RESPONSE FORM for 2018

Standardization needs and suggestions to EURAMET for consideration in their upcoming EMPIR calls

In the frame of the between CEN, CENELEC and EURAMET, CEN and CENELEC have been invited by the EURAMET Management to put forward their **testing and measurement needs in research** for consideration by metrology institutes for future calls under EMPIR*.

Relevant technical groups (sector fora, advisory boards, coordination groups, TCs, WGs...) are invited to contribute with

- a short introduction or an overview paper of their unaddressed standardization needs for testing and measurement, and
- a contact person (secretary, chair, convenor, liaison officer, etc.) whom proposers for the Potential Research Topics can contact,

by using this Response Form and send it at any time during the year to:

STAIR EMPIR WG, Mr Ortwin Costenoble: empir@nen.nl

Deadline for the consultation: **19 December 2017**. All late submissions will be submitted to EURAMET but cannot be guaranteed inclusion at the opening of STAGE 1.

Only identified needs with a proof by the standardization experts will be considered in time. Proof of need by the TC/SC is highly recommended for a successful submission.

Source of the identified need (identification of TC, WG, etc, incl. title)	☒ CEN/TC 193/WG 4 ☐ CLC/TC 0/WG 0 ☐ ISO/TC 0/SC 0 / WG 0 ☐ IEC/TC 0/SC 0 / WG 0 ☐ Other, namely *Identification, Title*
European entity responsible for submission of the need	*DIN German Institute for Standardization*
Person that can be contacted for more detail (name, e-mail and telephone number)	*Christoph Strangfeld* *christoph.strangfeld@bam.de* *+49 30 8104-4273* *Germany*
Unaddressed need (short description)	*European standard for the determination of the moisture content of screeds/subfloors*
Further explanation of need (TC business plan, road map, formal decision, work item, etc.)	*With regard to European & globalized markets and rising international activities of constructors it would be desirable to have an European standard method for the determination of the moisture content of screeds/ subfloors available. The direct measurement of the water content, which is the generally recognized code of practice in Germany seems not to be the method of choice as it is not accepted in most other countries, which is considered to be a barrier of trade. Furthermore,*

	material changes of cement screeds happened during the past 40 years and the market share of calcium sulphate based screeds with different compositions permanently increased. It would therefore be desirable to provide an European standard for the easy assessment of the dryness of subfloors prior to the installation of floorcoverings. The method should be independent from materials and applicable with available equipment. In order to achieve this goal the Convenor of CEN/TC 193/WG 4 informed DIN and BAM about the need for research. *The total project period is 2 years.*
Enclosures	☒ Yes ☐ No

*For more information, please consult: **EMPIR website**
CEN/CENELEC website "Standards and metrology"

B. Summary of the project

Overview

Most subfloors are made on-site based on mineral building materials mixed with water. Only a part of this water is needed as a reactant for the hardening process, most of it needs to evaporate. Subfloors shall be reasonable dry prior to the installation of a floor covering. Therefore, it has to be proven that the subfloor is satisfactory dry and no moisture damage occurs. In most countries of the Union, local codes of practice exist including deviating methods and thresholds. For quality control and to prevent damages in the future, a reliable and unified moisture measurement system applied in all European countries should be established.

Need

Determination of the moisture content of subfloors is essential in civil engineering. Up to 90 litres of water per square meter living space are utilised in new buildings. Although a major part is hydrated in the porous, mineral building material, several litres of water have to evaporate from the subfloor. However, in all cases the moisture content of the subfloor has to be known to prevent damages of the floor covering, even in new construction or during renovation. In Europe, different standards exist. In Germany, the so-called Kiln drying method or the calcium carbide method (CM) (TKB data sheet No. 16) are common. Outside German speaking countries, the so called corresponding relative humidity (CRH) method is used; nevertheless, three different national standards exist (BS5325, NT Build 439, NT Build 490). The European Union is trying to liberalise the trade of building materials. However, different measurement principles and competing standards regarding the determination of the moisture content in subfloors act like a massive market barrier. Therefore, a new and unified standard including firm thresholds is needed. Based on this consistent and coherent standard: 1. manufacturers of building materials are able to optimise their products; 2. flooring installer have a reliable approach for quality control; 3. manufacturers of moisture metrology have to consider only one parameter for optimisation of their devices.

Objectives

Several very different subfloor types and subfloors exist. They consist of different chemical substances and possess different physical properties. Therefore, several experimental tests are required to cover a broad range of subfloors. Most tests will be performed in climate chambers with high precision control of ambient conditions, mainly air humidity and temperature. The test schedule is the following:

