CERAMIC SANDWICH PANEL WITH HIGH IMPACT RESISTANCE AND IMPROVED THERMAL AND ACOUSTIC PROPERTIES

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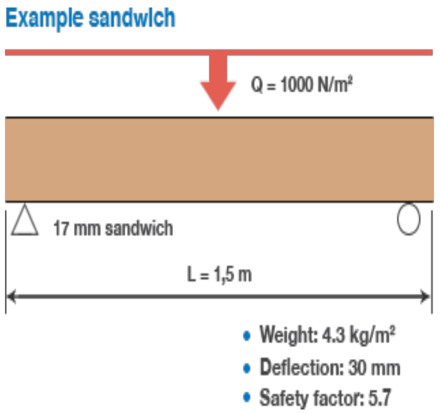
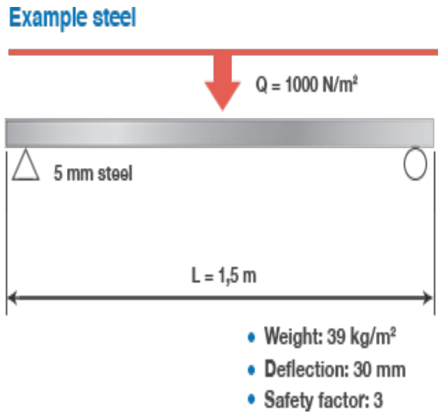
ABSTRACT

This ceramic sandwich panel with high impact resistance and improved thermal and acoustic properties has been developed with the intention of improving the properties of porcelain slabs with thicknesses between 3mm and 12mm, and ceramic materials in general.





The system bonds different types of structural PET cores to the porcelain slab depending on the specific needs it has to satisfy or its intended use.

It provides technical improvements in its various applications:

- Furniture / Washbasins / Shower trays / Kitchen worktops.
- Dry work (sandwich panel glued to the wall with no use of cementitious adhesives)
- Modular / industrialised construction
- Ventilated façades
- Raised technical flooring

It provides the following characteristics:

- High impact resistance
- Improved mechanical and flexural strength
- Easy slab cutting, even with cuts at different angles
- Withstands stresses in the porcelain slabs, preventing breakage in handling or transport.
- Provides thermal and acoustic properties (improved insulation)
- Is not affected by water or damp.
- Improves the hollow sound, characteristic of materials made with porcelain slab
- Allows slabs 3-6mm thick to be used for purposes hitherto not possible
- Hardly adds weight to the assembly and is practically unnoticeable.

The result in thicknesses between 3 and 6 mm is a lightweight material with an impact resistance similar to or even higher than a 12mm slab.

On working on the slab with the sandwich panel, the typical breakage produced by stresses in porcelain stoneware is suppressed, which means the slab assembly can be drilled and cut with water jet and/or disc, CNC and diamond, with absolute safety in handling. The system is especially useful when working with slabs between 3 and 6 mm thick.

1. INTRODUCTION

It is a proven fact that porcelain slabs are increasingly used in new-build and renovation projects, and also as individual furnishings (countertops, tabletops, sinks, shower trays, etc.).

In principle, lower thicknesses (between 3mm and 6mm) have been installed as tiling, even on façades or ventilated façades.

The use of this material for furnishings is beginning to grow, and one can find examples of 12mm slabs used as tabletops, countertops or other items mentioned above. In view of the problem of breakage for different reasons, manufacturers of porcelain slab decided the solution lay in increasing thickness and thus offering the market slabs up to 20mm thick. This solution improves breakage compared to a 12mm slab of material, but has a negative impact in terms of weight, price, handling by transformers, and obviously increases energy consumption during manufacture, transformation and transport.

For all these reasons, slabs between 3mm and 6mm thick have been practically discarded because of their brittleness under impact and breaking strength, for these types of elements.

All these considerations led us to develop a ceramic sandwich panel that profits from the qualities of lower thickness tiles (3mm-6mm) while improving their properties, so they can be used in the applications mentioned above.

After testing different types of cores available on the market to assess the properties they afford, it was decided to use PET cores, which were seen not to react negatively to adhesives, solvents or liquids.

Furthermore, they add very little weight to the sandwich panel (with a 6mm porcelain slab, the weight of the tile increases between 8% and 10%) and it is easy to handle both for cutting and in transformation jobs.

