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Rice

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[54] **MEANS AND METHOD OF TESTING EXPANSIVE CONCRETE**

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[52] **U.S. Cl.** .... **73/432 R,** 73/88 C, 33/179

[51] **Int. Cl.** **G01b 3/10**

[58] **Field of Search** .... 73/88 C, 16, 432; 33/179; 249/53, 82, 152, 173; 425/140, 141, 172

[56] **References Cited**

UNITED STATES PATENTS

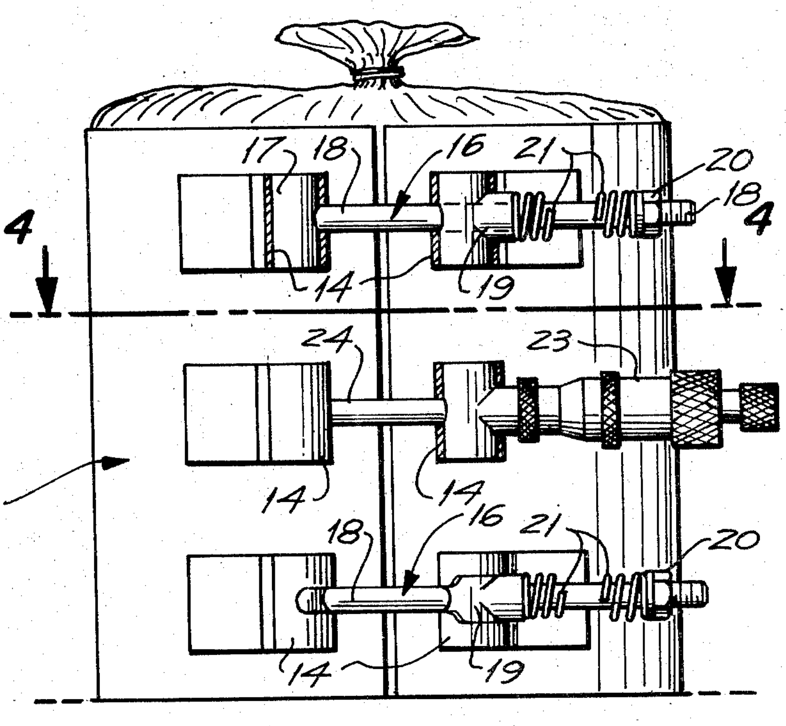
2,637,907	5/1953	Aubrey, Jr. et al.	33/179
3,619,463	11/1971	Budin et al.	73/16

Primary Examiner—James J. Gill
Assistant Examiner—Anthony V. Ciarlante
Attorney—Charles G. Lyon et al.

[57] **ABSTRACT**

A method of testing expansive concrete wherein a sample of concrete is permitted to expand while subjected to a predetermined restraint, and subsequently to contract, measurements being made of the expansion and contraction. The means of testing expansive concrete comprising a split cylinder which receives a test sample of concrete contained in a pair of plastic bags having low friction characteristics. A measuring device indicates the amount of expansion and contraction occurring in the cylinder.

