GROUT DEFORMATION MODULUS: HOW CAN IT BE MEASURED?

[(1)] Rocha-Gomes, Leila Verônica da
[(2)] Tristão, Fernando Avancini

[(1)] Teacher at the Centro Federal de Educação Tecnológica
Student at the Civil Engineering Post-Graduation Program
Universidade Federal do Espírito Santo - Brazil
leila@cefetes.br

[(2)] Professor of Civil Engineering Post-Graduation Program
Universidade Federal do Espírito Santo - Brazil
fernandoavancini@ct.ufes.br

ABSTRACT

Grout is one of the components of the ceramic coating system, which might be responsible for a number of pathological manifestations occurred in the ceramic-coated building façades, such as loose tiles and cracks. Such pathologies might be directly associated to whether or not grout has the ability to absorb stresses suffered by ceramic coating system. The purpose of this work is to discuss methods to measure grout deformation capacity, since no testing standard has been included in the Brazilian Association of Technical Standards (ABNT) yet. Literature revision involved three stages: Conceptual approach, review of the main methods used to measure grout deformation and evaluation of the influence of temperature over ceramic coating system behaviour. As a result, it was noticed that some concepts regarding grout deformation are being inappropriately adopted, e.g., the word "flexible", and that the current testing methods being used are not adequate to measure grout deformation capacity.

1. OBJECTIVE

To discuss method for measuring grout deformation capacity.

2. INTRODUCTION

Brazilian standard NBR 13816 (ABNT, 1997) defines Ceramic Tile Coating as "a set formed of ceramic tiles, ceramic tile adhesive and grout". Grout is mortar used to fill grout joints between the ceramic tiles. However, the Brazilian standard NBR 14 992 (ABNT, 2003) for grout specifies testing methods only for Portland cement based products, although the commerce of grout made up of other material, such as epoxy resin, is a common practice in the market nationwide.

Induced stresses created in ceramic coating layers – substrate shrinkage, ceramic tile expansion due to humidity absorption and thermal dilation, shrinkage due to drying of adhesive (BUCHER NAKAKURA, 1995) and shrinkage of the grout itself – result in deformations which may lead to severe pathological manifestations such as cracks and displacement of ceramic tiles. Grout is used, among other things, to seal ceramic tile grout joints, thus allowing for the absorption of deformations suffered by ceramic tile coating. In order to achieve this purpose, the material used for filling the joints shall be able to change its size while under stress, and go back to its original dimension without compromising performance (JUNGINGER et al., 2002), that is, material shall be able to absorb deformations (BAUER; RAGO, 2002) and have elastic properties. Very few materials are known to have linear elastic behaviour, in which initial relative deformation is essentially proportional to the stress applied to it.

In Brazil, some studies have been carried out since 1995 in order to find a method to measure mortar deformation capacity and develop an adequate testing method. However, research results suggest that new comparative studies should be carried out since there are no convergent conclusions yet. The aim of this work is to discuss the method to measure the deformation capacity of Portland cement-based grout, taking into consideration that ABNT has no standardized testing method yet.

3. METHODOLOGY

Literature revision focusing on three stages: Conceptual approach, review of the main methods used to measure grout deformation and evaluation of the influence of temperature over ceramic coating system behaviour.

4. LITERATURE REVISION

4.1. CONCEPTUAL APPROACH

During the implementation of the research, some concepts used to characterize mortar deformation capacity were observed to be inadequately used, which aroused interest in continuing conceptual approach initiated by Bastos (2003) with the purpose to resume and develop the discussion in the technical and scientific sectors.

Materials may suffer immediate specific deformation, also known as elastic deformation, which is reversible, or plastic deformation, which is irreversible, when unloading the stress applied. Elastic deformation occurs inside elastic limit while plastic deformation occurs outside this limit. Figure 1 shows Stress-deformation diagram of a fragile material such as ceramic materials[1].

