APPLICATION OF INTERNATIONAL STANDARDS IN CERAMIC PAVING AND TILING TECHNICAL CRITERIA FOR TILE SELECTION

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SUMMARY

According to a schematic chart indicating the state of progress in the preparation of ISO standards for ceramic tiles for pavement and tiling, two particularly significant project situations show how these new standards can help the designer of ceramic pavement and tiling by providing him correct and reliable guidelines for the choice of the most suitable tiles for specific usage conditions.

1. FOREWORD

It is known that the purpose of standards is to classify the various products they refer to, establishing their main attributes according to the product group to which they belong as well as to establish the requirements for standardized attributes, and to define the methods used in the measurement thereof.

It is clear that the standards are essential to reliably establish the quality of industrial products. They provide detailed and complete technical specifications for every product, through which consumers can know as much as possible about the products they are using or intend to use, establish quality standards with suppliers, and verify the compliance of the supplier with such standards.

Technical specifications based on standards are also a planning instrument in the sense that they represent the technical document on which a correct choice between the different types of products available on the market is (or should be) based, and which, by their characteristics, can best and most reliably develop the assigned functions in foreseeable usage conditions.

If we consider that quality assurance tests are carried out on specific laboratory samples, under conditions which are entirely different from those for which the product is intended, we may reach the conclusion that great care and attention must be used when dealing with technical specifications, especially with regard to durability testing. The problem of using technical specifications in planning functions as a basis for the correct and reliable choice of the most suitable product for each use is particularly delicate in the case of ceramic pavements and tiles, for which (as is the case with other building materials) in addition to the differences already mentioned between laboratory and real usage conditions, there is another and very significant difference, namely: in the laboratory tile components are tested on an individual basis, whereas in real working conditions they are part of a whole building system, or of pavement or tiled walls, concrete lining, or are intended for other uses, such as filling material for drains, support structures, etc. In the case of ceramic tiles, quality certification of standardized test results, as well as the features and behaviour which the designer must take into account, seem to be even more problematic.

The purpose of this note is to discuss, based on two significant examples, some of the problems the designer might face when choosing tiles for specific conditions, having at his disposal the standards-based technical specifications as a reference for all the products from which to choose.

In this discussion we include a schematic chart of the state of progress in the activity of ISO standards planning, referring particularly to the work carried out by the Technical Committee 189 - Ceramic Tile and by the two relevant working groups, in developing test methods (WG 1) and defining product requirements (WG2).

The examples shown below demonstrate how some of the modifications introduced by the TC ISO, which will distinguish the ISO standards for ceramic tiles from the actual European EN standards, aim to provide a better and more reliable use of the technical specifications for the design of ceramic pavement and tiles.

2. ISO STANDARDS FOR CERAMIC TILES

The work of ISO/TC 189, which began almost three years ago, is nearly finished. The committee had to adopt the European EN standards as a working document and thus as a reference base: a timely choice, as these standards were - and still are - the most complete and reliable regarding ceramic tiles.

In this discussion, we must consider the work done by WG 1, which must, as we have already mentioned before, define the product features to be standardized, as well as study and develop test methods. Table 1 shows the present situation:

It shows the evolution of preparations and methods approval process for every feature. As can be seen by the Table, and as confirmed by the forthcoming conclusion of the process, the test method for almost all of the features is near the approval stage. The procedure has yet to be concluded in the case of three features (frost resistance, slip ratio, and coefficient of restitution, which provide a measure of the product's shock resistance). WG 1 has prepared the working documents which are to be approved at the final meeting of ISO/TC to be held in June 1992 in the U.S.A.

As can be seen, the chart of product features reflects those of EN standards, with some significant additions. The first is the addition of breaking resistance among the features to be considered when evaluating mechanical performance of the tiles (in the EN standards the breaking factor was used as a temporary measure for calculating the breaking strength). Finally, there are four features, the last of which appear in Chart 1, which were not taken into account by the EN standards: lead and cadmium release, chromatic variation, slip and coefficient of restitution.

Without going into a detailed description of the different methods and all the new features considered by the ISO standards, we will try to show, by means of two significant examples, how the new innovations are meant to provide designers with the most reliable tile selection criteria, which allow not only the most complete and specific characterization of the quality of the tiles, but most of all provide a reliable example as to work performance.

3. MECHANICAL FEATURES, CHOICE OF TILES ACCORDING TO MECHANICAL REQUIREMENTS IN WORKING CONDITIONS.

The only mechanical feature that the EN standards took into account was the breaking strength. This was indeed the only feature for which requirements were set.

