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METHOD OF MIXING HIGH-STRENGTH CONCRETE

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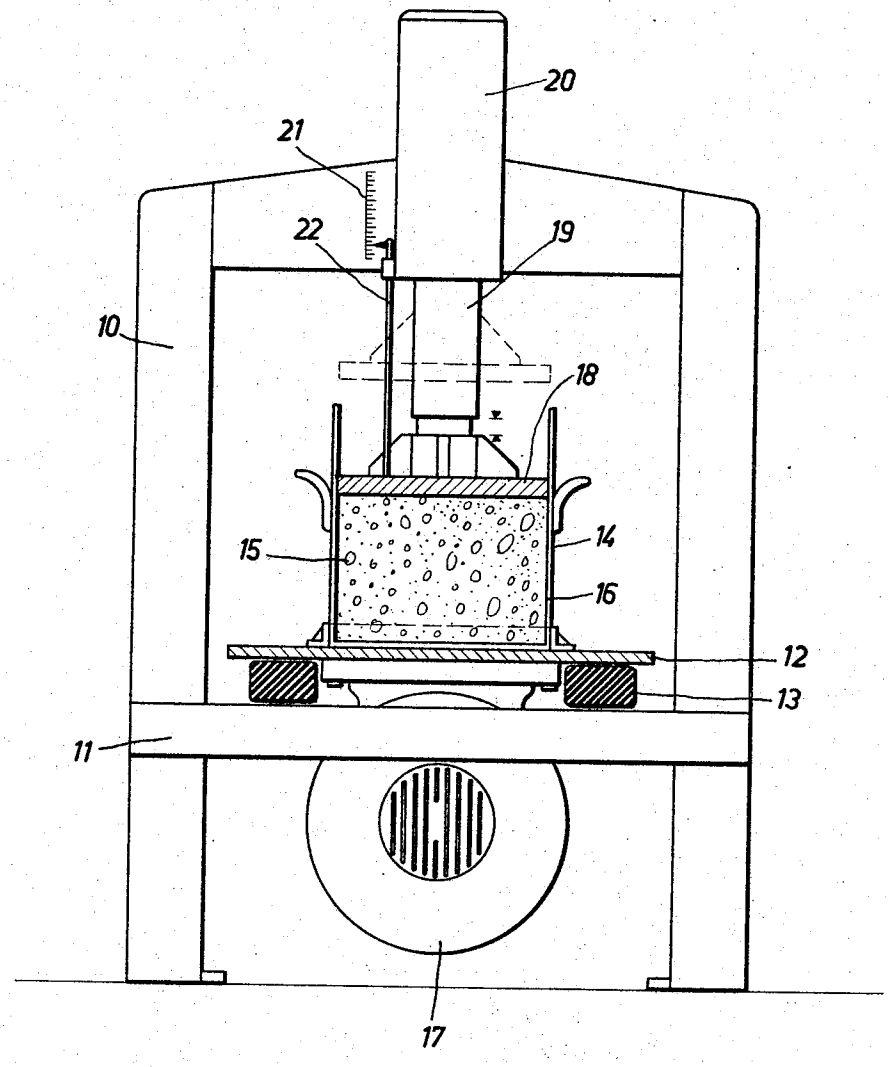

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METHOD OF MIXING HIGH-STRENGTH CONCRETE

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This invention relates to a method of and device for mixing high-strength concrete of a predetermined composion of aggregates.

In high-duty constructions, such as bridges, overground constructions, roadway covering sections, but also in prefabricated finished concrete parts, particularly concrete blocks, particular strengths are required of the concrete according to the stresses to be expected. In the mixing of high-quality concrete it is very important that the individual components, such as cement, water and aggregates, be combined with great accuracy. For this purpose, the aggregates, that is, sand, gravel and so on have been classified in standard grain sizes and the constituent amounts of the individual grain sizes have been determined by so-called screen lines. The composition of the aggregates according to grain sizes must be so chosen that the screen line is within an ideal range defined by upper and lower limits. In practice, however, the results obtained are still very inexact, which is chiefly due to the fact that within the individual grain size classes according to the specified screen line there will occur, according to circumstances, from time to time heavily differing grain size distributions which, as a matter of course, do not become manifest in the screen line, since this is subdivided into specific groups, such as 0–3 (sand), 3–7 and 7–15 (gravel).

On this natural inaccuracy supervenes the difficulty of determining the exact proportion of cement or cement glue (water and cement), respectively, for the concrete mixture. In practice it has been found that too large a portion of cement is as detrimental as too small a portion of cement.

Accordingly it is an object of the invention to provide a high-strength concrete of a specified grain size composition of the aggregates which contains exactly the amount of cement required to attain maximum strength concrete.