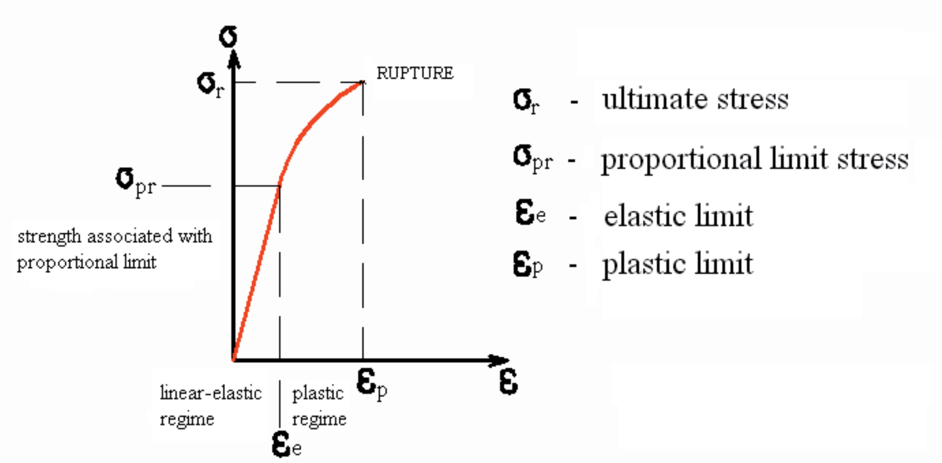

Figure 1. Stress-deformation diagram of fragile materials

To a certain extent of the stress applied, the material works on linear-elastic basis, that is, in compliance with Hooke's law and the specific linear deformation is proportional to the stress applied to the rectilinear stretch of the stress-deformation diagram. Proportionality constant called "longitudinal modulus of deformation" or "modulus of elasticity" (SILVA, 200-?) is the mechanical property which measures material interatomic bonding force, and is related to the rigidity of the resulting engineering product (VAN VLACK, 1984). It is determined by the ratio between the Stress applied and the resulting unit deformation (L.A. FALCÃO BAUER, 2006)

In static loading tests, elastic deformations can be observed in which deformations are proportional to the stresses, or plastic deformations (BASTOS, 2003), in which deformations are permanent. Material behaviour in relation to the type of deformation it will have depends on its mechanical, physical and chemical characteristics and properties.

As the grout is the material for filling tile joints which are necessary to accommodate size variations of the ceramic tile coating, it is essential that it has the ability to sustain deformation and that this deformation is reversible to allow expansion and shrinkage of the Ceramic Coating without affecting its functional performance. However, Portland cement based grouts are rated as "ceramic materials which generally are not subject to deformation and are usually stable under severe ambient condition", in accordance with the characteristics set out by Material Engineering (VAN VLACK, 1984, p.302).

In Brazil, several tile grout manufacturers adopt the term "flexible tile grout" to characterize a type of grout that "efficiently adapts itself to different situations" and, according to product marketing statement, has the ability to sustain stresses and follow

1. Ceramic material covers a variety of substances, such as glass, bricks, tiles, concrete, abrasives, varnish and enamel for porcelain, dialect insulators, non-metal magnetic material, refractory material for high temperatures, etc., (VAN VLACK, 1984, p. 301).

expansion and contraction movements caused by weather changes. However, the term has been misused, as a flexible material characterizes itself as being ductile, allowing bending, without rupture, which does not mean that the deformation is of the elastic type, i.e. reversible. A typical flexibility type of plastic deformation can be seen in the lamp (Figure 2) or the microphone (Figure 3) with flexible rod that can be bent or wound according to the position required by the customer and remains static in one position until another one is set.

Figura 2. Lamp. Available at: www.brindesuniao.com.br

Figura 3. Microphone. Available at: www.atera.com.br

"Resilience" is the term adopted by Exact Sciences to characterize certain material properties for accumulating energy, when they are loaded and stressed, and recover its original condition with no deformation. The concept of this term has been highly accepted and has been imported by Human and Biological Sciences in order to "describe the ability of an individual to positively surpass and build himself/herself under hardships" CARMELLO, 2004, p.12).

