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Detection of capillary moisture in a ceramic brick wall using coupled chilled mirror and conductometric method

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ABSTRACT

The salt that appears with dampness is the reason why many non-invasive dampness detection methods are ineffective. This requires resorting to invasive methods, which naturally limits the possibilities of performing building diagnostics. The results from these methods are often not available at the time of testing, as they require specialist laboratory tests. Combining the conductometric detection method with the chilled mirror psychrometer would allow for obtaining qualitative data on the state of dampness. These results would be available at the testing site during the inspection of the building. This would provide valuable data for diagnostics, as well as allow for better optimization of other tests in the form of more optimal selection of samples for testing using other research methods. The obtained mutual correlation of both methods at different levels of dampness is a justification for further research.

Keywords: pF, matric force, sorption force, salinity, dump, capillary state.

INTRODUCTION

Commonly used building materials, especially ceramic materials, are susceptible to moisture. One of the most important causes of this phenomenon is their internal porosity. Without porosity, moisture cannot occur, because water migrates within it. For this reason, it should be discussed at the beginning. The term porosity refers to the occurrence of voids within a solid body. If these pores are connected to each other, creating pneumatic contact, such a building material is called a capillary-porous body. These bodies can be described according to Pogorzelski [1] with the following parameters: a) total pore volume; b) structure of porosity, defining its distribution depending on diameter; c) specific surface area of pores and capillaries.

When describing porosity, the size of pores is equally important according to Charola [2] which can be divided into: a) micropores ($\emptyset < 0.1 \ \mu m$);

b) mesopores (\emptyset 0.1 µm < 1000 µm); c) macropores (\emptyset > 1000 µm).

These values are not specified and there are significant differences in the precipitates among different authors. There are also significant differences in the precipitates in soil science, and for example according to Tyszkiewicz [3] they are as follows: a) micropores ($\emptyset < 0.5 \ \mu m$); b) mesopores ($\emptyset < 10 \ \mu m$); c) macropores ($\emptyset > 10 \ \mu m$).

Water in building materials occurs in various forms. The most strongly bound is chemically bound water, also known as constitutive or crystalline water. This is water built into the crystal structure of some minerals. The most well-known example of such water is the water contained in gypsum, which is hydrated calcium sulphate $CaSO_4 \cdot 2H_2O$. Hydrated minerals (not only gypsum) also occur in ordinary and cellular concrete. This water is strongly bound and can be separated by calcination at a sufficiently high temperature. The EN ISO 16682:2017 [4] standard provides a temperature range of 170-200 °C for most minerals containing water of crystallization, although for masonry structures this range is from 500 to 1000 °C. These values are different because the dehydration temperature is a variable value and depends on the specific mineral. A special example is the aforementioned gypsum, which, heated at a temperature of 128 °C, gradually changes into hemihydrate gypsum (CaSO₄·0.5 H₂O), to pure anhydrite (CaSO₄) at 163 °C [5]. Nevertheless, these minerals may show instability. For this reason, so that the presence of this water does not affect the result of the gravimetric test, it is recommended to reduce the heating temperature to 50 °C for plasters in the ISO 16682:2017 [4] standard. In the case of gypsum, the temperature recommended in the EN ISO 12570:2002 [6] standard is 40 °C.

Another type of water is sorption moisture, also known as hygroscopic water [3]. This is water vapor coming from the air and bound physicochemically by van der Waals forces [7]. A distinction is made between surface sorption (adsorption) and deep sorption (absorption) on the internal surface of porosity. This water does not have the ability to dissolve salts, does not conduct electricity, because it does not occur in the form of a liquid. This type of moisture occurs only and exclusively on the surface of hydrophilic materials. In the case of this type of moisture, the developed internal surface is a factor contributing to its formation [2]. An additional factor increasing this type of moisture is salinity. In particular, nitrates such as sodium nitrate (NaNO₂) or calcium nitrate $(Ca(NO_3)_2)$ exhibit high sorption properties [8].

In conditions of relative air humidity up to 15%, sorption moisture creates a monomolecular layer of water particles on the surface [9]. In the range of 15-80%, a multimolecular layer of water particles is created on the surface [9]. At relative air humidity above 50%, capillary condensation already occurs [9]. The significance of capillary condensation depends on the porosity distribution [10]. This phenomenon consists in the maintenance of liquid water and is caused by the occurrence of water in the form of concave meniscuses. Due to them, a local increase in the dew point occurs at the contact with the adjacent air and it is possible to maintain water in the liquid state without exceeding the dew point [2, 10, 11]. This type of water can be tested by the oven method (Darr method) using the procedure described in EN ISO 12570:2002 [6]. This moisture

is characterized by high variability depending on the type of building material.