This type of PET core also adds improved heat and sound properties to the ceramics.

Differing densities and thicknesses can be used to ensure the panel provides the properties required by the project or needs to be met.

PET cores are available with high or even 100% proportions of recycled material.

Subsequently, a bonding system had to be developed, which would improve the qualities of the ceramic tile and produce a homogeneous ceramic sandwich panel that met the targeted requirements.

A number of different tests were carried out to confirm that the resulting ceramic sandwich panel delivered improvements. All the tests were undertaken with materials made from super white bodies, since that body composition tends to be the most fragile.

The PET filling is a structural core made of thermoplastic that is perfectly suitable for increasing performance and reducing weight in a wide range of sandwich panels. It has been used in industrial transport, naval and wind power applications. It is easy to machine and has good dimensional stability at high temperatures. It is suitable for numerous processes, including dipping, pre-impregnation and pressure bonding.

The material has a stable closed cell structure and is insensitive to moisture, decay or rot, making it an excellent substitute for organic materials such as balsa or plywood. The high-density PET core (PN200 and PN250) is especially suitable for floors, roofing, and both threaded and screw-in accessories, as it has good screw retention. These PET cores are 100% recyclable.

Property	Test[1]	Ud.		PN65	PN80	PN115	PN200	PN250
Compressive strenght[2]	ASTM D 1621	Mpa	Nominal	0,7	1	1,7	4	5,2
			Minimal	0,55	0,8	1,35	3,5	4,6
Compressive modulus[2]	ASTM D 1621 B-73	MPa	Nominal	65	80	115	244	297
			Minimal	41	65	85	183	237
Shear strength[3]	ISO 1922	MPa	Nominal	0,45	0,6	0,95	2	2,3
			Minimal	0,35	0,5	0,8	1,6	1,75
Shear moduli[3]	ISO 1922	MPa	Nominal	12	20	31	68	85
			Minimal	10	15	23	59	76
Shear elongation[3]	ISO 1922	%	Nominal	20	15	12	6	5,3
Density	ISO 845	Kg/m^3	Nominal	65	80	115	210	250
			Minimal	60	75	110	200	238

***Table 01**: PET core with property values measured at +23°C*

Characteristics[1]	Units	PN65	PN80	PN115	PN200	PN250	Type of test
Density range	Kg/m3	60-75	75-85	110-120	200-220	238-263	ISO 845
Thermal conductivity[2]	W/(m-K)	0,033	0,033	0,035	0,046	TBD	ASTM C177

1. *The typical values are approximate*
2. *Thermal conductivity at +10ºC*

***Table 02:** PET cores with thermal conductivity data / densities.*

2. TESTS CONDUCTED

2.1 IMPACT RESISTANCE TEST USING A FALLING STEEL BALL

This test was carried out using the method described in standard UNE 56875 v2, Section 4.7.3.7 "Resistance to ball drop impact. Kitchen furniture", which consists of making five impacts with a steel ball. These impacts are spaced 5 cm from each other and from the edges of the sample.

The steel ball weighs 324 ±10 gram and measures 42.8 ±0.5 mm in diameter.

Ball drop height depends on the intended use for the worktop.

- 40 ±1 cm for workplans involving general purpose use.
- 60 ±1 cm for workplans involving intense use.

The results of the test were as follows:

IMPACT NO.	BALL WEIGHT	DROP HEIGHT	DEFECT FOUND	RESULT	USE
1	324 g	60 cm	None	PASS	INTENSE
2	324 g	60 cm	None	PASS	INTENSE
3	324 g	60 cm	None	PASS	INTENSE
4	324 g	60 cm	None	PASS	INTENSE
5	324 g	60 cm	None	PASS	INTENSE

Table 03. *Results of impact testing*

Figure 01*: Test sample and impact points*

The sample was placed on a hard, continuous flat surface, so that no areas or gaps on the back face were left unsupported. The sample was held firm to prevent rebound on impact.

The steel ball was dropped onto the porcelain slab and caught by hand to prevent successive impacts on rebound. Four other impacts were repeated at different points.

Once the series of impacts had been concluded, the sample was observed and considered to be suitable when no defects were visible at any of the impact points.