Helvecia (2004) used this concept to describe human competence for dealing with the elasticity property – like the athlete pole vault, for instance – it is bent to the maximum limit without breaking, and immediately recovers its previous condition, throwing the athlete upwards.

According to Standard ASTM D2632 apud Vilar (2004), resilience is established according to the energy regained (recovered) after deformation caused by stress. It is usually measured by the energy percentage recovered and provides information about the material elastic character.

In Metallurgy, resilience means the property a certain material has to immediately recovering or adapt to a new situation. Resilience is also the property by which a body returns energy stored when it undergoes an elastic deformation as soon as the deformation stress is halted. A perfectly elastic material is 100% resilient and is a perfect absorber rated 0 (zero) (VILAR, 2004).

4.2. GROUT DEFORMATION CAPACITY

The Standard NBR 14 992 A.R. – Portland cement based grout for filling ceramic tile joints – Requirements and testing methods (ABNT, 2003) does not make any reference to this subject. Therefore, it is necessary to carry out further studies and experiments to provide support to the preparation of an adequate method to measure grout deformation capacity, taking into consideration the stresses sustained by the coating system under actual bad weather condition and the property of each material which the grout is made up.

Most researches carried out in Brazil to assess grout deformation capacity use international standards or an adaptation for the static modulus of deformation method for concrete testing sample, from the Brazilian Standard NBR 8522 (ABNT, 1984), although the latter has been doubted for its efficiency when applied to grout (BAUER; RAGO, 2002).

The ideal numeric value for tile joint grout modulus of deformation is a parameter that has not been established yet and it is difficult to be evaluated due to lack of correlation between this value and material behaviour after its application and use. Tests currently adopted do not take into consideration the factors that give rise to movements in the coatings and do not measure material reversible capacity.

Deformation capacity of Portland cement based bonding grout was evaluated by Bucher and Nakamura (1995) using three different methods from international standards. In the conclusion they say that results cannot be compared and tests described in these standards do not require testing samples to undergo humidity cycles, which is highly recommended for a sampling method that tries to simulate reality ceramic tile coatings are exposed to.

In the stress-deformation curve included in the work developed by Godoy and Barros (1999a), using the loading plan of the method of static deformation modulus of elasticity for concrete, NBR 8522 (ABNT, 1984), and the adaptation of the British Standard, BS 4551/80, for testing sample preparation, Portland cement based mortar for tile coating with additive showed a greater Modulus than Portland cement based mortar for coating without additive, when subject to the same stress. However, while comparing those two curves it was observed that the grout with greater Modulus sustained a greater rupture load and showed a greater deformation capacity. This result shows the difficulty the adopted method presented while relating the value found for the Modulus with properties and characteristics of materials present in both mortar types sampled.

Another research by Godoy and Barros (1999b), where styrene-butadiene resin (SBR) and styrene-acrylic resin (M) were used in mortars as sealing layer in wet places, showed that for the majority of mortars with polymer addition, the modulus of deformation decreased over time, while for reference mortars (without polymer resin) the Modulus value increased. However, they concluded that certain types of tensioactives build a strong polymer film that contributes to increasing compression strength, and might increase the value of the Deformation Modulus and, at the same time, develops the capacity for absorbing deformations. These apparently contradictory results indicate that further comparative studies focused on relating the Modulus of Elasticity to the material behaviour regarding its strength and deformation capacity should be carried out.

Another way for measuring mortar Modulus of Elasticity is the Dynamical method. The Dynamical Modulus of Deformation may be calculated by resonance frequency or by ultrasound wave propagation velocity. Monde and others (2007) carried out tests for comparing results from both methods and concluded that, although an excellent correlation between the two methodologies were confirmed by results, the testing sample shape has an effect on the Dynamical Modulus of Elasticity value. This factor is believed to be influenced by apparent mass density of different size testing samples and moulding procedures. Thus, they suggest studies, among other things, to establish testing sample moulding procedures which ensure homogeneity of apparent mass densities and researches to evaluate the influence of the mortar's Poisson coefficient on the Modulus value which is a variable of the ultrasound wave method.