For example, for ordinary concretes, mass moisture values reach up to 3%, while for wood and lignocellulosic materials even over 20% [1]. In the case of ceramic building materials, the maximum values of this type of moisture are assumed not to exceed 3% [12]. However, these are very approximate values. In order to correctly determine sorption properties or interpret gravimetric data, sorption absorption tests should be performed in several ranges of relative air humidity in order to obtain a sorption curve according to EN ISO 12571:2013 [13]. Alternatively, a simplified test according to ÖNORM B 3355: 2017 03 01 [12] can be performed in conditions of relative humidity of 85%. However, when performing this test at higher levels of relative humidity, the dynamic nature of capillary condensation, which causes a lack of mass stabilization, should be taken into account. Salinity is also a factor that increases the level of sorption. Some types of salts exhibit strong hygroscopic properties leading to the formation of saturated solutions of these salts. Depending on the temperature, liquid water may remain even when the relative dew point is not exceeded. For example, for sodium chloride, this happens already at RH from 75-76% and in the temperature range of 0-85 °C [14]. Even at this value of relative humidity, a significant increase in the value of humidity for this salt is observed. This also applies to other salts in other RH% ranges [15]. Despite the occurrence of saturated solutions of salts in equilibrium with air, this type of humidity is still treated as hygroscopic water in construction.

Another type of water that occurs is capillary water. This type of water is already in the liquid state, which means that it has the ability to dissolve salts and conduct electricity. The presence of this water already affects the deterioration of the insulating properties of the partition. This water is physically and mechanically bound to the building material [1]. Due to the forces of surface tension, in direct contact with water, water is pulled up within the capillary-pore body with pore diameters in the range of 200-10.000 nm [3]. The capillary movement that appears as a result of the above forces causes water to move in all directions within the partition, striving to equalize the suction potential of water within it. Salt ions accompanying the water move in this way. Another type of water that can occur

is gravitational water, also called free water. It remains in pores above 10.000 nm. The capillary forces occurring at these pore diameters are not able to hold water on their own, which gradually flows down due to gravity. This type of water is not described in many publications on construction. Hence the need to use definitions used in soil science [3]. This water can appear on buildings in the event of technical failures, pressure, or flooding. This water, together with capillary water, is detected by gravimetric methods described in the standards [4, 6, 12, 16], in order to separate them, they require determining the maximum hygroscopic level in order to interpret the obtained results. The moisture testing methods described so far, which were directly or indirectly based on heating. A method that does not require heating is the carbide method. The essence of this method is the reaction of calcium carbide (CaC_2) with water. As a result, calcium hydroxide (Ca(OH)₂) and acetylene (C_2H_2) are produced. The entire process takes place in a sealed container and the generated acetylene contributes to the increase in pressure. The amount of moisture is read using a calibrated pressure gauge.

One of the physical quantities characterizing the moisture content of porous media is water potential which has been used in soil science for many years. This value is described using the pF index. Initially, the creator of this term, Schofield [17], defined it as: suction in pF = log10 (in centimetres of water). However, the contemporary meaning of this term has changed and the soil water potential is used [18] and is expressed in units of $pF + \log h$ (cm H₂O). This is the decimal logarithm of the height of the water column h (cm), the pressure of which corresponds to the soil suction force. This force can also be expressed in pressure units, e.g. MPa, atm [19]. The sorption force of a porous building material or the soil is a component of a number of different forces and they are different depending on the degree of moisture [18]. It consists of: (1) the force of gravity and is the only force that has a specific direction, in this case vertical. In relation to the other forces, it represents small values of the order of maximum 0.01 MPa and can be the dominant force for water filling pores of 10.000 nm and larger. It also occurs in smaller pores, but it is not of significant importance, because its effect is masked by the matric force, which is related to the porosity itself. (2) The matric force also occurs in pores above 10.000 nm and contributes to the

temporary delay of water settling, as well as the slower flow of water under pressure through the porous medium. This force has a dominant effect for water in the hygroscopic range filling pores smaller than 100-200 nm. It is thanks to this force that capillary absorption is possible in all directions, including upwards. Another element of the sorption force is (3) the osmotic force (osmotic potential). Its existence requires the presence of liquid water with dissolved ions and depends solely on the concentration of water-soluble substances. The concentration of these substances is responsible for the development of osmotic pressure. The sorption force also includes (4) pressure potential energy. This force can be divided into atmospheric pressure potential and hydrostatic pressure potential. These forces occur in unsaturated and saturated conditions, respectively [20].