It is clear that the current rate is a feature of the "material" for which significant correlations can be identified with other properties inherent to the structure of the material itself, such as, for example, water absorption. As can be seen in the chart in Fig. 1, which is based on the results of different measurements established by the Ceramic Centre regarding samples of various tiles, the breaking strength decreases as the water absorption rate increases. This behaviour is predictable, as water absorption provides a certain measure of porosity (particularly open porosity). This has two effects: on one hand, the significance of water absorption among the general features of the material as a measure of tile compliance with EN and ISO standards, and, on the other hand, the development of acceptance requirements for the breaking strength in accordance with EN standards. These requirements are becoming stricter, going from high water absorption groups (water absorption above 10 %) to those of more compactly backed tiles (with a water absorption rate lower than 3%).

An aspect which is so obvious that it is sometimes overlooked is that the breaking strength does not provide a measure of the mechanical properties of the tile: features that depend mainly on its dimensions (as in a steel beam, e.g. the maximum load capacity, which depends not only on the mechanical features of the steel, but also on the beam's dimensions). More reliable indications of the tile's mechanical features are given by the breaking load, which takes into account the features of the ceramic material of the tile (particularly, the breaking strength) as well as the tiles' dimensions (especially its thickness).

This dependence is clearly illustrated in Fig.2, which shows the evolution of the breaking load, measured by a four-point load distribution system, following standard ASTM C648, according to the breaking strength for three different minimum values of tile thickness. The breaking load was measured according to the method established under standard EN100, specifying a three-point load distribution system which, like any other condition, tends to decrease when going from square to rectangular tiles. For this reason the new ISO standard provides for the ASTM method or a modified EN load rate, in order to eliminate dependence on the format. In addition to these methodological considerations, the substantial influence of tile thickness on the breaking load should be noted, as should the mechanical performance of the tiles: it can indeed be seen that a 2mm increase in thickness leads to a doubling of the breaking load.

Another circumstance, which is equally significant and can easily be seen in Fig. 3, where the same data appear as a means of highlighting the dependence of the breaking load with regard to tile thickness. It can also be seen that, for products with a higher breaking strength, the breaking load stays within low levels, even when the thickness is less than 6.5 mm.

Despite the notable difficulties when specifying accurate reference limits for the breaking load in relation to the projected load on floor tiles in real working conditions, a knowledge of the breaking load provides very interesting data for the designer. For the most commonly used pavements (e.g. for public and industrial sites, frequented by heavy vehicles -especially those equipped with small and hard wheels), the criterion for selection of tiles with a low water absorption rate - and therefore with a high breaking strength - represents a necessary, but not a sufficient condition: the tiles must have an adequate thickness, so that the breaking load may be as close as possible to predictable concentrated loads in the most extreme working conditions. It is obvious that the tiles should never be subjected separately to mechanical forces, but should always be used in conjunction with the rest of the essential paving elements. Thus, this criterion is certainly rather precautionary, although it is an unfortunately common occurrence that incorrect pavement dimensioning or bad execution of the tiling operations can lead to situations in which tiles are assigned structural functions which they should not have to bear individually.

4. CHEMICAL-MECHANICAL SURFACE ATTRIBUTES - CHOICE OF GLAZED CERAMIC TILES ACCORDING TO PREDICTABLE ABRASIVENESS OF WORKING CONDITIONS

The problem of choosing glazed tiles in accordance with predictable abrasion levels in working conditions or, more specifically, choosing the most appropriate tiles for the most difficult working conditions, is discussed, first analyzing the effects induced by abrasion on glazed surfaces.

The principal effect is, without a doubt, wear, i.e. the progressive deterioration of the surface material exposed to abrasion. The consequences of such wear are numerous, besides simple deterioration, which is considered acceptable until the exhaustion point is reached, i.e. until the enamel layer is completely worn through.

One consequence can be a change of surface colour - or, more specifically, an attenuation of chromatic hue. This risk, which is specifically controlled under the EN 154 test (PEI Method) by evaluating the abrasion resistance of glazed ceramic tiles, is normally higher for dark colours. In working conditions, on a glazed surface we can observe lighter areas, which correspond to the areas that are more exposed to abrasion.

Another consequence could be a loss of lustre. Tiles with glazed surfaces can show opaque areas as a result of abrasion, followed by a deterioration of the surface layer which is meant to confer lustre to the tile surface. This effect can be seen in working conditions, especially in bright lighting conditions.

These are readily visible consequences, as they alter the appearance of the glazed surface. But there is another indirect but no less important change: an increase in surface porosity.

