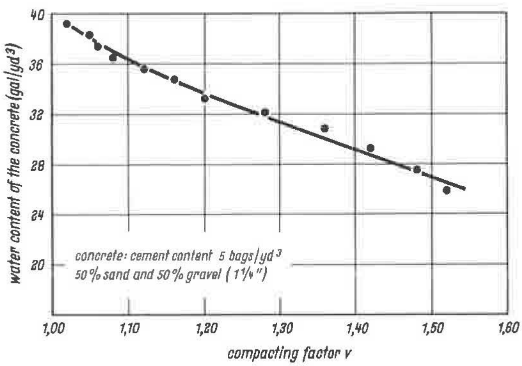

Figure 5. Compacting ratio v of a concrete with varying water content (28 to 40 gal/cu yd).

determined by measuring at four or more points. The consistency is measured by the compacting ratio

$$v = \frac{16}{h}$$

EXPERIMENTAL INVESTIGATIONS

Influence of the Water Content

When plotting water content against the compacting ratio of concrete with the same aggregate and cement content (Fig. 5), a strong dependence is evident. In plastic as well as in the stiff range, a relatively slight variation in the water content of the concrete resulted in a remarkable alteration of the compacting ratio. Figure 6 shows the results of concrete with the same aggregate; however, with different cement contents ($4\frac{1}{2}$ to 6 bags/cu yd).

Reproducibility

In order to evaluate the standard deviation of the test procedure caused by various persons, the compacting factor of a stiff and a plastic concrete was measured in turns by eight partly unskilled laboratory workers. The cement content was about 5 bags/cu yd; the aggregate consisted of 50 percent sand and 50 percent gravel ($1\frac{1}{4}$ in.).

The results for the stiff concrete were in succession

$$v = (1.42 + 1.43 + 1.42 + 1.44 + 1.45 + 1.45 + 1.45 + 1.47) : 8 = 1.44$$

The standard deviation was less than 0.02; it was, however, calculated from eight values only and included also the alteration by increasing stiffening of the concrete batch during the testing time of about $1\frac{1}{2}$ hours. The results for the plastic concrete were as follows:

$$v = (1.19 + 1.21 + 1.20 + 1.25 + 1.22 + 1.22 + 1.22 + 1.25 + 1.24) : 8 = 1.22$$

with a standard deviation of less than 0.02.

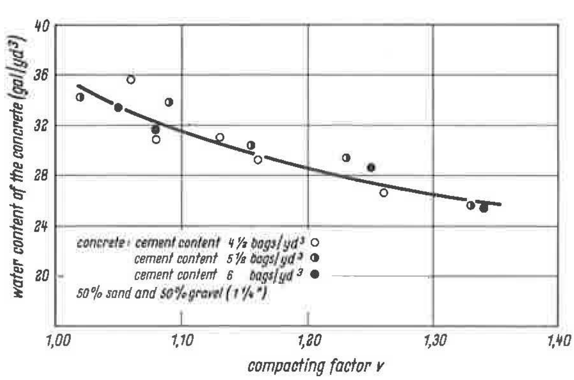

Figure 6. Compacting ratio of concrete with varying water content and cement content.

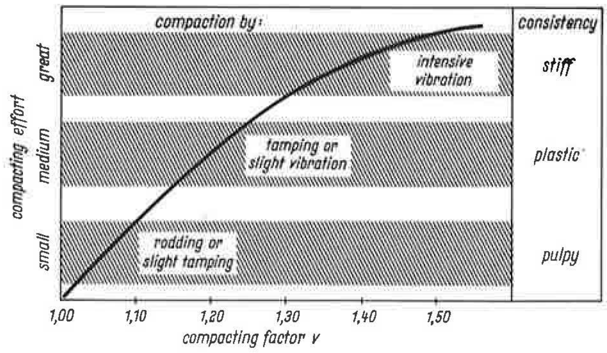

Figure 7. Compacting ratio (consistency) and compacting effort for concrete with aggregate 0-1¼ in.

Compacting Ratio and Compacting Effort

Figure 7 shows the relation between compacting effort and compacting ratio. For the compaction of concrete with a compacting ratio of 1.40, for example, on the building site, intensive vibration is necessary.

SUMMARY

The consistency in the range from stiff to pulpy concrete can reliably be measured by the compacting ratio v. It reacts already on small variations in the water content of a concrete mix. The procedure is easy, only simple and sturdy devices are needed. The exactitude of indication of this method (standard deviation) is quite satisfactory, if the test instructions are observed. The procedure can also be applied to measure the consistency of mass concrete with very coarse aggregates when a container of corresponding size is used.

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