New designs of the ceramic bricks of horizontal hexagonal hollow

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Abstract:

This article is intended to state that Technical Drawing is a multiple tool of expression and communication essential to develop inquiry processes, the scientifically basis and comprehension of drawings and technological designs that can be manufactured.

We demonstrate graphically and analytically that spatial vision and graphic thinking allow us to identify graphically real life problems, develop proposals of solutions to be analysed from different points of view, plan and develop the project, provide information needed to make decisions on objects and technological processes.

From the knowledge of Technical Drawing and CAD tools we have developed graphic analyses to improve and optimize our proposed modification of the geometry of the rectangular cells of conventional bricks by hexagonal cells, which is protected by a Spanish patent owned by the Polytechnic University of Madrid.

This new internal geometry of the bricks will improve the efficiency and the acoustic damping of walls built with the ceramic bricks of horizontal hollow, maintaining the same size of the conventional bricks, without increasing costs either in the manufacture and the sale. A single brick will achieve the width equivalent to more than FOUR conventional bricks.

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1 - Introduction.

Ceramics is composed by four simple elements: *earth*, *water*, *air and fire*. Today it is as modern as it was in antiquity. This material has always been submitted to continuous improvements. To produce it, the *earth* must be ground and mixed with other natural elements in order to give them certain properties. Once mixed with *water*, it must be moulded to yield different products, which can be grouped into: refractory ceramics, decorative ceramics, technical ceramics and structural ceramics. Then the ceramic material is introduced into an *air* dryer, and finally placed in an oven where with *fire* it acquires the desired physical properties.

Ceramics is a versatile material that has been used in many different ways. It can be seen as decorative elements or may be present as various passing us unnoticed building elements. A clear example is the ceramic bricks after being covered with plaster or any other coating material: we cannot see them, but we know that they are on the walls surrounding us.

Ceramic bricks can withstand temperature changes of the environment. For example, when cold passes through the brick, it loses intensity. The same goes for heat.

The secret is in the inner cells or chambers and in the tiny pores of the ceramic material (Fig.-1), which alters temperature transmission (hot / cold) that decreases as it moves through the brick until it dissipates.

A width greater brick there will be a greater damping. As a consequence of this, the conventional bricks with rectangular cells have given rise to large blocks, which acquire the name block ceramic brick.
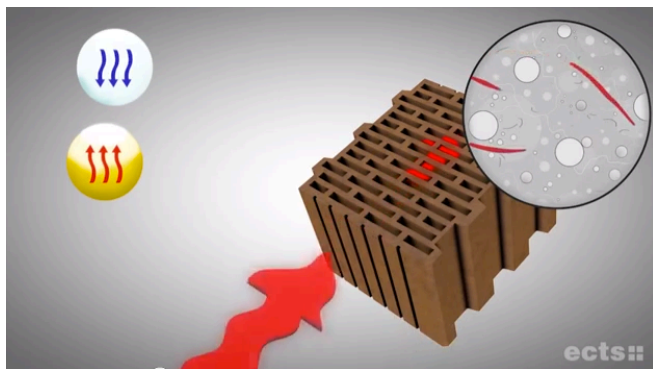

Figure 1: Image from European Ceramic Technology Supliers

Architects, construction engineers and brick manufacturers say: "*Ceramics is the building material with better thermal insulation properties. Proper insulation is the best solution to minimize power consumption in both heating and cooling. The use of ceramic materials therefore involves saving money by reducing energy consumption*". [E1]

For the same reason we can ask: Can bricks have acoustic insulation properties? Similarly wider dimensions of ceramic brick dissipate temperature transmission; they will also dissipate sound transmission.

In all materials that offer thin slits or porous appearance, when a sound wave enters, it will attempt to penetrate the material between its interstices. Thus the molecular movement is the incident sound energy will move the fibres and / or the pore walls, spending part of the sound energy into kinetic energy. At the same time the air within the pores or between the fibres will also be forced to move, generating other costs of sound energy that will be transformed into heat energy.

The thickness of the material is important to determine the maximum sound absorption. The sound energy penetrates the material only to a certain width, beyond the absorption or dissipation of sound does not increase. Isover Manual [C2].