Enamel is, at least in theory, supposed to be a glassy, ideally very compact layer. In fact, this is generally true as regards the surface, but due to various reasons connected with the material and manufacturing technology employed, there can be pores and tiny bubbles under the enamel surface. With the wear of the material resulting from abrasion, these pores are uncovered, thereby increasing the tile's porosity. The consequence is an inevitable worsening of the tile's polish: the pores in fact constitute penetration points and stubborn dirt collectors, rendering the cleaning of the glazed surface more difficult and less effective. This effect is readily seen especially on light and solid-colour surfaces, and better disguised by dark and chromatic heterogeneous surfaces ("melange"). This last effect, namely the increase of dirt, is the object of many discussions regarding light-coloured tiles, evidenced by a class of PEI IV abrasion resistance, according to standard EN 154, where a visible deterioration of the surface can be observed, with clear signs of abrasion, after a very short period of time.

Indeed, the PEI abrasion resistance standards have often been overestimated by manufacturers and users of ceramic products, including designers. This overestimation consists of the consideration that the use of a quality attribute such as the PEI class of abrasion resistance (a feature that, as we have already mentioned, measures only one of the multiple effects of abrasion) can be extended, without further controls and testing, to projections regarding not only performance and durability, which can be evaluated only if overall surface features (including hardness, shock resistance, strain resistance, etc.) are taken into account, and not only the microstructural features of the enamel. The method for measuring abrasion resistance, which will be included in the new ISO standards, represents an important step forward in comparison with the EN 154 method, as the difficulties mentioned earlier will no longer be applicable. As shown in Table II, the classification introduced by this new method includes a PEI V class in addition to classes I to IV, which are defined in the same way as in the EN 154 method. This PEI V class, which is assigned the highest level of abrasion resistance, will include ceramic glazed tiles which meet these two conditions: 1. that the effect of abrasion produced by 12000 turns of the abrasive load is not visible; 2. that the abrased surface be stain resistant and therefore easily polished.

With this classification (to which further specifications regarding cleaning shall be added), the designer has a more valid instrument allowing for better selection of the material to be used in specific cases: a choice made with great care, taking into account all the above-mentioned aspects (as well as the rather difficult correlation between behaviour of abrasion and surface shine, as well as the influence of colour and chromatic texture).

The new ISO classification also includes a PEI O class for glazed products with abrasion effects that are only visible after 100 turns of the abrasive load. This class specifies tiles deemed inadequate as coating material for floor tiles, regardless of how low the predictable level of abrasive wear may be.

5. CONCLUSIONS

The discussion of two exemplary cases allows us to reach the following conclusions:

- The criteria used in tile selection must be prepared taking as a reference the tile's technical specifications, which are checked against predictable levels of wear given specific working conditions;

- The main goal of the technical specification is to document a material's quality. The designer has to know that the performance of the tiled surface depends not only on the quality of the tiles, but also on the quality of the other composite materials, as well as on system dimensions and on correction and care used when placing tiles.

- The new ISO standards, which are currently in the definition and approval stage, include the features of some important components. This information is intended to aid the designer in choosing the most suitable material for specific applications.

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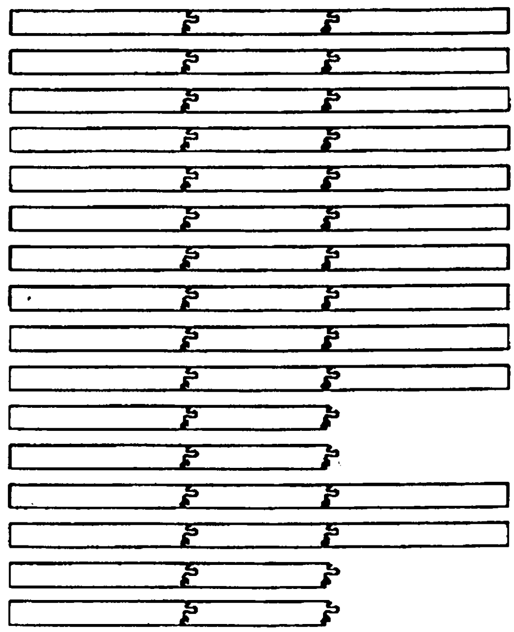
STATUS OF WORK ITEMS: ISO/TC 189
TEST METHODS