10 Claims, 5 Drawing Figures



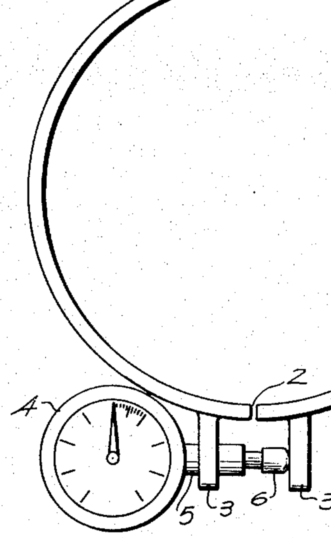


FIG. 1

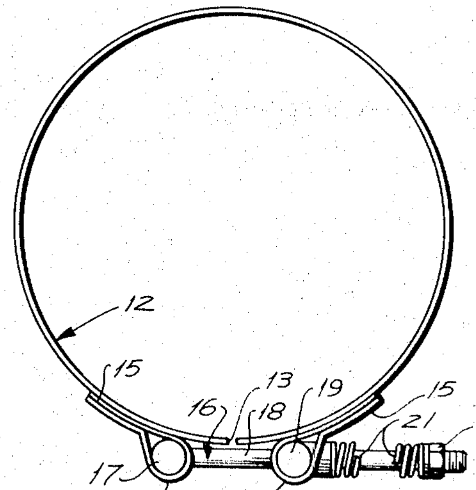


FIG. 3

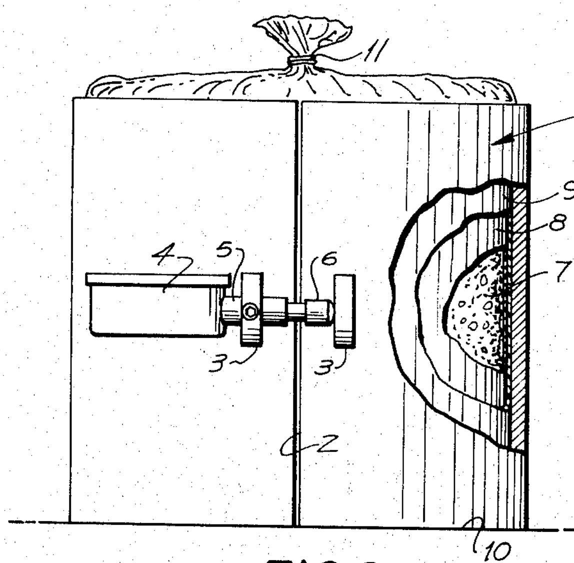


FIG. 2

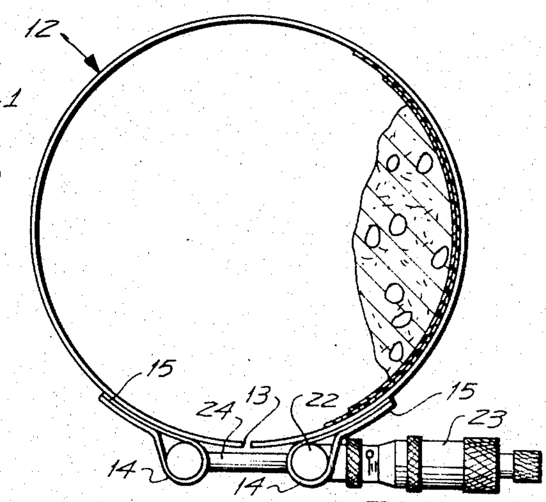


FIG. 4

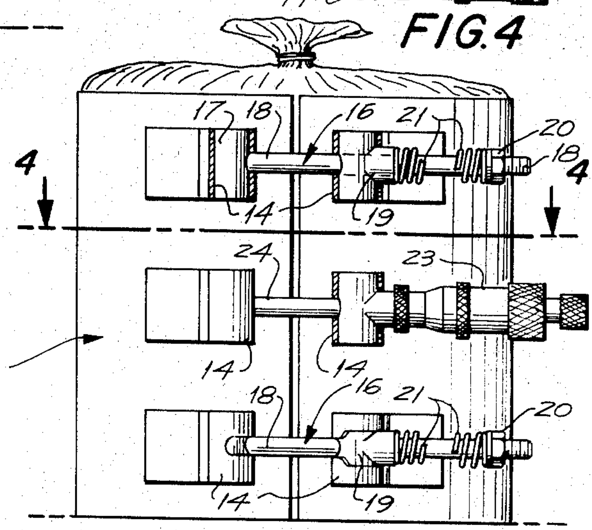


FIG. 5

MEANS AND METHOD OF TESTING EXPANSIVE CONCRETE

BACKGROUND OF THE INVENTION

Conventional portland cement and concrete mixtures containing portland cement shrink during the curing period. Field tests to measure shrinkage or other properties of such concrete are well established. Recently additives have been developed which, when incorporated with portland cement in concrete, cause the concrete to expand during the curing period. These additives are not in the nature of foaming agents which produce a porous product of reduced density, but instead affect the crystal growth and produce a concrete having improved structural properties including a reduction in porosity to the extent that the resulting structure may be water-proof.

Such expansive concrete may be divided into two categories, namely:

First, a shrinkage compensated concrete in which the amount of expansion control ingredient is calculated to cause expansion sufficient to compensate or slightly over-compensate for the otherwise expected shrinkage.

Second, an expansive concrete in which the amount of expansion control ingredient is calculated to cause a net expansion sufficient to place reinforcing contained in the concrete under tension. Typical of this type of cement or concrete, whether intended for mere shrinkage compensation or net expansion, are the compositions disclosed in U.S. Pat. Nos. 3,155,526, 3,251,701 and 3,303,037, issued in the name of Alexander Klein, inventor.

