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(54) Measurement of the compaction rate of granular material layers

(57) The invention relates to a procedure for the on-site measurement of the compaction rate of granular material layers, especially for the determination of the compaction rate of material layers containing a solid part, liquid, and also material in the gaseous phase e.g. soils, during which, on the first part, a determined amount of deformation work is exerted on the surface of the material layer to be measured via the measuring instrument and the deformation of the material layer is measured, and, on the second part, the water content of the material layer is determined in a way that is known in itself, then from the deformation and the water content of the material layer the compaction rate of the material layer can be determined.

The characteristic feature of the invention is that, that equipment containing a measuring head and a falling weight that may be moved as compared to the measuring head is used as a measuring device and the material layer under examination is subjected to the deformation impact work during the on-site compaction with the consecutive impacts of the falling weight of the equipment, and during the on-site compaction the material layer under examination is subjected to deformation impact work equal to the amount of the deformation impact work exerted during the compaction carried out by a standard laboratory compactor machine that is known in itself.

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Description

[0001] The subject of the invention relates to a procedure for the on-site measurement of the compaction rate of granular material layers, especially for the determination of the compaction rate of material layers containing a solid part, liquid, and also material in the gaseous phase e.g. soils, during which, on the first part, a determined amount of deformation work is exerted on the surface of the material layer to be measured via the measuring instrument and the deformation of the material layer is measured, and, on the second part, the water content of the material layer is determined in a way that is known in itself, then from the deformation and the water content of the material layer the compaction rate of the material layer can be determined.

[0002] When constructing various facilities and earthworks knowing the bearing capacity and compaction rate of the foundations is of basic importance during the planning of the facility, the selection of the construction method to be used and during construction and quality inspection. Several procedures have been worked out up till now for the measurement of compaction rate. For all these it is necessary to determine so-called "Proctor-density", during which several layers of a specified volume of a sample of the soil to be examined are compacted per layer under laboratory conditions with a prescribed number of compaction impacts, then, taking into consideration the water content of the soil, the dry density gives the compaction rate of the soil under examination is determined from the comparison of the laboratory result received and the on-site inspection. Information relating to this examination procedure is also contained in the book by Dr Árpád Kézdi Talajmechanika II. [Soil Mechanics] (Tankönyvkiadó publishers, Budapest, 1975, pages 400-409), and in the book by Dr Ervin Nemesdy Útpálya szerkezetek [Road Structures] (Tankönyvkiadó publishers, Budapest, 1989, pages 28-37).

[0003] Equipment used for the on-site compaction rate testing of an area under examination is presented by patent description registration number HU 186.306, the essence of which is that a sliding element of set dimensions is pushed into the soil under examination, and the amount of penetration of the sliding element and the force required to make the penetration is measured, and the soil compaction degree is determined from these data. However, the disadvantage of the tests carried out with such devices is that they can only be used in the case of highly compacted soil with difficulty or not at all, furthermore, these tests depend to a large degree on the skill of the person carrying out the test, so they are not as precise as would be desired.

[0004] Due to this measurement uncertainty these devices and the measurements made using them are only used in agriculture soil preparation, where the relative lack of precision of the results received can not lead to a later danger of accident.

[0005] Another method used for the determination of the compaction rate of material layers is isotopic compaction measurement, in which, however, a radiation source is used for making the measurement. As a consequence of this due to the possibility of damage to health the measurement requires special care, furthermore, the continuous medical examination of the persons carrying out the tests is also required, which means significant extra costs and with this significantly increasing the expenses involved with the procedure.

[0006] Another disadvantage is also that in the case of this procedure sample compaction under laboratory conditions is also required, in other words a so-called Proctor test, so the measurement consists of several steps, which further increases its time requirement.

[0007] With the procedure according to the invention our aim was to overcome the deficiencies of the known solutions and to create a version with which the compaction rate of the soil under examination can be determined on-site, the procedure can be carried out simply, it does not require that special safety at work and accident prevention prescriptions be observed and which provides results that conform to the requirements, are precise and reliable.