IN COURSE DRAFT APPROVED

- DIMENSIONS AND SURFACE QUALITY
- WATER ABSORPTION
- MOR & BREAKING STRENGTH
- SCRATCH HARDNESS
- ABRASION, UGL
- ABRASION, GL
- LINEAR THERMAL EXPANSION
- RESISTANCE TO THERMAL SHOCK
- MOISTURE EXPANSION
- CRAZING RESISTANCE
- FROST RESISTANCE
- CHEMICAL & STAINS RESISTANCE
- LEAD & CADMIUM RELEASE
- SMALL COLOR DIFFERENCES
- COEFFICIENT OF FRICTION
- COEFFICIENT OF RESTITUTION



RESISTANCE TO SURFACE ABRASION - GL

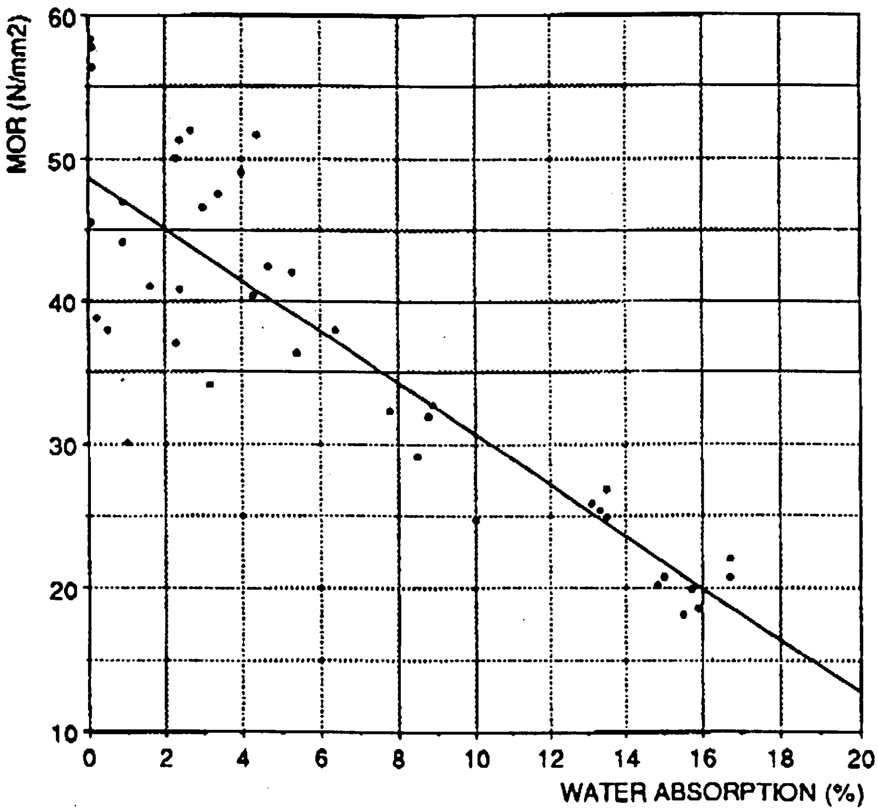
approved

1 - PROCEDURE PEI-type abrasion apparatus;
viewing box;
wet abrasion method.

2 - CLASSIFICATION

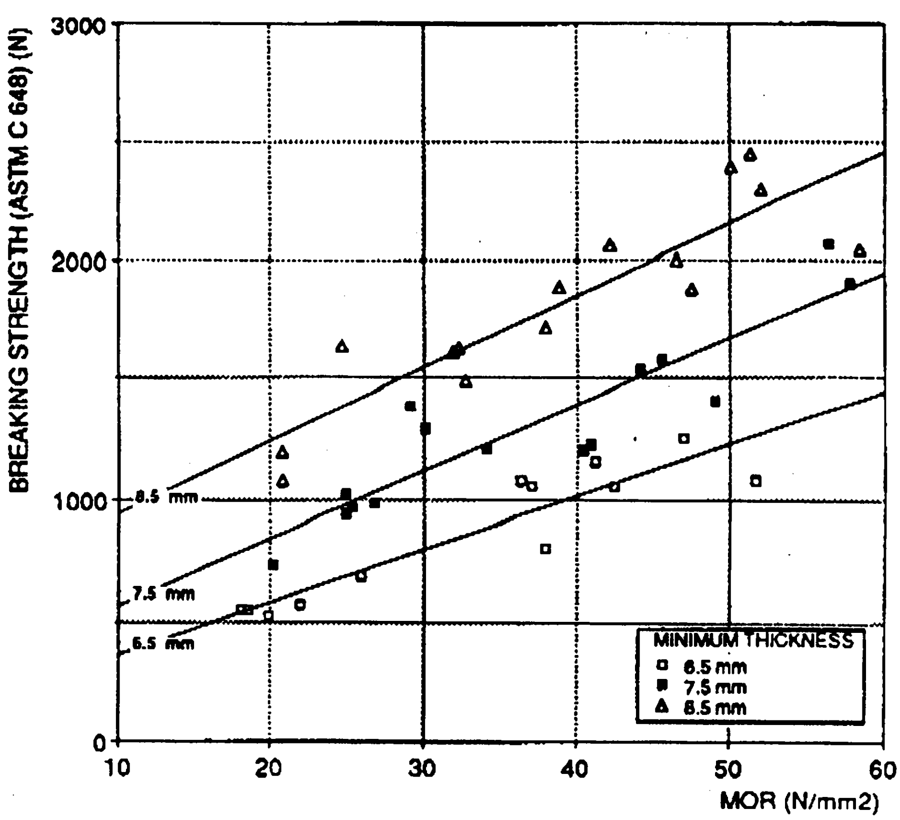
Abrasion stage; failure visible at (no. rev.)	CLASS
100	0
150	1
300, 450, 600	2
750, 900, 1200, 1500	3
2200, 3000, 6000, 12000	*4*
> 12000 *Stains resistance required*	*5*