1. Preparation of subfloor specimens with different compositions, in fact: a: cement based; b: calcium sulphate based; c: magnesia chloride based; d: added plasticizer or air entraining agent
2. Description of existing measurement methods, as far as they are not standardised.
3. Determination of characteristic values for moisture, verification of humidity thresholds (kiln-dry, CM and CRH). Thereby, the mobility of free water is of major concern because the mobile moisture really causes the damage
4. Evaluation of all factors which might influence the drying process and the corresponding moisture measurement, in fact: a: type of cement; b: water-cement ratio; c: aggregate-cement ratio; d: additives, e: age of specimen; f: thickness; g: ambient conditions, mainly humidity and temperature
5. Comparison of different test equipment and settings of the CRH approach, in fact: a: measurement close to the top; b: measurement in drill hole; c: measurement of samples taken from material; d: measurement humidity sensors embedded in the material during installation
6. Comparison of available humidity sensors with regard to accuracy, robustness and unit costs. Consideration of opportunities of data logging and monitoring for documentation and legal certainty
7. Determination of the reproducibility of the methods (Round robin tests)
8. Practical validation of CRH methods (3rd party verification)
9. Summary of all results and development of a draft standard

Progress beyond the state of the art and results

Screeds and concrete are made of porous, mineral building materials. This is the reason for the complex physics to describe the processes and the non-intuitive statement: water is not moisture. In porous, mineral building materials, a huge amount of the water is chemically bound (e.g. calcium silicate hydrate, ettringite, etc.) or physically bound (gel pore water, adhesive bound water in micro-pores, etc.). Different approaches for

drying generate different moisture levels because not only the free water is measured, chemically and physically bound water is partly recorded as well. Thus, depending on the drying method, different moisture levels can be determined for the same sample. In addition to the non-uniform measurement, the moisture content as an extensive quantity only poorly correlates with the risk of moisture induced damages. Not the water content itself, the mobility of the water is of major interest: the moisture transport. The moisture transport is governed by the water vapour pressure as an intensive quantity. The measurement of the water vapour pressure can be easily conducted by measuring the relative humidity of the porous material. In conclusion, if the relative humidity is equal in all layers (subfloor, floor covering, ambient air), the moisture transport is zero although different water contents exist in each layer. This is the thermodynamic equilibrium of the mobile, liquid water and the water vapour in the pores and layers. The moisture in each layer depends on the water vapour pressure and is defined by the sorption isotherm. If the humidity is unequal in the different layers, one is able to predict the moisture transport from the subfloor into the floor covering material. And this is the quantity of mayor interest because the mobile water causes the damage.

The relative humidity can be measured at different positions.

a) Directly on the top surface of the subfloor. Based on this approach, the result is mainly influenced by the near surface material. Thus, the measurement result may depend on the thickness of the subfloor. Tests have to quantify this effect. Another approach is to take a representative sampling of the subfloor material, crush the material and store it in a small, closed box or bag. A humidity sensor inside the bag or box give the humidity of the sampling material after the equilibrium moisture content is reached. This approach is destructive and monitoring is almost impossible.

b) Another approach is to drill a hole in the floor and inject humidity sensors. Depending on the bore hole size, this approach may take more than 24 hours and is destructive. Nevertheless, tests and optimisation could reduce the measurement time significantly and monitoring can be conducted easily.

c) The last approach is to embed sensors directly in the material during installation. This approach is non-destructive and includes monitoring over space (deepness of the subfloor) and time.

The tests and experiments have to reveal which approaches are practical within the required measurement certainty. The expected result is a detailed instruction to measure the corresponding relative humidity and evaluate in this way the moisture state of the subfloor. Based on this proven instruction, all participants (i.e. manufacturers of building materials, flooring installer, manufacturers of moisture metrology) can rely on the same measurement technique for quality control.

Some existing moisture measurement techniques (electrical, capacitive, acoustic, electromagnetic, etc.) measure the moisture content only qualitatively. Quantitative moisture measurements for extensive parameters (CM-%, Mass-%) require excessive calibration of each material. In contrast, the CRH (based on the intensive quantity: water vapour pressure), does not require any calibration for the material. This makes the approach very user friendly and interesting for practical applications as well as academic research.

Beyond the direct purpose of avoiding moisture induced damages on the floor covering, indirect progress with high research and market potential exists as well. Moisture monitoring based on CRH would generate a lot of data. Based on an advanced data analysis, very robust subfloors can be extracted and promoted. This would help manufacturer of building materials to design and optimise their products to special needs of the customers. Furthermore, new products, mixtures or additives do not need preliminary calibration because the CRH is calibration free. This highly reduces the market barrier for new and innovative building materials. In the future, based on the CRH data in combination with different drying conditions would yield valuable input for moisture transport models and simulations in material science. This would definitely help to understand material degradation (e.g. mould, corrosion, condensation, alkali silicate reaction, etc.).

Impact

Impact on industrial and other user communities

First of all, the flooring installer and the customer of construction work will directly benefit from this metrology research. An accepted and reliable method for moisture measurement in porous materials is a very powerful tool for quality control. At the moment, several standards and approaches exist in Europe. The techniques, which possess accepted validity during litigations, are partly destructive including a huge lag of repeatability and documentation. Thus, it is hard to judge if the moisture measurement was correctly conducted by the flooring installer. Other non-destructive methods highly depend on extensive quantities and the calibration is very complex. These devices are common in scientific laboratories but do not have the required robustness for practical use on the construction side. The CRH approach overcome all these issues and will deliver a robust and reliable approach of moisture measurement, which gives the floor installer much more legal security in case of damages. Furthermore, the common method in Germany, the destructive CM method, takes approximately 30 minutes for one single measurement point. The standard states that one moisture measurement is required for every 100 m² living space. In large constructions with thousands of m² (e.g. hotels,

hospitals, airport, etc.), moisture measurements with the current approach would take weeks or months. The CRH method could be non-destructive or embedded. Thus, taking several measurements at different positions is easy to perform. This will help to reduce significantly moisture induced damages of the floor covering and avoids inefficient, destructive moisture measurements.