This test demonstrates how this sandwich panel system meets the requirements for intense use.

Figure 02: *6mm, test piece without sandwich after a single impact*

When the same test was applied to a porcelain tile (6mm) without the sandwich panel system, the piece broke on first impact.

The test demonstrates how the ceramic sandwich panel system confers impact resistance properties on the ceramic tile which the porcelain slab on its own does not have.

One problem is thus overcome, namely that they cannot be used in certain product lines due to the breakage that occurs with 6mm slabs.

Impact testing is normally performed internally, adapting standard UNE 56875:2014 v2 and using a 324 g steel ball dropped from a height of 64 cm (force of 2 joules). The piece is held in a number of supporting grips, leaving the rest of the tile in the air. This test is more demanding, given that not all the slab is supported. Our prototype also passed this test successfully, as it did the ITC test using standard UNE 56875 v2 Section 4.7.3.7.

Figure 03. *Adaptation of standard UNE 56875:2014 v2 for impact testing*

2.2 DRY HEAT RESISTANCE TEST

The test was carried out following the method described in standard UNE 56875 v2 Section 4.7.3.4 "Resistance to dry heat at 180ºC. Kitchen furniture", which consists of putting the surface of the sample in contact with a receptacle having a pre-defined heat capacity, which is initially 180ºC. Subsequently, the sample is assessed by visual examination and classified according to the following table:

ASSESSMENT	CLASSIFICATION
No visible change	5
Slight change in gloss and/or colour, only visible at certain observation angles	4
Moderate change in gloss and/or colour	3
Pronounced change in gloss and/or colour	2
Damage and/or surface blistering	1

Table 04. *Degradation classes*

Figure 04. *Photograph of the tested sample*

The aim of the test was to demonstrate its feasibility for use as a worktop, as it simulates placing a hot tray or pan from the oven and leaving it to cool on the worktop or on a table.

No defects were seen, either in the porcelain slab or in the ceramic sandwich panel as a whole, so it was graded as Class 5 (No visible changes).

2.3 HEAT-WATER THERMAL SHOCK

This test seeks to verify how the ceramic sandwich panel behaves under temperature changes.

It is carried out by producing a thermal shock, whereby the samples are in a stove at 75ºC for 30 minutes and then immersed in water at room temperature.

This test is repeated over 70 cycles on the different samples.

Holes were made in the samples with a waterjet cutter, the idea being to simulate drain holes or any type of machining they may be subjected to. These holes make the piece weaker and if it is sensitive to thermal shock, cracks appear.