Knowing the matric strength of a given hydrophilic material, it is possible to determine its moisture content. In the range from pF 0 to pF 2.54, free water occurs [21], although values of pF 0 to pF 2 are also found [3]. The upper limit of the presence of capillary water occurs up to pF 4.5, above which water is already in a hygroscopic state [3, 21]. Standardly in soil science, the obtained results of the suction force are compared with volumetric moisture and presented graphically in the form of a pF curve. By comparing individual curves, it is possible to calculate individual types of porosity and thus also water retention or the effect of salinity [22]. To determine such a curve, data on both sorption force and water content are needed in various moisture ranges in the range of 0 to 7 pF [3]. There is no single universal method that provides such a wide range of testing and at the same time presents appropriate accuracy. Hence the need to use several methods, the description of which, together with the scope of their application, is provided below [19].

One of the methods of determining the pF value is the (1) sandbox method. The method is based on the suction force of the substrate on which the sample of the tested material rests. In the case of using a material with a sand fraction, results can be obtained in the range of 0 to 2 pF. When using kaolin, it is possible to test the sorption force in conditions from 2 to 2.7 pF [23]. This method allows for testing only the matric force.

Another way of testing the matric force is the (2) contact filter paper method. This, one of the oldest research methods, is based on the hygroscopic properties of paper. Two papers closed in a

tight container with a sample are used for testing. One of them is in contact with the sample and the other only with the air in the sample. In controlled conditions at a constant temperature, the moisture level of both paper filters is determined over a period of about a week. Then, the moisture level of both filters is tested using the gravimetric method and the matric force is calculated using the appropriate formulas [24]. This method allows for testing the sorption force in a very wide range, even up to pF 7 [25]. This method cannot be used for sorption forces below 2.5 pF [24].

Another method for determining the matric force is (3) tensiometer measurement. This method involves measuring the suction force (pressure) of the tested material in contact with water. The measuring solution is located in a container made of porous ceramic material and thus has hydraulic contact with the tested material. The suction force of the tested material causes the formation of a measurable negative pressure, which is measured using a barometer located in the container. This method allows for measurement up to 100 kPa using water [25]. One of the variations of this test is (full range tensiometer/High-capacity tensiometer), where the measuring solution is water with polymer. Changing the solution allows to increase the measuring range to 1500 kPa [25]. The membrane method is another method for testing water sorption forces. The device is structurally very similar to the dust block, although the idea of this method is more similar to the full range tensiometer/High-capacity tensiometer. The device operates on the suction force of a material with microscopic pores in contact with the tested material. However, the measurement takes place in an environment with increased pressure. When the sample in the pressure chamber is exposed to increased pressure, the water in the sample penetrates the membrane and is collected in a separate tank. Due to hysteresis, the measurement lasts until the conditions in the chamber stabilize, i.e. until the water stops flowing into the control tank. This method allows to obtain both the pF force value and the moisture level. The usability of this method is in the range of up to 1500 kPa [25, 26].

Another method possible to measure water potential is the method (4) using the Peltier thermoelectric psychrometer. This method is based on the assumption of the occurrence of equilibrium of relative humidity of the air in relation to the water contained in the sample. After stabilization of the conditions in a specific measurement environment, the relative humidity of the air is measured using a thermojunction. The current flowing in different directions cools or heats the junction in order to determine the dew point. This method allows to measure the matric force together with the osmotic force and gives satisfactory results in the pressure range of 0.4 to 6 MPa [27], although this method can be used to test the range from 0.2 to 7 MPa [28].