In the ultrasound method (figure 4), the modulus of elasticity is determined by the function of the velocity in which the ultrasound wave travels the distance between the two instrument electric pulse transducers (emission and reception), the material density and the Poisson coefficient – in the case of mortars it ranges 0.10-0.20 (CARNEIRO, 1999 apud SILVA; CAMPITELI, 2006). In the case of testing samples, the distance between transducers equals their height.

Figure 4. PUNDIT-Portable Ultrasonic Non-destructive Digital Indicating Tester

The Brazilian standard NBR 8822 (ABNT, 1994) prescribes a sampling method to determine the longitudinal wave propagation velocity by ultrasound pulses through concrete elements. This method has the following objectives: to check concrete uniformity, to detect occasional concrete casting internal defects, to evaluate fissure depth or other defects and to evaluate the modulus of deformation (FIGUEIREDO, 2005).

The standard DIN EN 125-04, (2004) "Testing Concrete in Structures – Part 4: Determination of ultrasound pulse velocity", which also determines the testing method to measure the ultrasound wave propagation velocity, reports that small defects or faults inside the testing sample has little or no effect on time, and, as a consequence, on the wave transmission velocity. Such statement might be used as a reference for more detailed studies in order to use the dynamic method to determine the mortar deformation modulus and check whether or not it has any influence over the testing result.

Silva and Campiteli (2006) used the dynamic method to evaluate the grout elasticity modulus and decided that both wave propagation modulus and velocity are significant variables which can be used to monitor performance of mortar coating as to mechanical strengths and the occurrence of cracks.

The advantage of the ultrasound method is that it is non-destructive, fast and easy to use (SILVA; CAMPITELI, 2006); in addition, it allows the use in testing samples, in laboratories and in already consolidated structures. Since it is non-destructive, when used in laboratories, it is also possible to measure the static modulus of deformation in destructive compression and tensile strength tests under bending, subsequently comparing the results.

Bastos (2003) managed to gather information during his work showing the variety of methods, testing parameters and testing samples adopted to determine the grout Modulus of Deformation that make it impossible to compare the results of different authors' research.

Bastos (2003) also points to the fact that the mortar research in Brazil has improved in relation to the characterization of material under controlled conditions, which increases the gap between the values of properties measured in testing samples and those same properties measured in the material applied (on the site) and subject to the effects of internal and external loading.

Few works have approached this property for grout specific studies, among which the following can be mentioned:

- Falcão Bauer and Rago (2001) carried out some tests – sectional deformation (EN 12002, CEN, 1997a), tensile force under bending (project of Brazilian Standard 18:406.05-001, current NBR 14992/2003) and tensile force under bending (project of European Standard prEN TC67/WG3 DOC nº.343, current EN 12808-3) – where testing sample deformations were measured at rupture occurrence. In the Final Considerations they suggest the inclusion of minimum values for tensile strength under bending and maximum values for stress/deformation rate, in the specification of mortar for joint filling grout;
- Kuko and Martins Neto (2001) studied methods for determining the static modulus of deformation of two different sized testing samples (5x10 and 4x4x16 cm), according to the testing method proposed by CSTB - CENTRE SCIENTIFIQUE ET TECHNIQUE DU BÂTIMENT) (Scientific and Technical Unit for Building), 1995. The differences between the results of the static modulus for the two different sized testing samples were not significant, although prismatic sample has presented some advantage over the cylindrical one because there is no need for capping. It was also noticed that neither one of the methods used (static and dynamic) allowed the difference between TYPE 1 and TYPE 2 mortars to be stated.
- Junginger et al (2002) carried out sectional deformation tests, in accordance with Standard EN 12002 (1997), in tile joint grout, with and without additives,

and checked the positive effect of additives on the workability and deformation capacity, although these contributed to a greater content of air added;

