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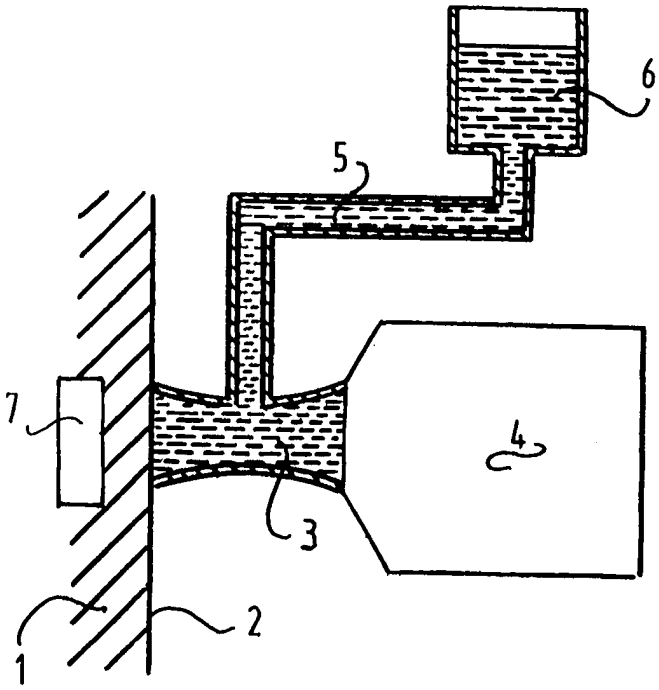
(54) Title: APPARATUS AND METHOD FOR MEASURING THE QUALITY OF CONCRETE

(57) Abstract

The invention relates to a method for measuring the quality of porous material, for instance concrete, whereby a body produced of said material is brought into contact with water, and that subsequently the migration of said water into said porous material is determined after which the quality is ascertained from the information thus obtained. As a consequence of said features it is possible to determine precisely the migration of the water into said concrete in which, with the help with the thus obtained information, statements can be derived relating to the permeability of the concrete, after which the remaining life time of the concrete can be estimated, and that possible reinstating measures, like the new application of an outside coat, the application of a paint coat or the injecting with plastics. The invention also relates to an apparatus for performing such a method.



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APPARATUS AND METHOD FOR MEASURING THE QUALITY OF CONCRETE

The invention relates to a method for measuring the quality of porous material, for instance concrete.

Such a method is generally known.

According to said prior art method a cylinder is removed from said body to be examined, after which said cylinder is tested in a laboratory. Thus there is question of destructive testing.

Further, an ISAT investigation is known, in which the quality of the concrete, in particular the permeability thereof is determined by the quantity of water which is absorbed by the concrete. However, this concerns a rather inadequate method.

The aim of the present invention is to provide such a method for testing the quality of concrete which is not destructive, and which is sufficiently accurate. It is noted that the determination of the permeability of concrete has a large economic value. In particular in the case of existing buildings the quality of the concrete, in particular the permeability thereof, gives an indication of the remaining life time of the concrete, and the information can also be used as an indication for possible reconstructive measures.

Thus the present invention provides a method which is characterized in that a body produced of said material is brought into contact with water, and that subsequently the migration of said water into said porous material is determined after which the quality is ascertained from the information thus obtained.

As a consequence of said features it is possible to determine precisely the migration of the water into said concrete in which, with the help with the thus obtained information, statements can be derived relating to the permeability of the concrete, after which the remaining

life time of the concrete can be estimated, and that possible reinstating measures, like the new application of an outside coat, the application of a paint coat or the injecting with plastics.

The present invention also relates to an apparatus for measuring the quality of porous material, for instance concrete, characterized by a nuclear magnetic resonance apparatus for measuring the concentration and the distribution of hydrogene atoms in a body made from said porous material by means of nuclear magnetic resonance, and by means for bringing said body made of said porous material into contact with water.