With regard to European and globalised markets and rising international building activities, it would be desirable to have a European standard method for the determination of the moisture of subfloors before the installation of floorings in respect to the humidity or moisture content of the screeds or subfloors available. This uniformity will give building material manufacturer much more certainty of their products. They can focus on the design of their materials in respect to the expected requirements instead of adjusting their materials to various, unreliable moisture measurement techniques. Furthermore, European manufacturer can easily expend to other markets with different ambient conditions (desert, rain forest, cold regions). The CRH is able to handle all ambient conditions because is relies only on intensive quantities.

Regarding the common CM method in Germany, the expected time of drying of screeds is mostly three to four weeks. Then, moisture measurements are taken which require physical presence and time-consuming, destructive sampling. If the moisture is too high, a lot of time is wasted without any economic benefit. The flooring installer has to return some days later and repeat the entire time-consuming process. On the other hand, if the subfloor is already fully dry due to good drying conditions, time is wasted as well (in this case for the building owner). CRH measurements are able to show the moisture state of the subfloor at any time, thus, corrective actions can be taken early if it does not dry. Therefore building owner are interested in this technique as well. If buildings are one or two weeks earlier ready to use, the return of investment starts earlier as well (e.g. rental revenues, production chain, etc.). In conclusion, all participants, the floor layer, the construction company, the building owner, manufacturer of moisture metrology, have their own personal interest to participate and contribute to this holistic approach of moisture measurement.

Impact on the metrology and scientific communities

If one tested and accepted standard for moisture measurements in porous, mineral building materials is established, manufacturer will develop different metrology devices for moisture measurements (non-destructive, embedded, monitoring, etc.). These devices will be used in all European countries and for all porous building materials. This highly contributes to a harmonisation of the European market in moisture metrology as well as in construction and building material business.

If a competitive market for moisture metrology based on CRH exists, research institutes could buy these devices instead of developing and manufacturing own prototypes for moisture monitoring. All scientific disciplines regarding material science, moisture transport, or diffusion processes, may benefit.

A new approach in civil engineering is building information modelling, also called BIM. With this system, condition assessment of buildings and infrastructure should be based on real, measured values instead of estimated and more unreliable empirical values. Approximately 50% of all degradations in infrastructure are related to moisture. Thus, robust and reliable moisture monitoring definitely will be highly required in the future of BIM.

Impact on relevant standards

At the moment, a variety of standards exist:

Calcium carbide method (CM): TKB data sheet No. 16

Corresponding relative humidity (CRH): TKB data sheet No. 2, DIN ISO 1257:2013

Measurements close to the surface: BS5325

Measurements in drill hole: NT Build 439, ASTM F2170

Measurements based on sampling material: NT Build 490

Anhydrous calcium chloride: ASTM F1869-16b

This project aims to develop a test method which shall be converted into a European Standard (and if possible International Standard) which can replace the above given national standards. Therefore, a new work item proposal for CEN/TC 193 and ISO/TC 61/SC 11 will be developed which shall result in an EN ISO standard.

Longer-term economic, social and environmental impacts

Moisture in subfloors is not only an issue in new buildings, also after flood events, heavy rain, or pipe leakage. During renovation and repair work, the moisture of the structure and the subfloor has to be tested to avoid mould, generation of harmful bacteria, or moisture induced damages of the new floor covering. The yearly damages in Germany amount to more than 3 billion Euro. Moisture induced degradation of German infrastructure amounts to approximately 5 billion Euro every year. Therefore, moisture in screed, concrete, mortar and other building materials generate a yearly damage in Germany of more than 8 billion Euro. If these numbers are projected for the entire European Union, one ends up with costs of more than 40 billion Euro every year. If an adequate and reliable moisture monitoring in civil engineering and infrastructure may reduce the costs by 3%, one would save 1.2 billion Euro every year by avoiding moisture induced damages.

Normative Joint Research Project

In general, moisture transport and drying tests are performed or simulated in a standardised atmosphere of 23° C and 50% ambient humidity. This was a reasonable approach for most European countries during the last decades. Due to the climate change, more intensive rain seasons and higher humidity are expected for central Europe, especially during the summer time. In 2017, the summer in Germany was very wet including high humidity over weeks. Several building constructions were delayed by one to two months because the interior construction stopped due to too high moisture content in the screed. The CRH approach is based only on intensive quantities and is able to incorporate changes of the ambient condition. Based on monitoring data, the CRH will help significantly to design and improve building materials for various environmental conditions.