[0008] The basis of the invention was provided by the physical fact that if impacts are exerted on an area of determined size of a material layer then the material layer subjected to a force will become compacted. The recognition that led to the procedure according to the invention was that the compaction rate of material layers in every case depends on how compact the material layer was before the force carrying out the compaction is exerted. In the case of a suitably compacted material layer the compaction taking place during the test is decidedly smaller than without any preliminary compaction. So in the case that we subject the material layer to the amount of compacting work that is normally accepted during other tests and we evaluate this in a way that is different from the known methods, then the task can be solved.

[0009] In accordance with the set aim the invention relates to a procedure for the on-site measurement of the compaction rate of granular material layers, especially for the determination of the compaction rate of material layers containing a solid part, liquid, and also material in the gaseous phase e.g. soils, during which, on the first part, a determined amount of deformation work is exerted on the surface of the material layer to be measured via the measuring instrument and the deformation of the material layer is measured, and, on the second part, the water content of the material layer is determined in a way that is known in itself, then from the deformation and the water content of the material layer the compaction rate of the material layer can be determined, which procedure is based on the principle that equipment containing a measuring head and a falling weight that may be moved as compared to the measuring head is used as a measuring device and the material layer under examination is subjected to the deformation impact work during the on-site compaction with the consecutive impacts of the falling weight of the equipment, and during the on-site compaction the material layer under examination is subjected to deformation impact work equal to the amount of the deformation impact work exerted during the compaction carried out by a standard laboratory compactor machine that is known in itself.

[0010] In a further realisation of the procedure according to the invention the material under examination is subject to deformation impact work equal to the amount of the deformation impact work exerted during the Proctor test, which is known in itself. As the exertion of impact work of this degree is sure to create the most compact state of the material layer that is under examination.

[0011] In still a further different version of the procedure during the compaction pressure-stress of between 0.2-0.6 MPa, advantageously 0.3 MPa is exerted on the surface of the material layer.

[0012] In an advantageous embodiment of the invention during the drops carried out in the process of the on-site compaction we create specific deformation characteristics from the amount of the impression of the granular material layer.

[0013] In a further advantageous embodiment of the procedure the compaction of the material layer is carried out in the same place, without any movement of the falling weight equipment.

[0014] In a still further version of the invention a body of mass 7-13 kg, practically 10 kg is used as a falling weight, as a measuring head we use a body that touches the surface of the granular material layer at a diameter of between 130-200 mm, advantageously 163 mm, e.g. a circular metal disc, furthermore the falling weight is dropped, without any damping, from a height of between 45-105 cm, practically 72 cm, onto the measuring head that is in contact with the surface of the granular layer under examination.

[0015] In a still further different realisation of the procedure before starting or following completion of the compaction a sample of the granular layer under examination is taken and the water content of the granular layer is determined in a way known in itself, and when determining the compaction rate the value of the water content is also taken into consideration.

[0016] The advantage of the procedure according to the invention is that in the case that it is used the test compaction can be carried out at the site of the measurement at the same time as the measurement, so precise values can be obtained that provide the actual result of the on-site compaction, which values are not dependent on the density or the possible density fluctuation of the soil.

[0017] Another advantage is that the measurement can be carried out simply and quickly, furthermore, it does not require structural elements that are dangerous to health or emit dangerous radiation, which results in fewer supplementary costs in connection with the procedure.

[0018] Another advantageous feature is that during the procedure not only can data be obtained that relate to the compaction rate of the soil under examination but also the bearing capacity (dynamic modulus) of the soil can be reliably determined on the basis of the same series of measurements.

[0019] Another favourable feature is that the procedure can be carried out anywhere, e.g. even in a work trench, due to the construction of the measuring device it is suitable for taking a great deal of measurements quickly and precisely, in other words with a great deal of efficiency.

[0020] An economic advantage is that due to the precise measurement results obtained as a consequence of the novel procedure the compaction rate and bearing capacity of roads can be checked and improved in the case of a fault during the construction phase, and so the roads do not subside or give way and the costly repair and maintenance work involved with this does not occur. A feature that can be listed here is that the procedure makes it possible for the measurements to be carried out simply and quickly, so tests may be carried out more frequently, which also serves more efficient quality control during manufacture.