This object is attained according to the present invention in that to the compacted aggregates a first amount of fluid cement glue is admixed which exactly corresponds to the hollow space volume between the grains as compacted, whereupon subsequently, after repeated consolidation, an additional amount of cement glue is added which corresponds to the volume of hollow spaces additionally resulting from the first added amount of cement glue.

For carrying out this method, the invention further proposes that the volume of the cavities existing in the compacted aggregates be determined with the aid of a measuring liquid, whereas the measuring of the volume of the cavities left after the first admixture of cement glue be effected by observation of the increase in volume.

Hence the invention starts from the reflection that the volume of the cavities between aggregates of various grain size groups can be assumed to be differing. The strength of the concrete, however, depends in a high degree on that the binding constituent, namely cement and water, is added in the same proportion as there are hollow spaces. To this end, the invention further proposes to compact the aggregates according to the specified constructional conditions and subsequently to determine the cavities still left to receive the cement glue.

In the realization of the method according to the invention it was found that the cavities ascertained by the measuring liquid are not completely filled out by the initially added cement glue, part of which clogs between the individual grains of the aggregates. Thus there will still remain some hollow spaces that are detected by the aforedescribed measure and then filled with additional cement glue.

Expediently, the process of the invention is carried out on a standard volume or quantity and then figured out for the actually required volumes of concrete.

To this end it is further proposed that the method of the invention be applied as a measuring method for determining the required exact amount of cement glue for a specified blend of the aggregates to obtain concrete of maximum crushing strength, by subjecting only part of the whole concrete mixture to this method and calculating the total amount of the constituents of the concrete mixture accordingly.

Another object of the invention is to provide a device for carrying out the proposed method, which comprises a resiliently mounted open top case for receiving a standard volume of aggregates, a force plate lowerable from above into said case and a high-frequency vibrator connected with said case. The high-frequency vibrator, particularly unbalance vibrator, is conveniently secured to the underside of a rubber body mounted plate on which the case is disposed so as to be removable and secured against transverse displacement by stop means. Furthermore, a stationary graduated scale is provided on which the amount of settling of the force plate can be read off.

With the aid of the device of the invention the volumes can be determined prior to, and after, compacting. In this case the force plate is conveniently moved by a hydraulic, pneumatic or mechanical piston.

The invention provides, above all, the advantage that it enables the exact amount of cement for obtaining maximum strength concrete to be added to the mixture for any specified grain size combination. What is chosen is merely the grain size composition which has the highest density after compaction, adding then with great accuracy the amount of cement blue which just fills out the cavities. Starting from this method then the required part of cement can readily be calculated, it being expedient that the cement glue has a suitable water-cement coefficient, e.g. of 0.4. This water-cement coefficient is necessary to achieve complete hydration of the cement.

The invention consists not only in the mentioned individual features but also in the different possible combinations thereof.

Further details and advantages of the invention will be more clearly understood from the following description of an embodiment of the device according to the invention, having reference to the accompanying drawing, in which the only figure is a somewhat schematical elevational view of the said device.

Referring to that figure, the device for carrying out the method of the invention comprises a stationary rigid frame **10** including a cross member **11** on which a plate **12** is resiliently supported, e.g. by means of interposed rubber bodies **13**. Disposed on the plate **13** is a case **14** adapted to receive a predetermined unit volume of aggregates **15**. The case **14** is removable but secured against transverse displacement on the plate by stop means **16**.

Secured to the underside of the plate **12** is a high-frequency vibrator **17** which is preferably of the unbalance type and intended to cause high-frequency vibration of the plate **12** and thus of the case **14** and its contents.

The case **14** is upwardly open and a force plate **18** can be lowered therein until it is placed on the aggregates. To this end the force plate **18** is secured to the piston

rod referenced 19 of a hydraulic or pneumatic pressure cylinder 20.

For determining the altitude differences of the force plate 18 a graduated scale 21 is provided on the frame 10 and associated with a vertically shiftable pointer 22 of the force plate 18 for cooperation therewith.

For determining the optimum cement constituent of a concrete mixture with a specified grain blend of the aggregates, the aforedescribed device is operated as follows for carrying out the method of the invention:

The aggregates are generally available in three separate grain size groups, viz. 0–3 mm., 3–7 mm. and 7–15 mm. Of these grain size groups an aggregate is blended which, according to common experience, may be within a suitable range. For carrying out the method of the invention a relatively small amount of about 50 kilograms will be sufficient. These aggregates are completely dried. Subsequently, the individual grain size groups are introduced by weight into the case 14 until there is a standard quantity of about 10 kg., which is considered a suitable quantity. In this quantity the parts of the grain size groups 7–15, 3–7 and 0–3 may amount e.g. to 60% (6 kg.), 5% (0.5 kg.) and 35% (3.5 kg.), respectively. These groups are previously mixed.