- Lobato and Carasek (2002) carried out testing of Modulus of Elasticity to characterize grout that filled tile joints in a panel coated with ceramic tiles for temperature testing, with and without additive, in accordance with Standard ASTM C 469 (1994). The grout with polymer resin showed a lower value for the modulus compared with simple tile joint grout and with cement paste.
- Junginger (2003) performed experimental tests for compression, and plotted the stress-deformation diagram for the static modulus of deformation using NBR 8522 (ABNT, 1984) Standard for concrete. They used two types of mortar, with and without additive. These results also presented a lower value for the Modulus of Deformation for mortar with additive;
- Feres (2006), in his review of the Brazilian standard for tile joint grout, addressed the subject relating the Modulus of Deformation to pathologies caused by heat shock that occur in ceramic tile coating and compared the standards ANSI (American National Standard), ISO (International Organization for Standardization) and ABNT (Brazilian Association for Technical Standards) for tile joint grout and found out that only the Brazilian Standard did not mention the Modulus of Deformation property.

No studies were found addressing tile grout microstructure and the chemical and rheological properties of its components[2], with differentiation between mortar for coating and for adhesive, mainly regarding the type of aggregate used.

Adopting the modulus of Deformation as a requirement for tile joint grout performance might be a way to encourage researchers and manufacturers to search for new materials and testing methods more adequate for products with elastic property and behaviour.

An example of an adequate test for measuring the capacity of a material recovering its original state after being unloaded is shown in Figure 5 where it is possible to see a simple method from the standards (NBR 8619 and ASTM D 3574) used for obtaining the resilience of low density flexible foams in which a ball of a standard size and weight falls on a foam sample, of standard height. The amount of energy recovered is obtained by the resulting rebound (VILAR, 2004). Although Portland cement based tile grout has properties and behaviour that considerably differs from low density foams, that makes it difficult to carry out measurements by this kind of test, the objective of this example is to give rise to questioning about the most adequate type of material to be used as ceramic tile grout joints and the types of testing adopted for measuring the modulus of deformation without relating it to the reversible capacity. An important factor arising from this discussion refers to the way force is applied, i.e., static or dynamic, which leads to different behaviour for the material being tested.

Another property that is less researched is the adherence of the grout to the ceramic tile and to the substrate. Adherence is a primary performance requirement to prevent problems related to water infiltration, displacements and ensure adherence of material to ceramic tile sides when they are subject to mechanical loading. Although

2. Components and their specific function in the mixture – Portland cement (resilience), carbonates (load), hydroxypropyl methyl cellulose (adhesive), lignosulfonates (dispersant), zinc estearate (hydrofugant), polymers (plasticity), fungicide (combats fungus), and pigments (colour). (ROCHA-GOMES; ALVAREZ, 2007).

the surface for effective contact is a requirement for adherence of the material to the substrate (TEMOCHE-ESQUIEL et al., 2007), in the case of tile grout this area is very small compared to that of coating and tile application mortar. This fact makes the interface tile grout/ceramic tile/substrate more vulnerable and even if the tile grout has elastic properties and recovers its initial state after contraction of the ceramic coating, lack of adherence may lead to penetration of water and further system breakdown. Therefore, adherence should be a property to be also taken into consideration as a requirement to be recommended by the tile grout standard.

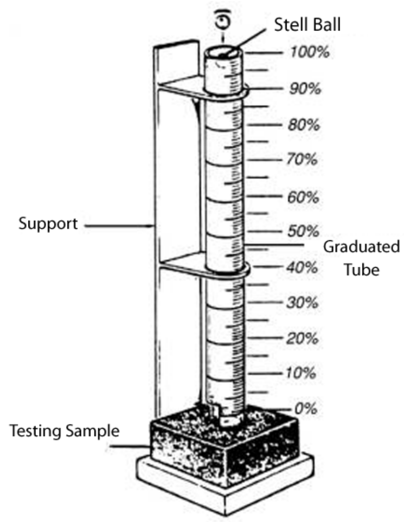

Figure 5. Obtaining the resilience of flexible foams. Source: Vilar (2004)

4.3. THE EFFECT OF TEMPERATURE ON THE BEHAVIOUR OF CERAMIC TILE COATING SYSTEMS

Expansion and contraction due to temperature are always volumetric, i.e. the body expands and contracts in all directions. When expansion or contraction occurs in only one direction it is called linear variation. If the variation occur in two directions of the section it is a surface variation, and if it occurs in the three directions it is called a volumetric variation. (RAMALHO; NICOLAU; TOLEDO, 2003).