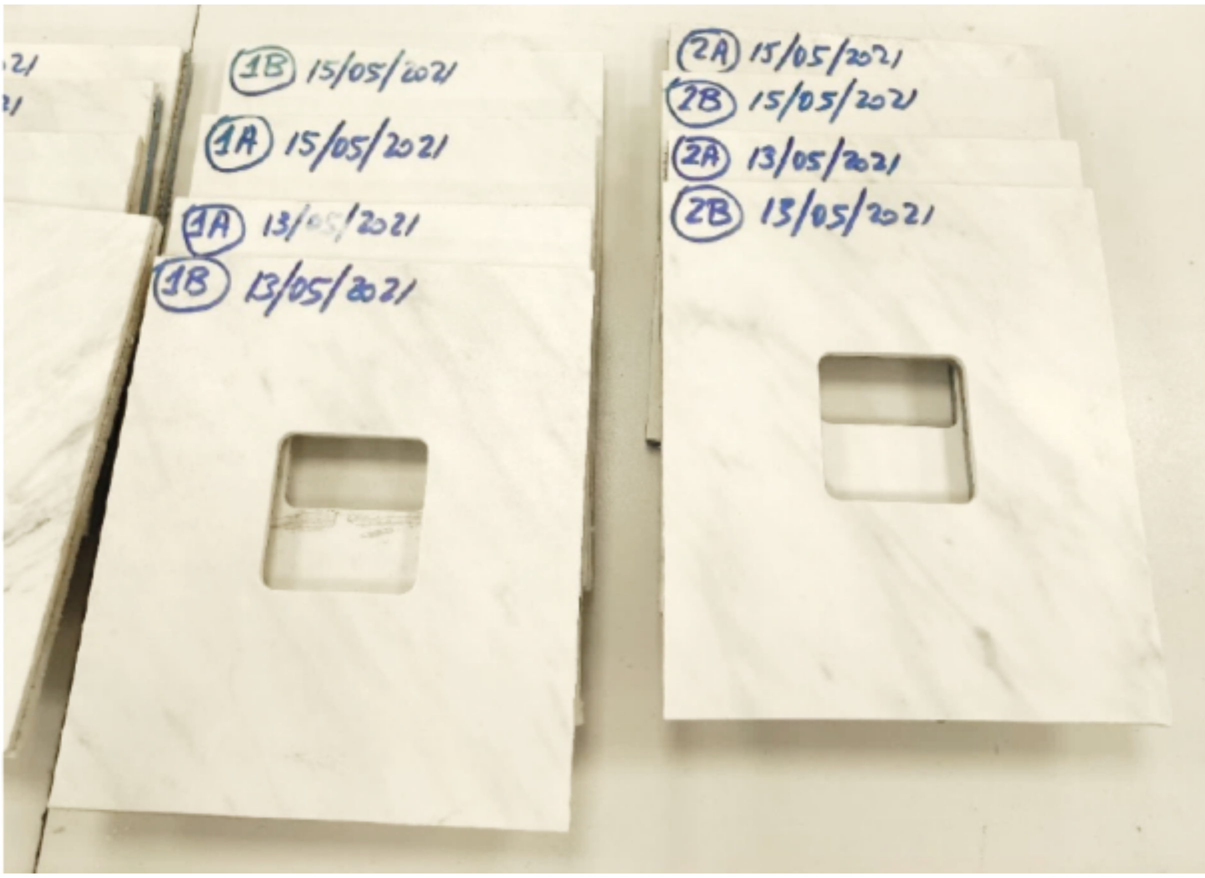


Figure 05. *Photograph of test samples with a 50x50mm hole*

Figure 06. *Photograph of test samples with a 40-mm diameter circle*

After each cycle was performed, methylene blue was applied to the pieces to check for cracking.

All the test samples successfully passed the 70 test cycles, thus demonstrating the viable use of porcelain slab sandwich for sinks, basins or shower trays, among other applications.

A total of sixteen samples were tested, eight with a 50x50 mm square hole cut with radius in the corners and eight with a 40 mm diameter circular hole in them.