In the case 14, the mixture is compacted for a predetermined period of time by the combined actions of the high-frequency vibrator 17 and the force plate 18 which is hydraulically, pneumatically or even mechanically operated at constant pressure. Then the case 14 is removed from the plate 12 and a measuring liquid, preferably water, is filled in the dry mixture until its level reaches the surface of the aggregate mixture. The quantity of filled-in liquid has previously been measured so that after the filling in operation the volume of the cavities in the aggregate can be determined by the amount of liquid filled in.

Cement glue having a water-cement coefficient, for example, of 0.4 is mixed and then its specific gravity is determined. Subsequently, a quantity of cement glue corresponding to the determined volume of the cavities is added to a new dry standard mixture of the grain blend which has proved suitable, i.e. particularly dense. Thus a concrete mixture is obtained which consists of cement, water and aggregates of a specific composition. This mixture then is filled again in the case 14 and once more vibrated for a certain period of time while simultaneously subjected to pressure by the force plate 18. Thereby it is found that the volume of the mixture has somewhat increased as compared with the dry aggregate mixture, which is due to the fact that the cement glue introduces itself between the individual grains of the aggregate, thereby forming new hollow spaces in the mixture which correspond to the increase in volume that has been ascertained. To substantially fill these hollow spaces an additional quantity of cement glue is added which corresponds to the increase in volume. Thus the optimum concrete mixture for a standard volume is obtained which ensures maximum strength of the concrete. For if the last-obtained concrete mixture were once again filled in the case 14, it would be found after repeated vibration that there occurred no further change of volume.

The results obtained by the method of the invention for the standard volume can be readily applied to large scale concrete mixing on building sites or in factories by simple multiplications.

Thus the invention enables the exact amount of cement required to attain concrete having maximum compression strength to be added to any specified sand-gravel-mixture.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative, and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

I claim:

1. A method of mixing high-strength concrete for any specified composition of the aggregates, comprising the steps of

compacting the aggregates,

adding a first amount of liquid cement glue to the compacted aggregates, said amount corresponding exactly to the volume of the hollow spaces existing between the aggregate grains as compacted,

compacting the aggregates once more and, subsequently,

adding an additional amount of cement glue, said further amount corresponding to the volume of hollow spaces produced additionally by said first amount of cement glue.

2. A method as claimed in claim 1, wherein the volume of the hollow spaces existing in the compacted aggregates is determined by means of a measuring liquid, whereas the volume of the hollow spaces still left after having added said first amount of cement glue is measured by observing the increase in volume.

3. A method of mixing high-strength concrete for any specified composition of the aggregates comprising the steps of compacting the aggregates, adding a first amount of liquid cement glue to the compacted aggregates in a volumetric amount substantially equal to the volumetric void of the aggregates, compacting the aggregate and cement glue admixture, and adding additional cement glue corresponding to the difference in volume of the admixture prior to and after the compacting thereof.

4. The method as defined in claim 3 including the step of vibrating the aggregates during at least one of the compacting operations.

5. The method as defined in claim 3 including the step of determining the volumetric void of the aggregates by introducing a liquid into an identical compacted aggregate and measuring the liquid so introduced into the identical compacted aggregate.

6. A method of mixing high-strength concrete for any specified composition comprising the steps of adding a first amount of liquid cement glue to an aggregate of granular material in a volumetric amount generally equal to the volumetric void of the aggregate, compacting the aggregate and cement glue admixture, and adding additional cement glue corresponding to the difference in volume of the admixture prior to and after the compacting thereof.

7. A method of mixing high-strength concrete for any specified composition comprising the steps of compacting an aggregate of granular material, adding a first amount of liquid cement glue to the aggregate in an amount generally equal to the volumetric void of the aggregate, compacting the aggregate and cement glue admixture, and additional cement glue to the admixture.

8. A method of mixing high-strength concrete for any specified composition comprising the steps of forming an aggregate of granular material, adding a first amount of liquid cement glue to the aggregate in an amount generally equal to the volumetric void of the aggregate, settling the aggregate and cement glue admixture, and adding additional cement glue to the admixture in an amount generally equal to the difference in volume prior to and after the settling of the admixture.

9. A method of mixing high-strength concrete for any specified composition comprising the steps of forming two generally identical aggregates of granular material, settling both aggregates, determining the volumetric void of one of the aggregates by introducing a measured medium therein, adding a first amount of liquid cement glue to the other aggregate in an amount generally equal to the determined volumetric void, settling the other aggregate and cement glue admixture, and adding additional cement glue to the other admixture in an amount gen-

erally equal to the difference in the volume prior to and after the settling of the admixture.

10. The method as defined in claim **9** wherein the other aggregate is settled by a compacting operation prior to the addition of the first amount of liquid cement glue thereto.

11. The method as defined in claim **9** wherein the volumetric void is determined by introducing a liquid medium into the said one aggregate.

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