CERAMIC COVERINGS THAT IMPROVE SAFETY AND COMFORT IN PUBLIC AREAS.

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ABSTRACT

Some results of an R&D&I project that aims to develop new uses and functions for ceramic tiles are presented. Specific reference will be made to a new line of products, a pioneer in the sector, which links user needs to the most innovative mechanical engineering techniques in the design of ceramic coverings. The concept of this product was born from the CERGOCIVIS R&D&I project, which strove to incorporate the user in the value chain of the ceramic process by generating knowledge concerning the needs people have when walking on hard surfaces. At the same time, conceiving the product as part of an integral solution led to the idea of including properties that are important within the context, such as issues affecting accessibility, combinations with other elements or the subject's perception of safety and comfort. Such properties are: safe friction for all users, design, toe clearance to avoid stumbles, tile installation and design that transmit safety and subjective comfort, adaptation to the specifications of the new technical code, ability to be adapted to the accessibility regulations in force where the tile is used, and finally the strengthening structural design of the rib relief on the back of the tile (Strongrib), which ensures greater mechanical strength and resistance to building pathologies than most outside covering materials of whatever nature on the market. For the first time, products incorporating these technologies (CIVIS AGORA line) have been used in a real life situation in some of the most emblematic streets in Castellón de la Plana, Spain.

1. INTRODUCTION

Strength-durability, safety, comfort and accessibility are four key attributes for achieving public coverings suitable for all users and scenarios. When we walk, we try to develop the most comfortable and safe pattern depending on our deambulation capacity and the speed we wish to maintain. Therefore, the philosophy that has been followed in the CERGOCIVIS project has consisted of adapting coverings to users, rather than users having to adapt to the conditions imposed by the materials. In this way walking becomes ergonomic in every sense.

The line of products developed incorporates design parameters that transmit safety and durability, thus adding emotional functions that make their usage more attractive. In this way, functionality and design blend together to develop an ergonomic and consistent exterior flooring that offers improved functions and transmits positive sensations to the pedestrian.

2. METHODOLOGY

On the basis of knowledge generated both by the IBV through projects developed in collaboration with IMSERSO and CEAPAT, and by the ITC on specifications that include user needs in the development of ceramic products, the necessary trials were carried out to complete those features which had thus far gone unaddressed, such as the determination of the optimum friction ranges, which floor properties lead to user fatigue, or how to get the maximum advantage from the rib design in order to make the tile more durable, stronger and easier to install. Apart from the functional issues, design specifications were incorporated that turned out to bear significantly upon the subject's perception of safety and comfort, as published in Qualicer 2006 under the title: "INCORPORATION OF EMOTIONAL DESIGN METHODS IN CERAMICS. DESIGN PARAMETERS AS FEELING MODULATORS".

3. TRIALS AND TESTS

Within the section on the study of specifications incorporating user needs, the project started at the knowledge transfer stage in which TAU converted into elements added to its products the specifications already defined by the IBV regarding the properties that interact with users, as well as the results of clinical studies that analysed the effect of relief and surface texture (toe clearance) design on safety when walking. At that point, the following trials were carried out with subjects:

- Application of Kansei engineering on the emotional design of ceramic products.
- Determination of flooring features to reduce fatigue in dynamic bipedestation.
- Study of the existence of a maximum friction level from the ergonomic point of view.

Different products and prototypes were tested during the trials by creating test passageways in which up to 30 subjects, free of any walking disorders, deambulated under controlled conditions. The subjects were linked to instruments during the trials so that their biomechanical variables, such as heel impact and its transmission throughout the musculoskeletal chain, evolution of the walking pattern and pressure distribution on the sole of the foot as cause and effect of fatigue in dynamic bipedestation, could be measured and recorded.

This monitoring of biomechanical variables was accompanied by recordings of the user's subjective perception of fatigue and safety, which then enabled user needs and/or preferences about each aspect of the floorings under evaluation to be detected.

Furthermore, as part of the section on the development of ceramic products, TAU, with the support of the ITC regarding the application of strengthening structural design for the rib relief on the back of ceramic tiles (Strongrib - developed jointly in previous studies), produced ceramic tiles adapted to the requirements associated with their use in urban furnishings, especially mechanical strength under high loads, which could cause tile fracture. Following a preliminary study regarding the type of common fractures affecting paving tiles used for urban sidewalks, it was confirmed that nearly half of such fractures involved breakage at the corner associated with voids under the tile, followed by fractures around the edges, both of which probably being due to inadequate mortar coverage under the tiles.

The strengthening design of the relief on the back of ceramic tiles (Strongrib) is achieved by combining theoretical stress calculations by finite elements with moment of inertia calculations. Using the finite element calculation, the critical positions of concentrated stress were analysed with regard to rib layout under different conditions of concentrated load on 40 x 40 cm porcelain tiles laid centrally on a circular mortar slab, 28 cm in diameter (Figures 1 and 2).