[0021] Another economic advantage is that with the novel procedure the measurements can be carried out with lower costs, which results in further savings. In turn, due to the quick measurement results the duration of the construction work can be shortened, which has a favourable effect on the length of road surface that can be made in the available amount of time.

[0022] In the following the procedure according to the invention is presented in more detail in connection with an example.

<u>Example 1</u>

[0023] In the presented procedure example we determine the compaction rate of a material layer containing material in all three phases, granular material, water and air. For the compaction test we used falling weight equipment which had a falling weight of 10 kg, the part of the measuring head on the material layer under examination that touched the surface of the material layer was formed as a disc with a diameter of 163 mm, and in this way we exerted pressure-stress on the surface of the material layer of 0.3 MPa.

[0024] In the present procedure version we carried out 18 impacts onto the material layer under examination with the falling weight of the falling weight equipment. During this number of impacts we fed deformation compaction work of a well defined value into the material layer under examination - which was of the same amount of compaction work that was subjected by the test body to be tested during the known and accepted laboratory standard test, in this case the Proctor test.

On the effect of the input work the material surface under examination became depressed, and with the a part of the air in between the solid and liquid phases was forced out into the environment, as a result of which the compaction rate of the material layer increased.

[0025] The falling weight was dropped from a height of 72 cm onto the measuring head and when carrying out the 18 impacts they were grouped into six groups of three, in turn the degree of deformation within the groups was averaged. From the averaged deformation values we determined the relative compaction rate, then we determined the water content of the material layer under examination in a way that is known in itself. The on the basis of the water content we carried out a correction and determined the compaction rate of the material layer.

[0026] The procedure according to the invention can be used to good effect during the on-site determination of the compaction rate of various granular material layers containing three material phases.

Claims

1. A procedure for the on-site measurement of the compaction rate of granular material layers, especially for the determination of the compaction rate of material layers containing a solid part, liquid, and also material in the gaseous phase e.g. soils, during which, on the first part, a determined amount of deformation work is exerted on the surface of the material layer to be measured via the measuring instrument and the deformation of the material layer is measured, and, on the second part, the water content of the material layer is determined in a way that is known in itself, then from the deformation and the water content of the material layer the compaction rate of the material layer can be determined, **characterised by** that equipment containing a measuring head and a falling weight that may be moved as compared to the measuring head is used as a measuring device and the material layer under examination is subjected to the deformation impact work during the on-site compaction with the consecutive impacts of the falling weight of the equipment, and during the on-site compaction the material layer under examination is subjected to deformation impact work equal to the amount of the deformation impact work exerted during the compaction carried out by a standard laboratory compactor machine that is known in itself.

2. Procedure according to claim 1 **characterised by** that the material under examination is subject to deformation impact work equal to the amount of the deformation impact work exerted during the Proctor test, which is known in itself.

3. Procedure according to claim 1 or 2 **characterised by** that during the compaction pressure-stress of between 0.2-0.6 MPa, advantageously 0.3 MPa is exerted on the surface of the material layer.

4. Procedure according to any of claims 1 - 3 **characterised by** that during the drops carried out in the process of the on-site compaction we create a specific deformation characteristic from the amount of the impression of the granular material layer.

5. Procedure according to any of claims 1 - 4 **characterised by** that the compaction of the material layer is carried out in the same place, without any movement of the falling weight equipment.

6. Procedure according to any of claims 1 - 5 **characterised by** that a body of mass 7-13 kg, practically 10 kg is used as a falling weight.

7. Procedure according to any of claims 1 - 6 **characterised by** that as a measuring head we use a body that touches the surface of the granular material layer at a diameter of between 130-200 mm, advantageously 163 mm, e.g. a circular metal disc.

8. Procedure according to any of claims 1 - 7 **characterised by** that the falling weight is dropped, without any damping, from a height of between 45-105 cm, practically 72 cm, onto the measuring head that is in contact with the surface of the granular layer under examination.

9. Procedure according to any of claims 1 - 8 **characterised by** that before starting or following completion of the compaction a sample of the granular layer under examination is taken and the water content of the granular layer is determined in a way known in itself, and when determining the compaction rate the value of the water content is also taken into consideration.