Subsequently, the present invention will be elucidated with the help of the accompanying figures, in which are depicted:

figure 1: a schematic cross-sectional view of an apparatus according to the present invention which is used with the execution of a method according to the present invention; and

figure 2: a diagramm for elucidating the action of the apparatus according to the present invention.

In figure 1 a concrete body 1 is shown, which is on one side delimited by a surface to air 2. As discussed before, the permeability of the concrete changes during its life time; with increasing age the permeability for water increases. To measure this permeability use is made of a method for measuring the permeability comprising a vessel 3 which is filled with water. The vessel 3 is opened on one side, at which side it is located against the wall 2 of the body 1 to be examined. At the opposite side of the vessel 3 an NMR apparatus 4 is located. In this respect it is noted that this concerns only the probe of an NMR apparatus; it is very well possible that the exitation quills of the NMR apparatus are located elsewhere relative to the body 1 to be examined. By means of a supply channel 5, connecting the vessel 3 with a hopper 6 water is supplied to the vessel 3. Hydrostatic pressure may be used as well.

According to an embodiment use can be made of a pump for maintaining a pressure within the vessel 3. When the method is executed the following procedure is applied.

The apparatus described above is located with the open side of the vessel 3 against the wall 2 of the body 1 to be examined. The body 1 to be examined can be a concrete building, for instance a viaduct, a bridge, a constructive part of a power station or another concrete construction. Subsequently, at a time t_0 water is supplied from the supply vessel 6 to the vessel 3 after which the water starts entering the concrete. The speed with which this entering process is executed is of course dependent of the permeability of the concrete. It is noted that normally already a certain amount of water is present in the concrete. This water will give rise to an NMR-signal S_0.

This amount of water comprises the so-called cristal water of the concrete, whereas it is not necessary, but very likely, that as a consequence of the normal humidity of the air "free" water is present in the concrete.

For measuring the water concentration in a volume 7 located in some depth under the surface, use is made, as stated before, of an NMR apparatus. Such an apparatus is known per se, for instance for medical applications. Therein such an apparatus is used for localising irregularities in a living body to be examined.

In the present application such an NMR apparatus is used for determination of the density of water, differentiated to place and time in the concrete.

To make things more clear figure 2 shows the signal of the NMR-apparatus at a certain location in the concrete as a function of time. At a time t_1, an increase of the signal is observed due to the arrival of some of the supplied water in volume 7. At the time t_1 the increase of the signal and the shape of the curve are used to estimate the quality of the concrete. It is noted that by means of an NMR apparatus a constant magnetic field is applied onto which is superposed a secondary

magnetic field varying in time and location. The H-atoms which are influenced by the magnetic field configuration mentioned above give thereon a certain reaction which reaction is measuring by means of the detection quills (probe). By varying the distance between the NMR probe and the surface of the body to be examined it is possible to scan certain areas of the concrete body. Thus it is possible to obtain a depiction of the concentration of the H-atoms, and thus the H_2O-molecules as a function of depth, the lateral coordinates and time. Thus, the present invention allows to obtain a three-dimensional depiction in the time of the migration of the water; thus, an image can be made of the permeability of the concrete after which statements can be drawn relating to the quality of the concrete.

It will be clear that besides for concrete the present invention is also applicable to other porous and permeable materials.

Further it is noted that the humidification of a part of the surface can also be made by other means.

CLAIMS

1. Method for measuring the quality of porous material, for instance concrete, **characterized in that** a body produced of said material is brought into contact with water, and that subsequently the migration of said water into said porous material is determined after which the quality is ascertained from the information thus obtained.

2. Method according to claim 1, **characterized** in that preceding to the bringing into contact with water, initially the distribution of the water already present in the porous material is determined.

3. Method according to claim 1 or 2, **characterized** in that the determination of the distribution of the water takes place by means of the localisation of hydrogene with the help of nuclear magnetic resonance.

4. Apparatus for measuring the quality of porous material, for instance concrete, **characterized** by a nuclear magnetic resonance apparatus for measuring the distribution of hydrogen atoms in a body made from said porous material by means of nuclear magnetic resonance, and by means for bringing said body made of said porous material into contact with water.