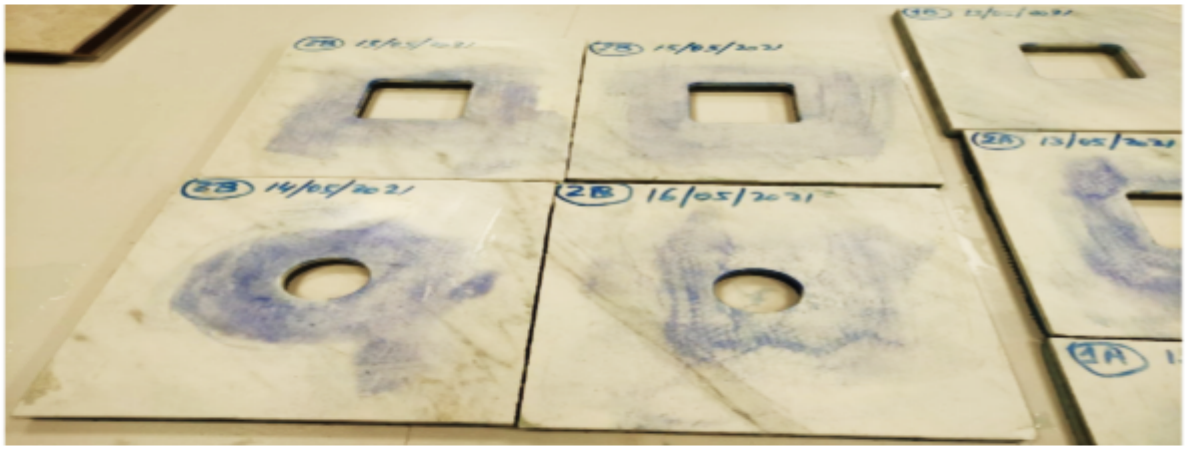


Figure 07. *Photograph of samples tested, verified with methylene blue*

TEST SAMPLE	TYPE	CYCLES	RESULT
1A (13/05/2021)	PORCELAIN 6MM + CORE 10 mm (B)	70	PASS
1B (13/05/2021)	PORCELAIN 6MM + CORE 10 mm (B)	70	PASS
2A (13/05/2021)	PORCELAIN 6MM + CORE 10 mm (D)	70	PASS
2B (13/05/2021)	PORCELAIN 6MM + CORE 10 mm (D)	70	PASS
1A (14/05/2021)	PORCELAIN 6MM + CORE 10 mm (B)	70	PASS
1B (14/05/2021)	PORCELAIN 6MM + CORE 10 mm (B)	70	PASS
2A (14/05/2021)	PORCELAIN 6MM + CORE 10 mm (D)	70	PASS
2B (14/05/2021)	PORCELAIN 6MM + CORE 10 mm (D)	70	PASS
1A (15/05/2021)	PORCELAIN 6MM + CORE 10 mm (B)	70	PASS
1B (15/05/2021)	PORCELAIN 6MM + CORE 10 mm (B)	70	PASS
2A (15/05/2021)	PORCELAIN 6MM + CORE 10 mm (D)	70	PASS
2B (15/05/2021)	PORCELAIN 6MM + CORE 10 mm (D)	70	PASS
1A (16/05/2021)	PORCELAIN 6MM + CORE 10 mm (B)	70	PASS
1B (16/05/2021)	PORCELAIN 6MM + CORE 10 mm (B)	70	PASS
2A (16/05/2021)	PORCELAIN 6MM + CORE 10 mm (D)	70	PASS
2B (16/05/2021)	PORCELAIN 6MM + CORE 10 mm (D)	70	PASS

Table 05*. Results of heat–water thermal shock testing of test samples*

2.4 HEAT-FROST THERMAL SHOCK

This test consisted of twenty-five cycles in which the samples were put into a stove at 75ºC for an hour and subsequently into a freezer at −20ºC.

The samples had a hole of 50x50 mm and minimal radius in the corners, the idea being to weaken the pieces and simulate possible actions by manipulators when working with the porcelain sandwich.

The test was performed on 6 samples. All test pieces withstood the test without any issues.

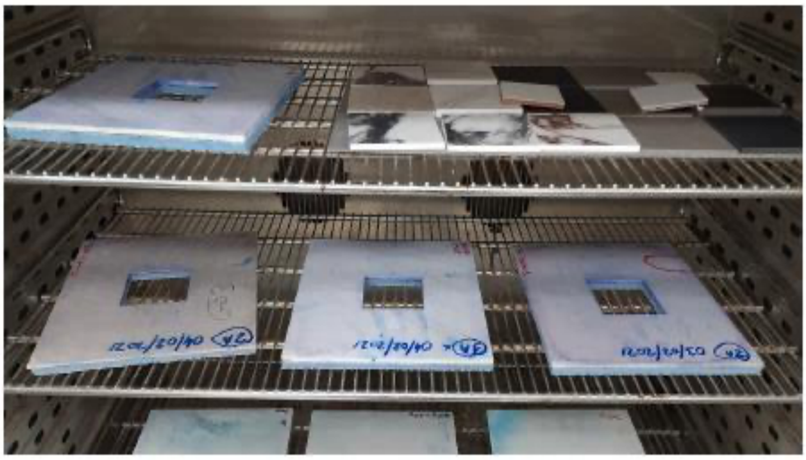


Figure 08. *Photograph of tested samples, verified with methylene blue*

2.5 MECHANICAL STRENGTH OF THE SANDWICH WHEN MITRE-GLUED

This test aims to see how joints between porcelain sandwich pieces behave when glued with adhesive. This is widely used in the work of marble-workers and transformers, for producing different items with porcelain stoneware.

We made sample pieces with the 6mm porcelain slab with no sandwich and others with the porcelain slab sandwich, in order to compare results.

Figure 09*. Photograph of test pieces glued at an angle of 90º*

We used a force meter to measure the force in kilos that the pieces withstood before breaking and thus assess the differences between the pieces without the sandwich and those used in the porcelain sandwich panel.