The walls of the rectangular cells perpendicular to the faces of the ceramic brick transmit cold, heat and airborne noise, perpendicular and directly to outer faces of the brick. The thermo-acoustic damping and absorption capacity shall be limited by the width of the ceramic brick, among other factors.
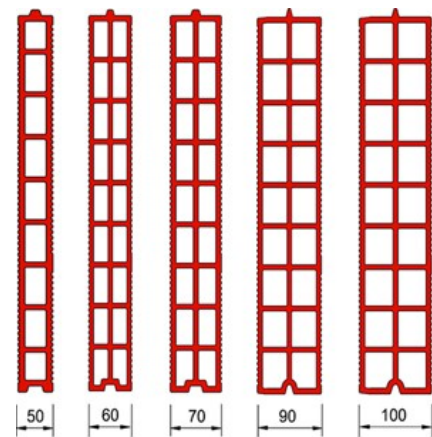

Figure 2

Such is the reason whereby other bricks of greater dimensions and ceramic blocks can replace the conventional ceramic bricks of horizontal cells in parallel to the bearing surface. That is the best solution to the problem of damping lack thermo-acoustic (Fig.-2).

Nevertheless, an alternative ingenious solution that satisfies the requirements of thermo-acoustic insulation of walls can be achieved with a new design of the brick internal geometry maintaining the outside dimensions of conventional brick.

A Spanish Patent [1], offers an innovative geometric modification of cells of the ceramic fired clay destined to the manufacture of bricks, according to an hexagonal cells geometry [P1].

2 - Principles of the Research and Innovation

A heavy concrete wall is a good airborne noise insulator that does not allow passes much noise through the wall from one side to another (Fig.- 3) -the following diagram shows the behaviour of sound when there is a concrete wall, from which we deduce the model to study the sound insulation, the walls in this investigation-. This example makes us think about the hypothesis that acoustic insulation depends on the width of the wall or mass quantity that has to go through it [L1].

While the concrete wall reflects almost all noises that come from inside the same room, because it is an insulator but it is not an absorbent, noise that penetrates is weakened according progresses through the wall.
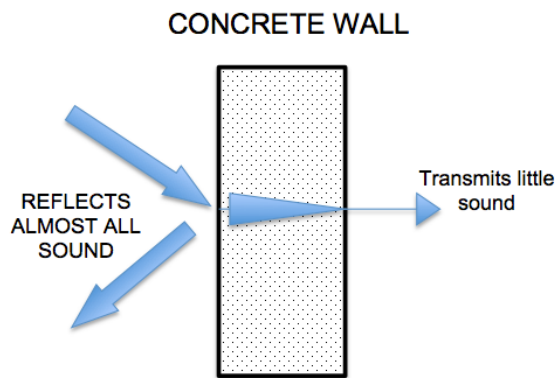
Figure 3

This explains the above mentioned increase in the size of bricks and gave us the idea of replacing conventional rectangular holes by hexagonal holes, in order to increase the distance between the outer faces of the brick, just changing the shape of the cells and maintaining the external dimensions of the conventional bricks.

We are aware that the sound insulation depends not only on the mass but also on the geometry of the piece, the percentage of voids or holes, on the "loss" (loss of internal factor), and on the velocity of propagation of longitudinal waves (CL), which is related to Young's E modulus (depending on the clay type, additives, drying and baking). However, without going into complex studies, it is enough to note that the intensity of the sound signal decreases exponentially with the same path according to the following expression:

$$I = I_0 \exp(-\beta x)$$

I_0 is the intensity of the emitting source, β is the absorption coefficient and x is the path of the wave. From this expression, we can easily deduce the following result: for the same material and the same wall thickness, the observed intensity, I, decreases when the path is increased performed by the sound [CF1].

Subsequently we show both analytical and graphically that those new designs of the ceramic bricks of horizontal hexagonal hollow, as the exposed hypothesis that a longer path increases thermal or acoustic dampening, compared with traditional brick rectangular holes, assume that these new bricks will buffer better the airborne sounds.

Under this approach, our investigations [C1] enable us to document the morphological characteristics of the cells of the new designs of ceramic bricks and to make other recommendations to manufacturers.