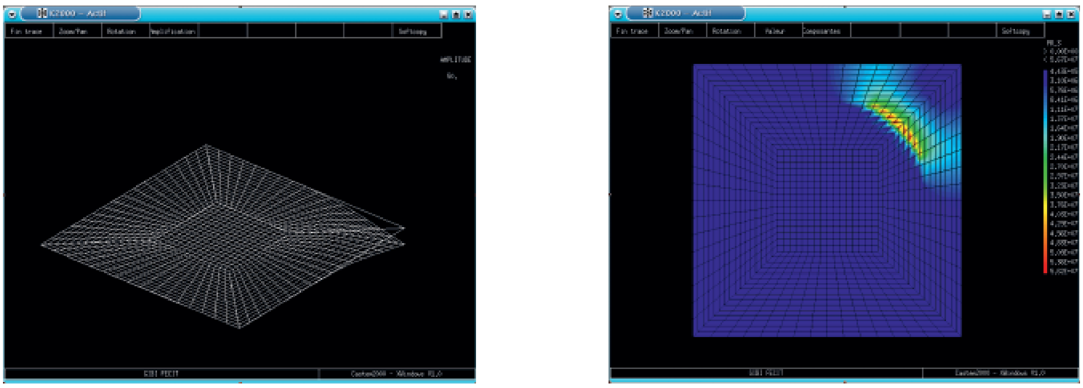

Figure 1. Main deformation and strain under load concentrated in the corner.

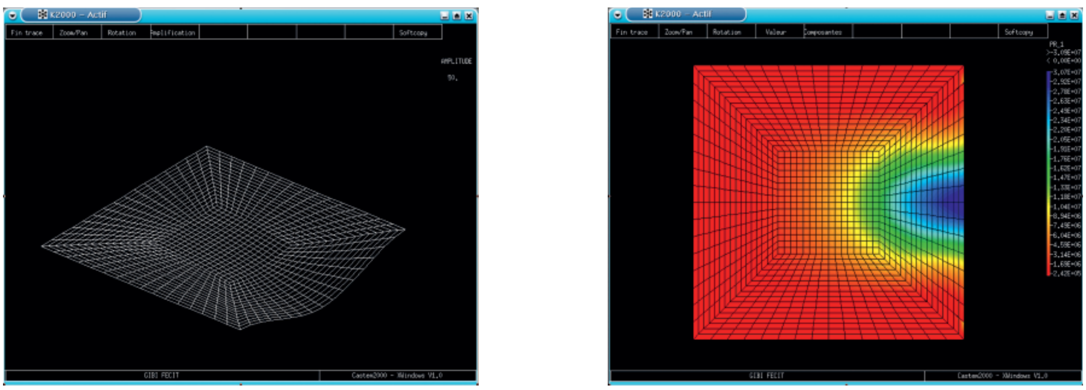

Figure 2. Main deformation and strain under load concentrated on the centre of the edge.

Thanks to this analysis, the optimum position for arranging the strengthening ribs was established in order to reduce the risk of breakage under the different load situations analysed. This in turn led to the final design of the relief on the back of the tile, known as Strongrib (Figure 3).

Once the layout for these strengthening items had been defined, the calculation using the moment of inertia was applied to define the optimum width, depth, and shape of these ribs to guarantee that the tile would withstand the load levels required for urban paving, in accordance with the most habitual types of fracture observed in the preliminary study.

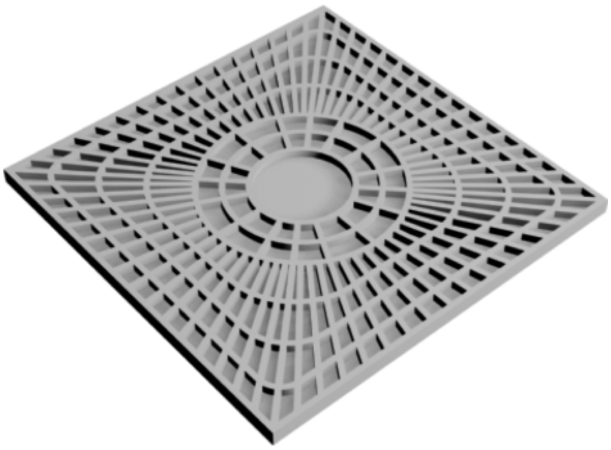

Figure 3. Structural design of the strengthening relief on the back of the tile (Strongrib).

Finally, given that all the estimations had been carried out on the basis of a modulus of rupture similar to that associated with porcelain tiles of usual thickness (between 9 and 12 mm), it was decided to validate these theoretical calculations by testing prototype tiles made under industrial manufacturing conditions.

In the same way, bearing in mind the great variety of real life conditions under which these floor tiles are installed and the loads to which they are subjected, it was considered necessary to cross check the performance levels attained by comparing them to other materials habitually employed for this type of urban service.

4. CONCLUSIONS

The knowledge obtained has made it possible to discover key design parameters in the interaction with the user, which until now had not been taken into consideration in the development of conventional ceramic products. Furthermore, the technical characteristics achieved have significantly increased the durability and strength of the system, placing it well above the average level on the outside flooring market (Table1). They have also helped to define a line of high durability products for outside areas that are not tied to the rigidity of a single regular format but which transmit a feeling of safety and comfort to the citizen.

The final result transcends the concept of a ceramic tile and constitutes a building system which, as such, affects both the ceramic materials, the way they are installed, and the other items used in the flooring. Likewise, integral accessibility concepts should be included in urban specifications and design to ensure an optimum result.

CHARACTERISTIC	CIVIS AGORA CERAMIC FLOORING	CONVENTIONAL CEMENT-BASED FLOORING
Format (mm)	400 x 400	400 x 400
Thickness (mm)	17,3	40,0
Distributed central load (N)	7057	4142
Load concentrated on corner (N)	8071	6041
Load concentrated on edge (N)	5474	5043

Table 1

NOTES

- The final poster to be presented at the Congress will include more graphs and illustrations to make it easier to understand the work and its scope).
- The Cergocivis R&D&I project was carried out with the support of CDTI, IMPIVA, and MITYC.