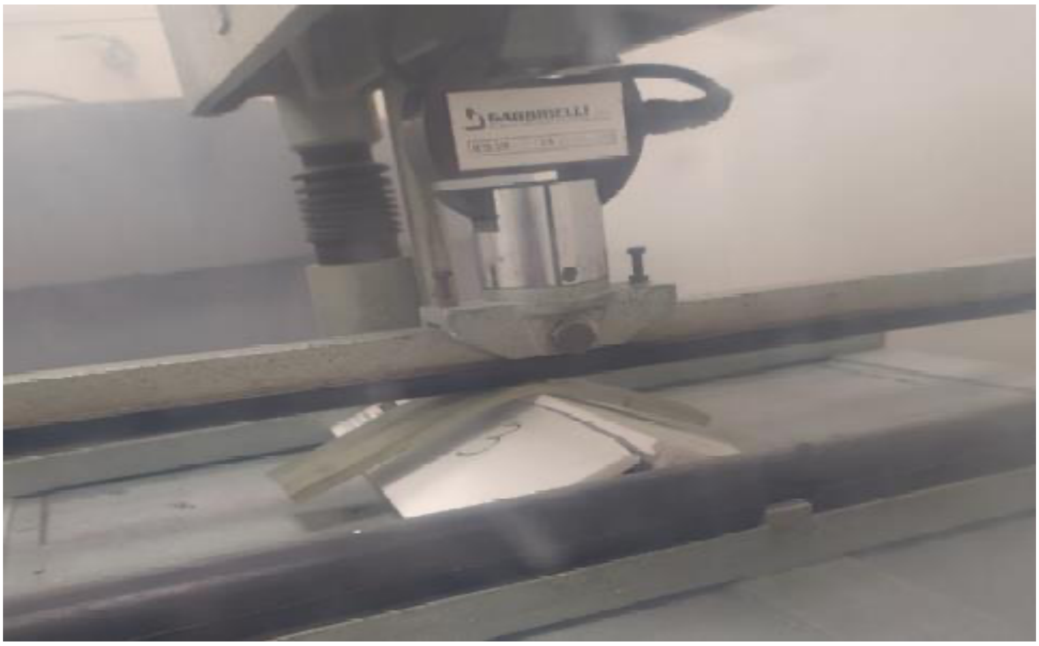


Figure 10. *Photograph of the force meter used in the test*

Figure 11. *Photograph of the force meter used in the test*

A 10% improvement was seen in the samples with the porcelain sandwich (6-mm porcelain tile plus 10-mm sandwich panel) compared to the 6-mm porcelain tile with no sandwich.

2.6 BENDING STRENGTH TEST ON 6-MM SLAB

This test was carried out following the method described in standard UNE-EN ISO 10545-4:2019 "Ceramic Tiles – Part 4: Determination of modulus of rupture and breaking strength", which consists of subjecting the tiles to a progressive force at constant speed, by means of a roller exerting pressure on the middle of the tile until it causes failure. Meanwhile, the tile is supported on another two rollers, each located at a distance of one centimetre from the ends.

Figure 12. *Photo of sample no. 1 in the test*

Seven samples were made from the ceramic sandwich panel (6-mm porcelain tile plus the sandwich system), and 7 samples using only the 6-mm porcelain tile from the same manufacturer. The results of the samples are compared in the table below.

Sample 1: **6-mm PORCELAIN SLAB WITH 10-mm PN80 PET CORE AND CERAMIC SANDWICH PANEL WITH FULLY DEVELOPED ADHESION SYSTEM**

TILE	BREAKING LOAD (N)
1	1,383
2	1,451
3	1,412
4	1,451
5	1,481
6	1,550
7	1,500
Mean value	**1,440**

Table 06.

Sample 2: **6-mm PORCELAIN SLAB WITH NO CERAMIC SANDWICH**

TILE	BREAKING LOAD (N)
1	1,187
2	1,304
3	1,236
4	1,334
5	1,255
6	1,226
7	1,265
Mean value	**1,260**

Table 07.

A comparison of the results shows that the samples made with the ceramic sandwich panel have on average 14.3% higher bending strength.