3 - Graphical investigation

The first graphical analysis of hexagonal brick geometry has detected that the line defined by two opposite corners of the hexagonal cell polygon (diagonal of hexagon), if placed parallel to the outer face of the brick used in the manufacturing of the early prototypes, only increases the travel 15.49%. (Fig.-4). The path from one to another side of the wall of 70 mm wide with hexagonal cells would be 80.84 mm. With the same analysis applied to another brick 100 mm wide, the path would be 115.49 mm. In this case, the percentage value is obtained directly discounting 100. We will see it in the following figures.
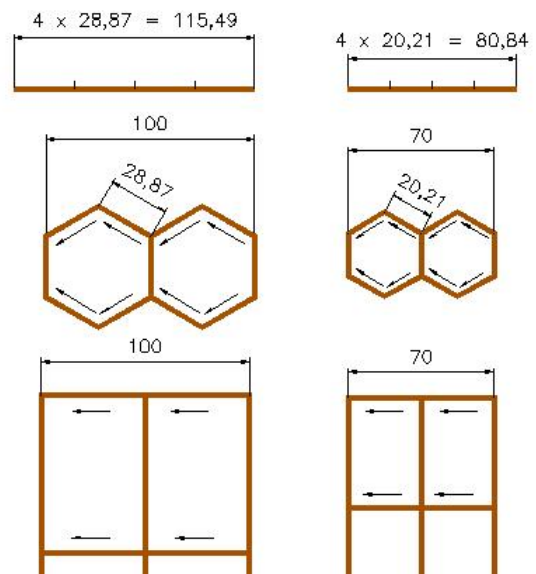

Figure 4

This diagram shows graphical analysis for bricks 70 and 100 mm wide between faces, so that in the hexagonal cell the path increases 15.49% compared with the rectangular cell.

On the other hand, one rotation of 90° sexagesimal degrees in the placement of the hexagonal cells, provides that the diagonal of the hexagonal cell is positioned perpendicular to the outer faces of the brick. In this way the path increases (Figure-5).

As told before, that the path from one to another side of the wall of 100 mm wide, would be 142.86 mm. The increase is 42.86%. If the path between the faces of the wall is 70 mm in width, it would be 100 mm.
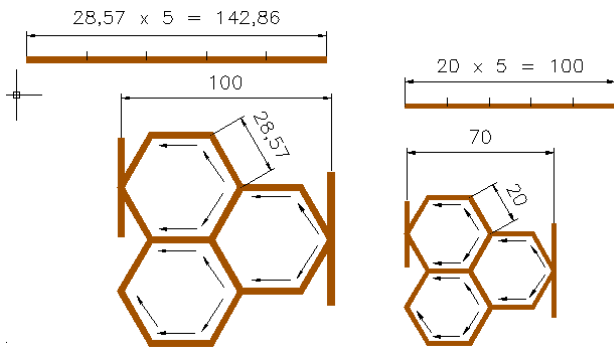

Figure 5

These schemes representing the graphic analysis come to justify that when the orientation of a diagonal of the hexagon is rotated and placed perpendicular to the faces of the brick, the path is increased with respect to the initial case (Fig. 4), in which the diagonal of the hexagonal cells remains parallel to the brick faces.

It is noteworthy that increasing the number of hexagonal cells, keeping the distance between the faces, it doesn't provides any gain in the path (Fig. - 6). If the number of hexagonal cells between the faces of the brick is the lowest possible the path will be the longest and therefore there will be a higher thermo-acoustic absorption. For example, keeping a distance of 70 mm between the faces of the brick, two lines of "complete hexagons" juxtaposed represent a path of 100 (20x5 = 100). When one row is increased from two to three lines of juxtaposition of "complete hexagons" it means a lower path (7x14 = 98) with respect to the initial case. In that case the path between the faces of the ceramic brick is lower (- 2,86 %).

$$(5x20=100) > (7x14=98)$$
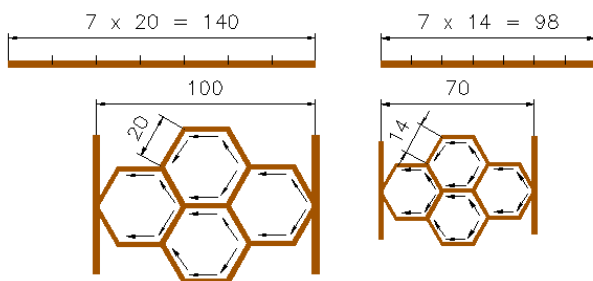
$$42,86\% > 40\%$$

Figure 6

These schemes of graphical analysis show that increasing the number of cells and keeping the distance between the faces of the ceramic brick, no gain is provided.