Heretofore, tests to determine expansion properties of this type of expansive concrete have been limited to laboratory tests, the test equipment involved a steel rod with steel end plates and a surrounding mold. If, in the test U. S. standard was used, the end plates were 2 inches square and spaced 10 inches. Otherwise, the molds and related test equipment conformed to the requirements of ASTM Specification C–490 for Apparatus for Use in Measurement of Volume Change of Cement, Mortar and Concrete.

As the laboratory test was too complex for field use, it was necessary to prepare the mortar at the laboratory; thus, it was impossible to provide an exact duplicate of that which actually was poured at the site, and while changes in length of the test specimen could be made, there could not be any assurance that the measurements would correspond to the material poured at the job site.

SUMMARY OF THE INVENTION

The present invention is directed to an improved means and method of testing concrete which is particularly adapted for the testing of expansive concrete, and is summarized in the following objects:

First, to provide a means and method of testing expansive concrete which is particularly suited for conducting field tests at the job site utilizing specimens taken from the concrete as actually used so that discrepancies between the properties of the test specimen and the concrete being used at the job site, and other differences such as temperature and humidity, are virtually eliminated.

Second, to provide a testing procedure which may be reliably performed by unskilled workers.

Third, to provide a means and method of testing expansive concrete wherein a specimen of the concrete is placed in a cylindrical mold which is capable of expanding while exerting a predetermined constricting force, the mold also remaining in conformity with the specimen in the event of subsequent shrinkage.

Fourth, to provide a means and method of testing, as indicated in the preceding object, wherein means are provided for readily measuring the amount of expansion or contraction as occurring during the curing of the specimen.

Fifth, to provide a means and method of testing, as indicated in the preceding objects, wherein the specimen is contained in a pair of thin wall bags formed of low friction plastic material and disposed between the specimen and the mold wall thereby to prevent bonding of the specimen material to the mold wall and to minimize any friction therebetween incidental to change in dimension of the specimen, whereby mold expansion or contraction proceeds continuously rather than intermittently.

DESCRIPTION OF THE FIGURES

FIG. **1** is a top view showing one embodiment of the means for testing expansive concrete, with the concrete sample omitted.

FIG. **2** is a side view thereof showing the concrete sample in place and with portions broken away to show underlying structure.

FIG. **3** is a top view showing another embodiment of the means for testing expansive concrete, with the concrete specimen omitted.

FIG. **4** is a transverse sectional view taken through **4—4** of FIG. **5** with the concrete specimen indicated fragmentarily.

FIG. **5** is a side view thereof with portions in section and with the concrete specimen shown in place.

Reference is first directed to FIGS. **1** and **2**. The construction here shown includes a cylindrical mold **1** split axially at one side, as indicated by **2**. At the axial midportion of the mold, a pair of projections **3** extend outwardly from the mold at opposite sides of the split **2**. One of the projections supports a gage **4** by means of its stem **5** so that a measuring shaft **6** may engage the other projection.

The mold is intended to receive a specimen **7** of concrete or mortar. The specimen is contained within an inner plastic bag **8** which, in turn, is surrounded by an outer plastic bag **9**. The bags are dimensioned to fit within the mold **1** without being stretched or folded appreciably; that is, the bags are preferably the equal to the internal dimensions of the mold but may have a greater axial length. The two bags form a pair of laminations to facilitate low friction relative movement between the specimen material and the cylinder.

The method of conducting a test with the means thus described involves the placing of both plastic bags **8** and **9** within the mold and placing the mold on an underlying surface **10**. The inner bag **8** is then filled with the specimen of concrete or mortar, preferably to a level above the mold **1**, and the specimen is tamped or vibrated to eliminate air bubbles. The bags are then closed by a tie member **11**.

The walls of the mold are of predetermined thickness to provide a circumferential restraint of predetermined value but not sufficient to prevent expansion of the expansive concrete or mortar forming the specimen. It is intended that the specimen be taken at the job site from a supply truck or other source and that the test be conducted at the job site so that the specimen is exposed to the same conditions as the rest of the material being poured at the job site, so that the characteristics of the specimen will be truly representative of the material actually being used.