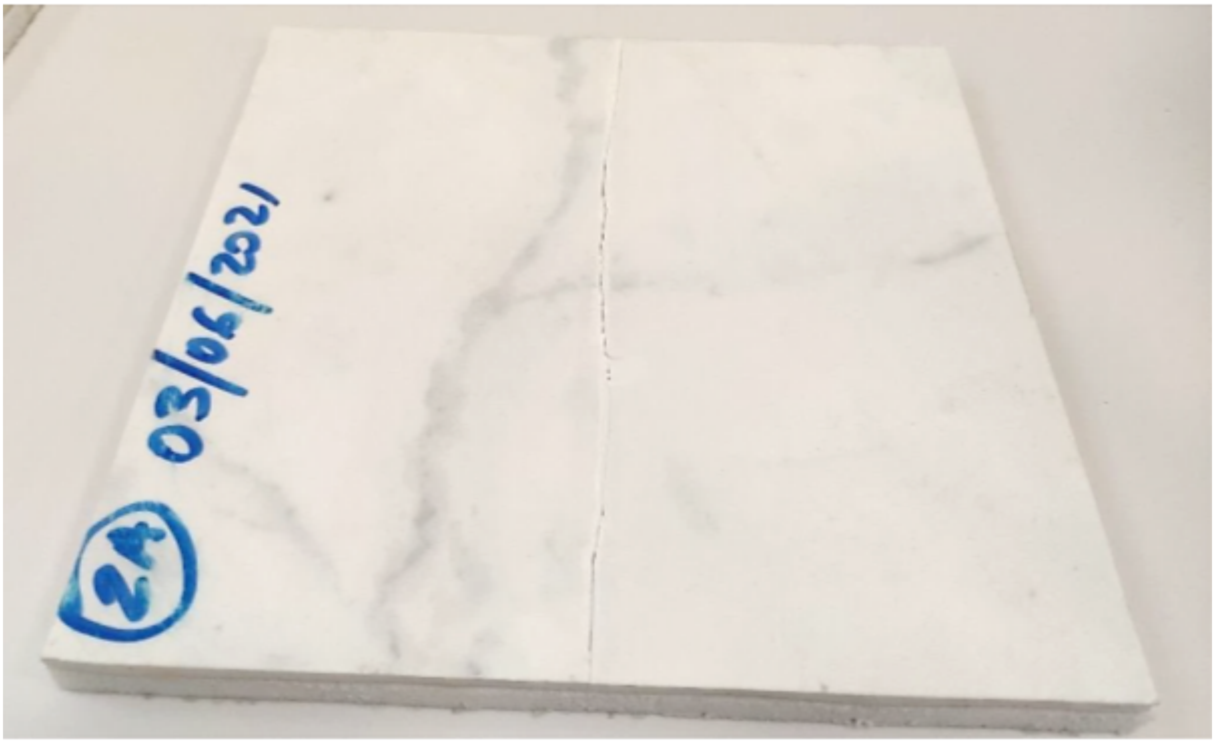


Figure 13. *Photograph of a piece ruptured by bending*

The bending values shown are those that the porcelain tile withstood before rupturing; the samples with the ceramic sandwich panel remained bonded by the sandwich system, without any type of breakage appearing in the panel system.