Subsequent investigations, other graphic analyses (fig. 7) in which a rotation of 90° was applied with additional deformation of the hexagonal cells that maintain their angles of 120°, show that the path increases progressively - hex orientation as in Fig. 4- from 15.49% to 29,9% and - hex orientation as in Fig. 5- from 33.33% to 66.66% maximum, as illustrated in the following study:
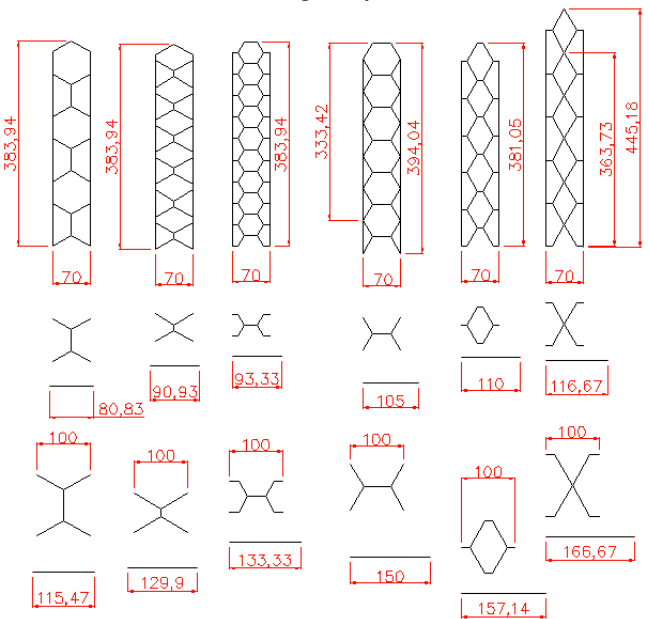

Figure 7

From left to right, there is an illustration of graphic analysis in which the deformation of the hexagonal cells provides greater lengths and increases the insulation.
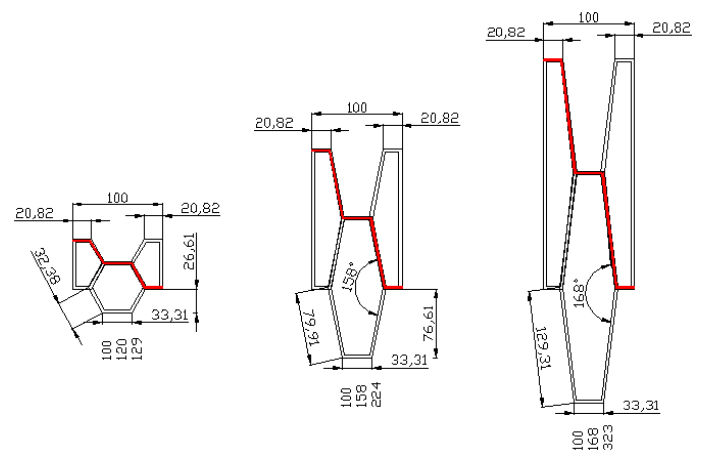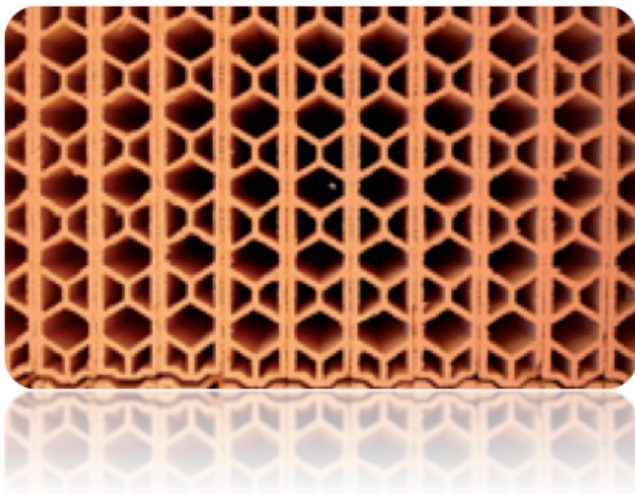