5. Apparatus according to claim 4, **characterized** in that the apparatus for supplying water to the body made of said porous material comprises a vessel of which at least one side is open, and which is arranged for bringing into contact with a plane of said body.

6. Apparatus according to claim 5, **characterized** in that at least one detection element or excitation element of the NMR apparatus is connected with the side of the vessel, opposite the open side of said vessel.

7. Apparatus according to claim 6, **characterized** in that the vessel is connected with an apparatus for supplying water to said vessel under super-atmospheric pressure.

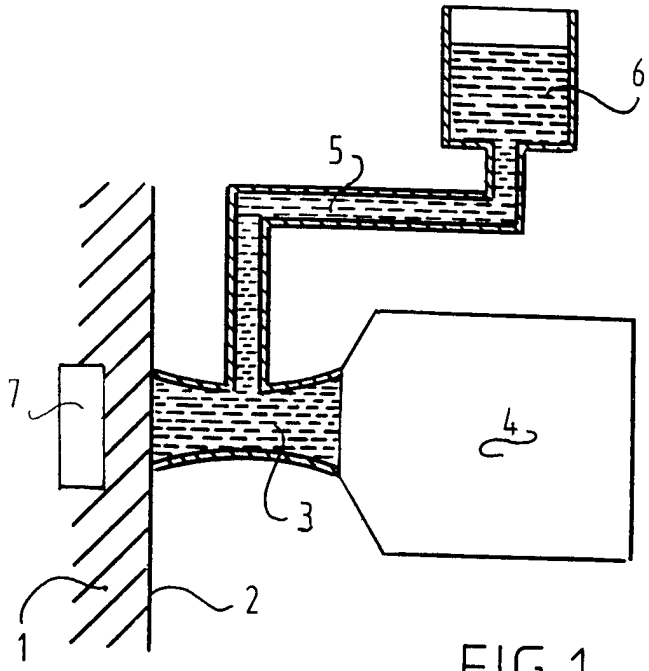

FIG.1

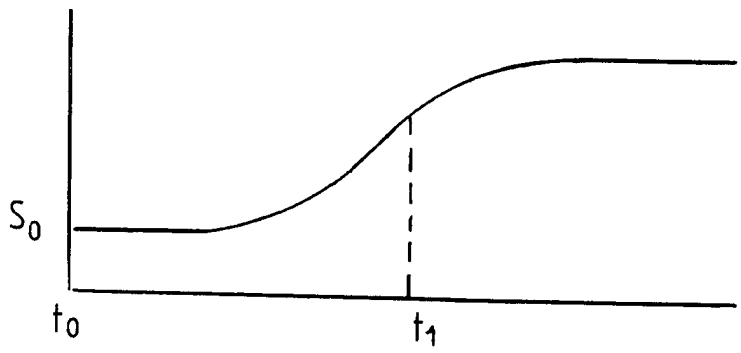

FIG.2

INTERNATIONAL SEARCH REPORT

Inte ›nal Application No
PCT/NL 97/00719

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G01N15/08 G01N33/38 G01R33/44 G01N24/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 979 390 A (SCHUPACK) 25 December 1990 see abstract see column 11, line 56 - line 65	1
A	see column 12, line 10 - line 23 see column 13, line 17 - line 34	7
Y	see figure 8	3-5
Y	US 5 055 787 A (KLEINBERG) 8 October 1991 see column 1, line 18 - line 21 see column 8, line 10 - line 13 see column 8, line 25 - line 30 see column 8, line 35 - line 43 see figure 1	3-5
A	US 4 291 271 A (LAUFFER) 22 September 1981 see column 1, paragraph 1 see column 1, line 25 - line 29 see column 4, line 41 - line 59	3,4

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
18 March 1998	25/03/1998

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte ›nal Application No
PCT/NL 97/00719

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4979390 A	25-12-90	CA 2003659 A	01-06-90
US 5055787 A	08-10-91	US 4933638 A	12-06-90
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US 4291271 A	22-09-81	NONE	