The value of the linear increase (ΔL) of a material is directly related to its original length (L_0) and to temperature increase ($\Delta\theta$) which it is subject to (Equation 1). However, each material has its own coefficient of thermal expansion (α) which will affect directly the ultimate value of the material expansion.

$$\Delta L = \alpha \times L_o \times \Delta\theta$$

Equation 1

The surface expansion (ΔA) is directly proportional to the original area, to temperature increase and to the coefficient of surface thermal expansion (Equation 2).

$$\Delta A = \beta \times L_{o\,x} \Delta\theta, \text{ where } \beta = 2\alpha$$

Equation 2

The volumetric expansion (ΔV) is directly proportional to the original volume, to temperature increase and to the coefficient of volumetric thermal expansion that is three times the value of the coefficient of linear thermal expansion (Equation 3).

$$\Delta V = \gamma \times L_{o} \times \Delta\theta, \text{ where } \gamma = 3\alpha$$

Equation 3

For the three cases of expansion, for the same original length and the same temperature increase, the greater expansion will be sustained by the material that has a greater coefficient of expansion α.

The ceramic tile coating system is made up of different material layers that are interconnected. The link between these layers form a single set that prevent expansion and contraction of each layer individually. This restraint for a free motion of layers originates internal stress forces that may lead to rupture or deformation to the whole set. However, technical solutions shall be implemented in ceramic tile coating to allow expansion and contraction and prevent pathologies such as fissure, displacement and tile detachment that may lead to serious damage to material and people.

Ribeiro (2006) classified the displacements that occur in ceramic tile layers, as shown in Table 1.

Nature	Displacement	Reversibility
Temperature increase	Sudden displacement by thermal shock	Reversible
	Thermal displacement	
Effect of moisture	Humidity displacement	Irreversible
	Expansion by moisture in ceramic tiles. Contraction of wall mortar or tile laying mortar	
Inherent behaviour of building components and elements	Displacement of concrete structure due to permanent loading: weight, expansion and contraction	
Effect of wind	Building displacement due to wind loading	Irreversible/Reversible

Table 1. Classification of construction element displacement based on the nature and reversibility. Source: Ribeiro (2003)

Knowing external weather conditions is important for these represent the primary requirements for obtaining materials and technical procedures that reduce at the most or eliminate pathologies arising in ceramic tile coating.

Goulart; Lamberts; Firmino (1998) compiled weather data from 14 Brazilian cities: Design temperature - ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers), Degree-day, Degree-hour, BIN Temperature, Temperature

Reference Year (TRY), Summer and Winter Typical Design Days are presented. In addition to that, they characterize climate in the cities analysed through statistical description, presenting values such as: Monthly and Yearly Mean, Maximum and Minimum Absolute Values: Dry Bulb Temperature, Temperature Range, Maximum and Minimum Mean Temperature, Wet Bulb Temperature, Net Humidity, Humidity Content and Wind. This information may be used as a reference to a testing method to be conceived and that should take into consideration climate conditions of each region in order to verify displacements and deformations supported by ceramic tile coatings.

Standard BS 5385: part 2 (BSI, 1991) and Standard ASTM C1472 (ASTM 2005) take into consideration that the thermal displacement is the prevailing effect on building component size displacements and on adhered coatings. As the thermal displacement is restrained, this effect becomes a major inducer of cyclical stresses, which, above all, tend to lead to fatigue of bonding between layers over time (GOULART; LAMBERTS; FIRMINO, 1998).

Temperature generated by the solar radiation on ceramic tile coating may be subject to the effect of wind and moisture, the ceramic tile surface colour and type of component material, that according to its potential to absorb heat and, as a consequence, in the behaviour of its surface temperature will contribute to a greater or lower thermal dilation that will have an effect in the coating layer behaviour (GOULART; LAMBERTS; FIRMINO, 1998).