Figure 8

Further investigation about the hexagonal deformation at the extreme case, modifying the angles of the hexagonal cells leads to higher path over than 300% with respect to the distance between the opposite faces of the brick. Such as seen (Fig.- 8) the deformation it posed from the angular variation of the adjacent sides of the cell, for example: from

120° to 158° and 168°, without modifying the distance between the faces of conventional ceramic brick. It increases considerably the length of bridges of transmission between the two opposite faces of the brick with the increase of one pair of opposite angles of the hexagonal cells.

4. Research Results.

The exploitation of the mentioned invention, patented by Polytechnic University of Madrid, is open to all manufactures. It has been materialized as shown in Figure-9, under the name CERAGRAN-H ®, manufactured by RosoSL company, located in Illescas-Toledo (Spain), with the following nominal dimensions:

LENGTH	HEIGHT	WIDTH
710	500	50
710	250	50
710	500	60

Figure 9: Matchboard ceramic bricks CERAGRAN H® Made in Spain

This new ceramic product replaces the conventional ceramic rectangular hollow brick used for making walls, as they are sold in Europe and worldwide with square or rectangular cells.

Revised this new design of ceramic brick called CERAGRAN H®, made by that company of Toledo, the results of acoustic damping has been very low, because of the hexagonal cell orientation, defined by position of the hexagon, as in Fig. 4.

They applied a deformation of the hexagonal cell that still maintains all angles of 120° (second case of Figure 7). In this case the path only increases 15.49%. The trajectory between the faces of a brick of 60mm wide increases only 9.28 mm, and obtains the equivalent width to 69.28 mm, that is very low (first case of Figure 10).

Therefore, the acoustic attenuation of CERAGRAN-H ® is the lowest studied in this article and it does not achieve the highest levels of isolation obtained with the new geometries and new designs.

This design of the brick manufacturer could be improved if a diagonal is placed perpendicular to the outer surfaces and it amends the orientation of the cells of the brick. In this way the path increases around 52.91%. That is, the path between the faces of one ceramic brick of 60 mm wide would reach a width equivalent to 91.75 mm.

However, results must increase significantly if the same orientation of the hexagonal cell is maintained (a diagonal remains perpendicular to the outer surfaces of the brick) and if it also applies a deformation to hexagonal cells that modifies the angle of their faces.

Changing the angle of 120 ° to, for example, an angle of 168°, the path would be 442.37%. In this case, the path between the faces of one ceramic brick of 60 mm wide would reach a width equivalent to 265.42 mm. This is approx. equal to a path of 4,5 conventional bricks.
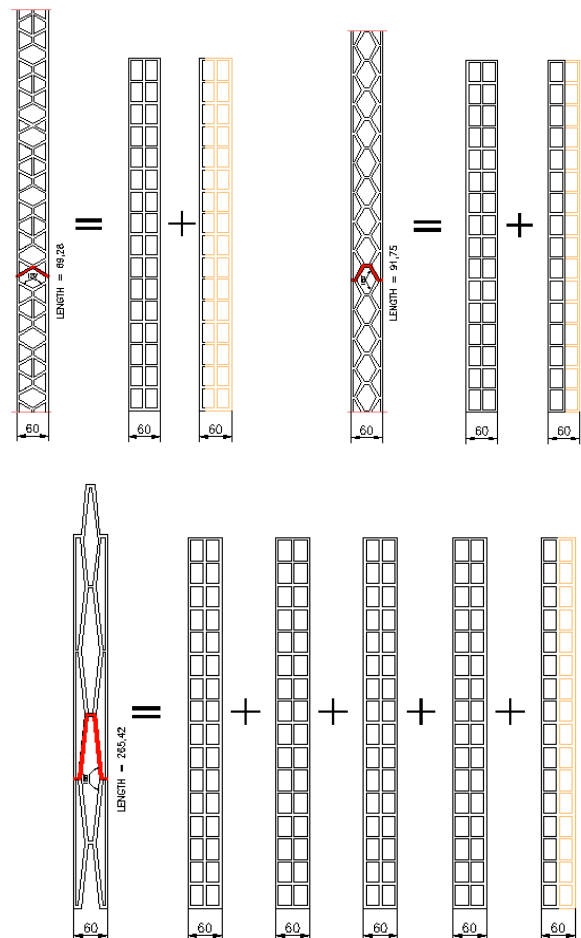
Figure 10: Comparative analysis of the new geometries.