Chilled mirror psychrometer (5) is another method also based on measuring the relative humidity of the air in equilibrium with the sample [29, 30]. To speed up this process, a fan is placed inside a sealed test chamber. In this chamber, there is a mirror that reflects light from the diode to the recorder. When condensation occurs on the mirror, the light rays are interrupted. At this point, the sample temperature is also accurately read using a pyrometer [31]. Then, using the formula, the result is calculated:

$$\psi = \frac{RT}{M_w} \ln \frac{e_s(T_d)}{e_s(T_s)} \tag{1}$$

where: $e_s(T_d)$ – saturation vapor pressure of the air at dew point temperature; $e_s(T_s)$ – saturation vapor pressure at sample temperature; R – gas constant (8.31 J/mol·K); T – sample temperature (K); M – molecular mass of water (18.01528 g/mol).

This type of measurement allows for measuring in the range of 0-300 MPa. However, the accuracy of ± 0.05 MPa in the range of 0 to 5 MPa, 1% in the range of 5 to 300 MPa should be taken into account. According to American standards, this technique can be used for measurements in the range of 0.5-100 MPa (ASTM D 6836 - 02). This method allows for testing the sorption force, which consists of the matric potential and the osmotic potential. All the more so because the device itself is calibrated on salt solutions (standard KCl, but different ones are possible, such as NaCl, LiCl) according to the manufacturer's instructions. However, it is possible to separate the osmotic and matric potential. In soil science, the method of measuring electrical conductivity is widely used [32]. For this purpose, the sample should be soaked to saturation and then its electrical conductivity (EC) should be measured using the formula Pos (Mpa) = -0.036EC (ds/m). Then, from the ratio of water content in the sample (W%) to the water content in the saturated state (WS%), the osmotic force P =Pos(W%/WS%) can be calculated.

The aim of the study is to check the possibility of detecting capillary moisture in building materials using a combination of two measurement methods: measuring the water potential using the Chilled mirror hygrometer method in combination with the conductivity method. Due to the small size of the necessary measuring devices, the proposed research methodology allows for performing in-situ tests and obtaining useful information on the existence of moisture in the capillary state.

MATERIALS AND METHODS

Measuring setup

The sorption force tests were carried out using a Chilled mirror hygrometer according to ASTM D 6836 - 02 using Metler's WP4C (Figure 1). According to the manufacturer's instructions, the tests were carried out in the mode that allowed obtaining the most reliable data, i.e. in the p mode. The device was calibrated using the sets provided by the manufacturer.

Electrical conductivity tests were performed using the conductometric method using a TDR device with built-in conductometric detection. The basic set consists of a FOM2 control unit (E-Test, Lublin, Poland) and a measuring sensor (Figure 2). For comparison purposes, several LP-ms (laboratory probe) sensors were used, as well as FP-mts (field probe) field probes. During the tests, some of the probes were modified by shortening their measuring elements. For comparison purposes, a Mettler Seven2Go S7 conductivity meter was also used.

Sample preparation and test procedure

The research was divided into 2 stages. The initial stage was used to learn the operating characteristics of individual types of TDR probes, as well as to compare them with devices determining osmotic force. Aqueous salt solutions were used for this purpose. The following salinity levels (by mass) were used: 0.1%, 0.2%, 0.3%, 0.4%, 0.5%, 1%, 2%, 3%, 4%, 5%, 10%, 15%. In the initial stage, the prepared solutions were parameterized directly in the vessels in which they were prepared. Comparisons with a conductivity meter were also carried out. Vessels with a capacity of 250 ml were used for the tests: 6 (six) FP-mts field probes, 2 pcs. LP-L, and 6 pcs. LP-S

The next stage included comparative studies of modified TDR probes. For this purpose, the FP (field probe) was shortened from its original length of 9.7 cm to 1.7 cm (Figure 3). Comparative studies were also carried out in a smaller vessel, which was a modified syringe.



Figure 1. Device for testing the WP4C sorption strength, and containers with a capacity of up to 15 ml (with cap) for carrying out the test



Figure 2. 250 ml vessel with TDR probes used in research, from left: FP-mts (field probe), LP-ms (laboratory probe) 2 different types short (S) and long (L), FOM2 control unit



Figure 3. The 9.7 cm FP field probe compared with the shortened 1.7 cm version. Also visible is the container in which the shortened version of the field probe (TDR FP ss) was tested, and the FOM2 control unit

RESULTS

Figure 4 presents the results of solution salinity tests in the form of a comparison of the results obtained from the TDR meter with the methods used so far, i.e. conductometers.