If the expansive ingredient is proportioned so that its effect is principally to compensate for shrinkage that would otherwise occur, the mold will expand during approximately the first 7 days of the curing period and then will contract to its original dimension or slightly greater than the original dimension. For example, after the concrete has been placed in the bags and vibrated or tamped in preparation for the test, an initial reading is taken which arbitrarily becomes the zero reading. Then, at intervals during the expansion period, other readings are taken. For convenience, the mold is 6 inches in diameter and 6 inches in axial length. With these dimensions, the concrete sample can be expected to expand twenty-five to fifty thousandths, depending on the specific properties of the sample. Ninety percent of such expansion will occur during the first 3 days. After the 7th day, the sample will gradually contract and, when stabilized, may indicate a net expansion in the order of zero to ten thousandths of an inch. The values given are merely representative and may vary under different conditions.

Although the cylindrical mold is yieldable, it does place some constraint on the specimn so that its expansion or growth is partially restricted. This simulates the condition to which the concrete is exposed when poured to form part of a concrete structure. It is not intended to be an exact simulation, for the forces applied to the concrete comprising a structure vary in different parts of such structure. Some constraining force is desirable, however, for it tends to produce a stronger structure than would be the case if the concrete were totally free of restraint.

It has been discovered that constraint may be limited to two axes; that is, in the construction illustrated, the concrete specimen is unrestricted in the vertical or axial direction as distinguished from the two horizontal directions. Such constriction does not cause appreciable increased expansion in an axial direction as might be expected. Instead, it seems that constraint in two directions limits the individual crystal growth and, as each crystal has essentially a predetermined shape, constriction along two axes of the crystal tends to cause constriction along the third axis; otherwise, the crystal would become elongated or change its form.

As previously indicated, the means and method of testing expansive concrete may be applied to highly expansive concrete; such concrete may require more constraint in order to develop its maximum strength. The test procedure in the case of highly expansive cement is essentially the same as previously described; however, the readings during the curing process are several times the readings obtained for shrinkage compensating cement or concrete.

Reference is now directed to FIGS. **3, 4** and **5.** It has been found, particularly in connection with shrinkage compensating concrete that relatively nominal compressive force need be applied in order to test the cement, mortar or concrete. Consequently, the mold **12** may be a sheet metal cylinder split at one side as indicated by **13.** Secured to the mold at each side of the split are pairs of loop members **14,** which may be similar to loop members such as used in metal clamps, for example, clamps as illustrated in U.S. Pat. Nos. 2,368,929 or 2,426,423. In the structure shown, three sets of loop members **14** are provided, each having tabs **15** which are spot welded or otherwise secured to the mold **12.**

The upper and lower pairs of loop members receive T-bolts **16,** having a transverse journal **17** fitting in one of the loop members and a bolt shaft **18** extending from the journal through the other loop member, the loop members having appropriate clearance slots. Mounted on each bolt shaft is a T-shaped slide **19** journalled in the other member of each pair of loop members. The extremity of each bolt shaft **18** receives a nut **20,** and interposed between the nut and the T-slide **19** is a spring **21.** By selection of appropriate springs and adjustment of the nuts **20,** the desired constricting force may be applied to the mold **12.**

One of the central pair of loop members may journal a T-mounting **22** similar to the T-slide **19,** but dimensioned for incorporation in a micrometer **23.** A conventional measuring probe or shaft **24** extends from the micrometer to the other loop member.

The means for measuring the expansion or contraction of the mold **1** or **12** may be conventional; that is, a conventional micrometer may embrace the loop members **14** or engage the outer sides of the projections **3,** or the periphery of the mold itself may be measured with an appropriate band.

It is, of course, recognized that the readings obtained are not direct measurements of the change in volume of the specimen, but the change in reading measurements are accurately related mathematically to the change in volume. Thus, it is merely necessary to calibrate the mold so that the readings obtained may be translated into terms of volume.

It is essential, in the conducting of field tests of this nature, that the tests be capable of performance by relatively unskilled personnel. In conducting the expansion test, it is merely necessary to set the mold on a flat surface, insert a pair of plastic bags of the proper dimension, fill the bags to a level above the mold, then tie the bags, care being taken only that the specimen is a solid mass; this being accomplished by tamping the mixture or using a vibrator, which may be a part of the surface on which the mold is placed. Subsequent micrometer readings are easily made and noted.

The use of a pair of plastic bags having low coefficients of friction has been found desirable in order to obtain accurate data, as any appreciable friction between the specimen and the mold, particularly if the movement is slight, causes the mold to expand in increments rather than continuously.