This comparison (fig. 10) proves that the companies that manufacture bricks still have much to improve about the design of their bricks to increase the insulation.

Finally taking as a reference the study of orientation and deformation of hexagonal cells and the ceramic bricks matchboards, we can define a full range of new designs: single hollow brick, triple hollow brick, large format brick, blocks of brick, single hollow brick board, triple hollow brick board ... (Fig. 11). This proposal for new designs of ceramic bricks could be inside the HORIZON 2020 program in order to contribute to improve the thermo-acoustic absorption in better performing buildings.
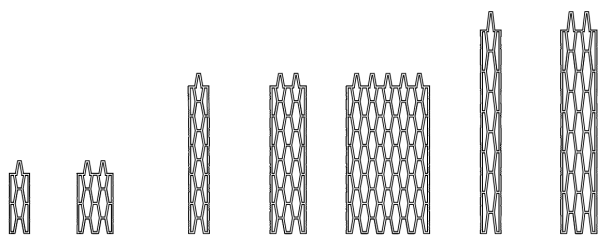

Figure 11

These new designs of the ceramic bricks matchboards have the innovation that the horizontal locking tongue and groove take the form of the cell to avoid paths perpendicular to the faces of the wall in horizontal joints. Nevertheless these joints should necessarily be filled with a thin layer of adhesive or gripping paste. Thus the transmission bridges between the two faces of the walls by the joints of bricks are avoided.

Foreseeably these new large formats brick with horizontal hollow are those that have a better performance in the thermo-acoustic absorption, keeping the conventional width of the walls. Therefore, we are talking of the most competitive design for building walls with ceramic bricks.

The advantages of these designs in large format bricks compared to traditional solutions, taken directly from the Spanish Manufacturers of Fired Clay for Roof Tiles and Bricks, Hispalyt Association, [H1] are as follows:

1. Ruggedness and lower cost of execution on site.
2. Quick and easy installation on site execution.
3. Spotless in execution on site.
4. High performance execution on site.
5. Best finish and planarity of the completed wall.
6. Ability to tilling directly on the brick.
7. Grooves easier to implement and less costly in time.
8. Since it is a ceramic element it has good thermo-acoustic properties, fire resistance, and resistance to suspended loads and impacts.

9. Large format LGF-LD, uncoated commercial bricks are obtaining an attenuation of 33 dBA (CTE DB-HR) and the LGF-LD "ladriyesos" ceramic bricks coated with plaster with a thickness between 5 and 10 mm are obtaining an attenuation over 50 dBA.

5. Conclusions

We have to point out that if the manufacturers decide to use the new designs of ceramic bricks developed by our investigation, **it would be necessary to revise upward the acoustic damping values indicated on this last point**, No.9, both for uncoated and coated bricks, multiplied by more than FOUR times.

We show graphical and analytically that spatial vision and graphic thinking get the graphic research on new alveolar geometries. This research has led to concept of new designs of ceramic bricks that will improve the walls construction system.

This first step in graphic research needs to contact institutions and brick manufacturers interested in financing and participating in this research project, in order to determine the real coefficients of both thermal and acoustic absorption, and mechanical resistance (vertical load, horizontal load) in laboratory and work placement of these new designs.

We would offer this research to suppliers of machinery and technology for the ceramic industry, to manufacturers and users of bricks. We would offer them the use of these designs and the patent for their participation with us in this project R+ D + I, with the sale of operating licenses and / or our expertise advise. For more information, stakeholders may contact Professor Corbella by e-mail using the references cited at the heading of this article.

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