Effects caused by temperature changes can affect the performance of the ceramic tile coating system due to occurrence of cyclical stresses together with other stresses the coating is subject to, and a fatigue mechanism may develop over time (LOBATO PAES; CARASEK, 2002). Therefore, a methodology for determining any property shall identify the physical-chemical phenomena present and that are responsible for changes in the property analysed (TRISTÃO; ROMÁN, 1999).

The amount of energy absorbed by tile depends on its own characteristics. Thus, tiles with different composition present different coefficients of thermal expansion (JUNGINGER, 2003).

Campante (2001, as cited by Junginger, 2003, p.47) presents several temperature measurements carried out for different colours of tiles and obtains temperature values that reach 70 ^{0}C for dark-coloured tiles and 48 ^{0}C for light-coloured ones, both positioned on the façade facing West.

Andrade (2006) simulated the calculation of temperature in white and black-coloured ceramic tiles on a site where the temperature was 15°C and reached temperature values of 80.2°C for the black-coloured and 59.4°C for the white one, respectively. The temperature increase of 65.2°C for the black tile and 44.4° for the white one demonstrate the importance of considering tests that take into account not only ambient temperature, but also the actual temperature of the coating. Some researchers followed this approach and developed studies trying to simulate situations closer to reality.

In the study carried out by Lobato and Carasek (2002) about the performance of grout and coating joints in the thermal behaviour of the ceramic coating system, the grout modulus of elasticity, the adhesive and the wall mortar arose as primary property for the research results. Thus, they recommend that systematic studies should be carried out about mortar modulus of elasticity and that testing methods for its determination should be standardized.

Roman et al. (2000) used climate chamber to evaluate tile laying mortar, changing temperature and humidity during 120 cycles of three hours, corresponding to 15 days of testing, and verified no significant difference between the panels cycled and the reference ones, although they observed that there was not full adherence between the ceramic tiles and the wall mortar. They also observed that the number of aging acceleration testing cycle might not be enough to cause system breakdown.

Vaz Sá and Freitas (2005a), following the same objective, evaluated the performance of Portuguese tile laying mortar, called glue-cement, by subjecting testing samples to accelerated aging test in climate chamber that allows temperature, humidity, solar radiation and rain changes. Results showed a significant decrease in adherence after 112 aging cycles of 12 hours (corresponding to a two-month period) and indicated the end of lifetime in 140 and 210 cycles, with an adherence strength of 0.3 MPa, for the two types of adhesive used.

Other work by Vaz and Freitas (2005b) correlates tile laying mortar lifetime in the artificial accelerated test above with the actual lifetime by natural exposure by means of forecasting model. Results showed that 210 cycles (greatest value found) corresponds to a six-year lifetime in actual time.

5. FINAL CONSIDERATIONS

The evaluation of mortar “flexibility” presented in certain works issued, follows the Standard EN 12002 of Sectional Deformation that determines the displacement of material subject to tensile test under bending. Therefore, what is measured is material deformation limit up to application of the maximum rupture stress. In certain publications the term “flexibility” is being misused as a requirement for reversibility performance.

The terms “resilient” and “reversible” are more adequate to qualify materials with elastic deformation.

Testing methods use tensile stress under bending and material deformation to calculate the static modulus of deformation or the ultrasound instrument for the dynamic modulus, without considering cyclical stresses supported by the ceramic coating exposed to the environment and bad weather conditions.

Although the dynamic method is more appropriate as it is simple, non-destructive and allows comparison to other methods results carried out with the same testing sample, it is important to find the means to relate the value found for the modulus with material behaviour when applied under and subject to actual stress conditions.

In order to try to approximate testing conditions to reality to which the coating is exposed, we suggest the production of testing samples from ceramic tiles laid and grouted in accordance with technical standards, then subjecting them to temperature change cycles, in the laboratory, to verify their actual deformation capacity, after the interaction with ambient agents.

Another factor observed is the lack of researches that propose use of new materials, with elastic properties compatible with the need and capacity of the grout to absorb stresses supported by the ceramic tile coating.

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