The Mettler Seven2Go S7 device, shows an increase and then a decrease up to a certain point. The manufacturer of this device declares a useful test range of 0-10 S/m, so it is not suitable for highly

saline aqueous solutions. The WP4C is a different story, measurements carried out in the device in the MPa mode show values that increase with increasing salinity. This relationship is confirmed by the R^2 determination coefficient of 0.9862. Due to the smaller range of read conductivity values obtained using TDR probes with conductometric detection, they were shown in a separate graph for better visualization (Figure 5). They clearly show the differences between the individual probe types.



Figure 4. Results of electrical conductivity measurement S/m of aqueous solutions depending on salt concentration. Mettler conductivity meter, WP4C (result shown in MPa), TDR with probes: field FP, laboratory short (LP S), laboratory long (LP L)

The data from the results of electrical conductivity measurements in different salinity environments for individual probe types presented in Figure 5 indicate significant differences between them. Laboratory probes: both short (TDR LP S) and long (TDR LP L) show lower values of the determination coefficient R² compared to the field probe (TDR FP). measured using WP4C (Figure 6), one can also see a better match for the measurements made with field soda (TDR FP), for which the coefficient of determination is 0.9167, while for the laboratory probe it shows 0.696 and 0.6452 for the long probe (TDR LP L) and the short probe (TDR LP S), respectively.

Comparing the data of individual TDR probes in relation to the osmotic force measurements

The second series of tests included testing with a modified probe (TDR FPss) in a large container with a volume of 250 ml and a smaller one



Figure 5. Results of measurement of electrical conductivity S/m of aqueous solutions depending on salt concentration. TDR probes: field FP average results from 6 probes, laboratory LP S average results from 6 probes, laboratory LP L average results from 2 probes



Figure 6. Relationship between the electrical conductivity readings (S/m) measured by TDR and the osmotic force of the solution (MPa) tested by WP4C

of 10 ml. As can be seen in Figure 7, the shortened probe shows a better fit coefficient in relation to salinity than the previously presented unmodified ones. The value of the coefficient of determination for the volume of 250 ml is 0.9067, while in the case of tests in the environment and a smaller volume of 10 ml it increases to 0.9168.

By comparing the electrical conductivity of the tested shortened field probe with the osmotic force (Figure 8) we obtain an even better fit for 250 ml and 10 ml. The coefficient of determination is 0.9736 and 0.9792, respectively.

DISCUSSION

The presented electrical conductivity measurements with different TDR probes show that there are significant differences between them. The best adjustment to variable salinity conditions



Figure 7. Relationship between conductivity readings (S/m) and salinity (%) tested using a shortened field probe. The study was conducted in 2 environments in volumes: 250 ml (FP ss) and 10 ml (FP sss)



Figure 8. Relationship between electrical conductivity readings (S/m) measured by TDR and osmotic force of solution (MPa) tested by WP4C. The study was conducted in 2 environments in volumes: 250 ml (FP ss) and 10 ml (FP sss)

is shown by the TDR field probe. Laboratory TDR probes show a worse adjustment. Additionally, the shortened TDR field probe shows an improvement in correlation, as evidenced by the increase in the determination coefficient. For technical reasons, it was not possible to check whether a similar phenomenon would occur in the case of TDR laboratory probes. This was caused by their construction, or more precisely, their built-in transistor, which was not able to perform the measurement after shortening. Additionally, the electrodes of laboratory probes are characterized by low stiffness, they are suitable for measurements in solutions and soil, but they may not necessarily be suitable for building materials. In the case of the field probe, the mentioned electrodes are characterized by much greater stiffness. As studies have shown, their shortened version tested in a 250 ml environment shows a determination coefficient value of 0.9736, while in a smaller volume of 10 ml solution even 0.9792. The latter environment is characterized not only by the best correlation, it is also the sample volume used for testing using WP4C. The estimated relationship of this formula (Figure 9) in relation to the data from WP4C is Y = 0.2739x + 0.2814 with a determination coefficient of 0.9736. The presented relationship confirms this possibility.

The demonstrated relationship between the electrical conductivity of the short TDR field

probe and the sorption force (WP4C) demonstrates the validity of a new approach to testing moisture in the presence of salt. As practice shows, most buildings, if not all, that exhibit moisture of capillary origin experience salt accumulation over time. This is due to salt concentration as a result of water evaporation. The increased presence of salt also contributes to an increase in the level of sorption moisture and creates problems in detecting the level of moisture. Non-invasive methods of detecting moisture based on detecting electrical conductivity in the presence of large amounts of salt fail. It is true that one can try to correlate them [33], but this requires accurate data on the level of salinity, which cannot be obtained without taking samples and delivering them to the laboratory. In conservation practice, the results obtained using non-invasive methods are not considered reliable [3, 34].