FIG. 1

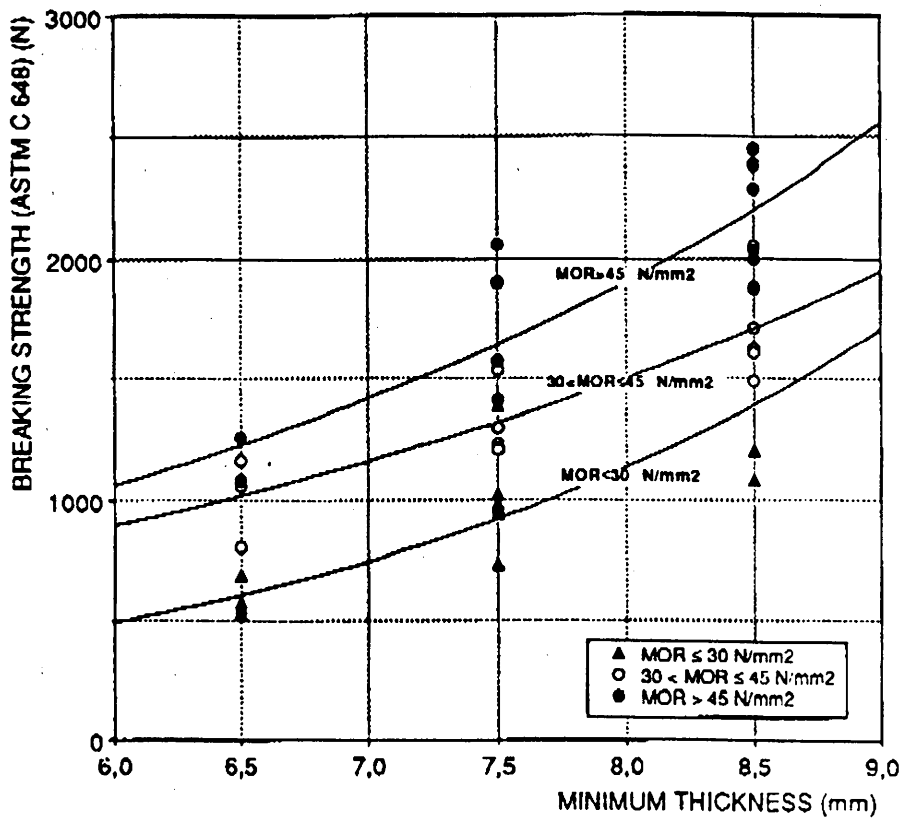


MOR (N/mm2)
60
50
40
30
20
10
0
2
4
6
8
10
12
14
16
18
20
WATER ABSORPTION (%)

FIG.2



BREAKING STRENGTH (ASTM C 648) (N)
3000
2000
1000
0
8.5 mm
7.5 mm
6.5 mm
10
20
30
40
50
60
MOR (N/mm2)
MINIMUM THICKNESS
6.5 mm
7.5 mm
8.5 mm


BREAKING STRENGTH (ASTM C 648) (N)
3000
2000
1000
0
6,0
6,5
7,0
7,5
8,0
8,5
9,0
MINIMUM THICKNESS (mm)
MOR>45 N/mm2
30<MOR<45 N/mm2
MOR<30 N/mm2
MOR ≤ 30 N/mm2
30 < MOR ≤ 45 N/mm2
MOR > 45 N/mm2