Polyethylene has been found suitable for the bags. While one bag will function, as its frictional contact with the mold wall is low, two bags one within the other further reduces the friction. Also, if desired a coating of tetrafluoroethylene may be sprayed on one or both confronting surfaces of the bags or on the outer surface, if a single bag is used. By minimizing friction, the expansion or contraction of the mold is essentially progressive, rather intermittent, and therefore the readings are more reliable.

While the means and method has been directed primarily to the testing of expansive concrete, the embodiment shown in FIGS. **3, 4** and **5** can be adapted to test net shrinkage of a specimen by adjusting the springs to apply a predetermined compression calculated to be insufficient to cause axial expansion, or to make such adjustment after initial set.

While the slot 2 may be covered with a sliding strip disposed inside the mold, in practice this is not necessary particularly when the amount of expansion is small.

For some test purposes, it has been found that a pair or more of O-rings plain or containing a spring wire provides sufficient constraining force.

While particular embodiments of this invention have been shown and described, it is not intended to limit the same to the details of the constructions set forth, but instead, the invention embraces such changes, modifcations and equivalents of the various parts and their relationships as come within the purview of the appended claims.

I claim:

1. A means for testing a specimen of material which is initially in a semi-fluid state and which undergoes change in volume in the course of conversion into a predetermined solid state, said means comprising:

a. a circumferentially expansible and contractible cylinder for receiving a specimen of said material;

b. means exerting a force tending to constrict the cylinder;

c. means for measuring the change in circumferential dimension of the cylinder in conformity with change in the circumferential dimension of the specimen material;

d. and a flexible and yieldable container disposed within the cylinder to receive a specimen of said material in sufficient volume to fill the cylinder.

2. A testing means as defined in claim **1,** wherein:

a. the walls of the container are divided by a split and are biased to exert a constricting force and thereby constitute the force exerting means.

3. A testing means as defined in claim **1,** wherein:

a. the walls of the cylinder are split axially to permit expansion and contraction;

b. and yieldable connector means join the two sides of the split to form said force exerting means.

4. A testing means as defined in claim **1,** wherein:

a. the container includes two relatively slidable laminations to facilitate low friction relative movement between the specimen material and the cylinder.

5. A means for testing a sample of expansible cementitious material as the specimen material passes from its semi-fluid initial state to its cured state, said means comprising:

a. a split cylinder open at its axial ends to permit change in the volume defined by the cylinder;

b. a flexible and yieldable container formed of plastic material having a low coefficient of friction and dimensioned to fit within the cylinder to receive a sample of specimen material whereby the specimen material completely fills the cylinder;

c. and means for measuring change in the circumference of the cylinder thereby to determine change in volume of the cylinder in response to change in volume of the specimen material.

6. A testing means as defined in claim **5,** wherein:

a. the walls of the cylinder offer a predetermined resistance to expansion thereby applying a predetermined resistance to expansion of the specimen material.

7. A testing means as defined in claim **5,** wherein:

a. the margins of the cylinder at opposite sides of the split are joined by yieldable connecting means including a spring exerting a predetermined force tending to constrict the cylinder thereby to apply a predetermined force on the specimen material opposing expansion thereof.

8. A testing means as defined in claim **5,** wherein:

a. the container includes two relatively slidable bag members having a low coefficient of friction to minimize friction loss during change in dimension of the specimen material.

9. A method of testing a specimen of a cementitious mixture containing an expansion agent beginning with the specimen in a semi-fluid condition and terminating with the specimen in a cured condition, the method characterized by:

a. molding the specimen, while in its semi-fluid state, into an essentially cylindrical shape, and circumferentially confining the specimen to such shape until the specimen is cured, while axial ends of the specimen remain unconfined;

b. applying a predetermined constrictive force to the circumference of the specimen yieldably opposing any radial expansion of the specimen incidental to increase in volume of the specimen and yieldably complying with any radial contraction thereof that may occur;

c. and periodically measuring a dimension change related to volumetric change in the specimen.

10. A means for testing dimensional change in a sample of cementitious material as the specimen material passes from its semi-fluid initial state to its cured state, said means comprising:

a. a cylindrical member open at its ends and having an axially extending slit, the cylindrical member being subject to volumetric change upon change in the width of said slit;

b. a flexible and yieldable container disposed within the cylindrical member to receive a said specimen material in sufficient volume to fill the container;

c. and means for measuring change in the width of said slit in response to expansion and contraction of said specimen material.

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