It is no wonder then that the gravimetric method is still considered the only reference method for determining the level of moisture in building materials and structures. However, it is not without its flaws. The obtained result is presented as a percentage loss of mass of the tested material during the drying process. The forms of water presence in building materials discussed at the beginning indicate that the interpretation of this percentage result is not so simple, because apart from water in a capillary state, it could be



Figure 9. Compatibility of the obtained correlation of the short TDR probe in the tested volume of 10 ml in relation to WP4C

sorption moisture or crystalline water. Not to mention that the measured mass loss during the gravimetric test may also result from the evaporation of petroleum substances used in construction. As a result of the factors mentioned earlier, the tabulated degrees of wall moisture are formulated in a very conservative manner, not taking into account both the differences in the structure and the level of salinity load (Table 1).

The issues described above should also be applied to the moisture analyzer method, as it is essentially its field variant, but based on a smaller number of samples and a shorter testing time.

Attempts have been made to tabulate the issue of the maximum level of sorption moisture, e.g. EN ISO 12524:2003 [35]. However, this standard, like many others, has been withdrawn. Therefore, in order to correctly interpret the result of a gravimetric test, it is necessary to determine the actual level of sorption moisture. The EN ISO 12571:2013 [13] standard serves this purpose, but acting according to its guidelines, this process is long and can also be expensive. For this reason, this standard is not used in routine tests of existing objects. A certain solution that is more adapted to routine tests of this type is the ÖNORM B 3355: 2017 03 01 [12] standard, which allows for determining sorption properties in one moisture environment, namely 85% RH. This is the limit value for determining the level of mycological threat, but it is still

Table 1. Wall dampness levels used in Polishconstruction literature, source: Monczyński [10]

Moisture level	Mass moisture <i>u</i> [%]	Moisture classification
I	0÷3	Wall with allowable moisture
II	3÷5	Wall with increased moisture
	5÷8	Moderately damp wall
IV	8÷12	Very damp wall
V	> 12	Wet wall

not above which moisture occurs in the capillary state, and it occurs only above the dew point, i.e. at 100% RH. A certain explanation for the use of these values is the hygroscopic properties of salts, which can absorb water and become wet at relative humidity significantly below 100% RH, such as NaCl. As can be seen, the presented methods of testing the moisture level do not provide the possibility of in situ unambiguous determination of the presence of water in the capillary state. The presented relationships between: measurements of sorption force measured using a mirror psychrometer and electrical conductivity using TDR probes, are an attempt to find a new way of testing moisture in structures. The new methodology derived from methods recognized in soil science also allows the use of terminology used in soil science. The terminology used to determine moisture states also comes from soil science and, according to the author,

describes the levels of moisture in building materials very well. By using this terminology, it is possible to clearly determine whether the tested material contains liquid water or not.

CONCLUSIONS

The conducted studies indicate the usefulness of the method of testing moisture using a mirror psychrometer with parallel measurements of electrical conductivity. Electrical conductivity measurements made using a TDR device with a built-in function of testing electrical conductivity can be carried out on various probes, but field probes are the most suitable for this purpose. This is due not only to their better correlation, but also to their greater stiffness and the possibility of shortening them. Shortening the probe has a positive effect on improving the correlation. The obtained correlation enables qualitative determination of the presence of moisture in the capillary state. Due to the speed of the test, which takes several minutes, and its field nature, the information obtained as a result would be of significant importance for the process of field inspection of the tested object. The discussed correlation may be the basis for developing a research methodology for field detection of water if the pF result indicates a result below pF 4.5, or electrical conductivity is demonstrated if pF is above 4.5. The obtained results would be a valuable tool during field work. They could be used to optimize the number of samples taken, thus speeding up the duration of the inspection and reducing the amount of interference with the object. There is also a chance for correlations that would allow obtaining quantitative results. However, a number of research works should be carried out to demonstrate such a possibility. To carry them out, samples with a known pF value (matrix) and variable salinity would be necessary. This type of test should be carried out on building materials. The obtained results are an incentive for further research, this time based on building materials.

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