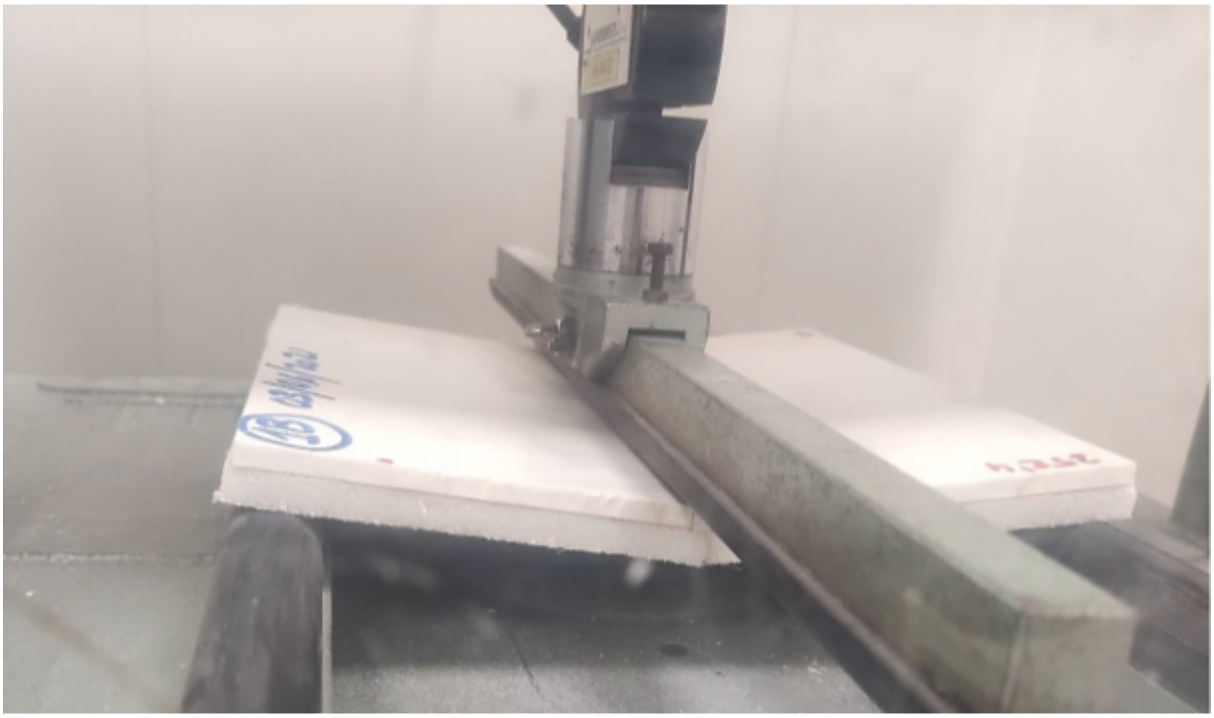


Figure 14. *Photograph of the ceramic sandwich subjected to bending force*

2.7 BREAKING STRENGTH TEST ON RAISED TECHNICAL FLOOR

The aim of this test was to demonstrate the results obtained by the ceramic sandwich panel using porcelain floor tiles in a raised technical floor.

The trial included samples that had undergone previous impact, in which one tile was already cracked and others were not cracked after the impact, while the remaining pieces had not undergone any impact testing.

The idea was to demonstrate how the ceramic sandwich panel system behaves in this type of product.

The system comprised a 10-mm thick porcelain floor tile and a PET core with a thickness of 10 mm and density of 80 kg/m^3.

REFERENCE	IMPACT	Impact force (320-g steel ball)	SIZE	SUPPORT (mm)	WIDTH (mm)	Total thickness (mm)	Modulus (N/mm²)	Kilos	Kilos Corrrected	Load (N)	Force (N)
PORCELAIN	NO IMPACT	STANDARD	30x30	270.0	298.3	10.1	54.9	429.5	420	4124	3732
3A (26/08/2021)	WITH IMPACT/CRACK	1,50 JOULES	30x30	270.0	296.9	20.5	10.4	333.1	326	3198	2908
1B (24/08/2021)	WITH IMPACT/ NO CRACK	1,25 JOULES	30x30	270.0	297.8	20.8	10.5	347.1	340	3333	3021
			30x30	270.0	297.8	20.8	19.4	643.0	629	6173	5597
2B (24/08/2021)	WITH IMPACT/ NO CRACK	1,25 JOULES	30x30	270.0	298.5	20.8	19.0	632.5	619	6073	5493
1A (26/08/2021)	WITH IMPACT/ NO CRACK	1,25 JOULES	30x30	270.0	298.5	20.9	15.4	517.1	506	4965	4491
2B (26/08/2021)	NO IMPACT		30x30	270.0	297.8	21.0	12.8	433.7	425	4164	3775
			30x30	270.0	297.8	21.0	17.0	575.7	564	5527	5011
1B (26/08/2021)	NO IMPACT		30x30	270.0	297.3	20.7	13.0	425.6	417	4086	3711
			30x30	270.0	297.3	20.7	15.4	505.4	495	4852	4407
3B (26/08/2021)	NO IMPACT		30x30	270.0	298.6	20.7	15.8	520.9	510	5001	4522

Table 08. *Breaking strength measurements for the different samples*

The tests that exhibit two results do so because the machine stopped during the measurements and the final result is given in red when it continued until it stopped applying force.

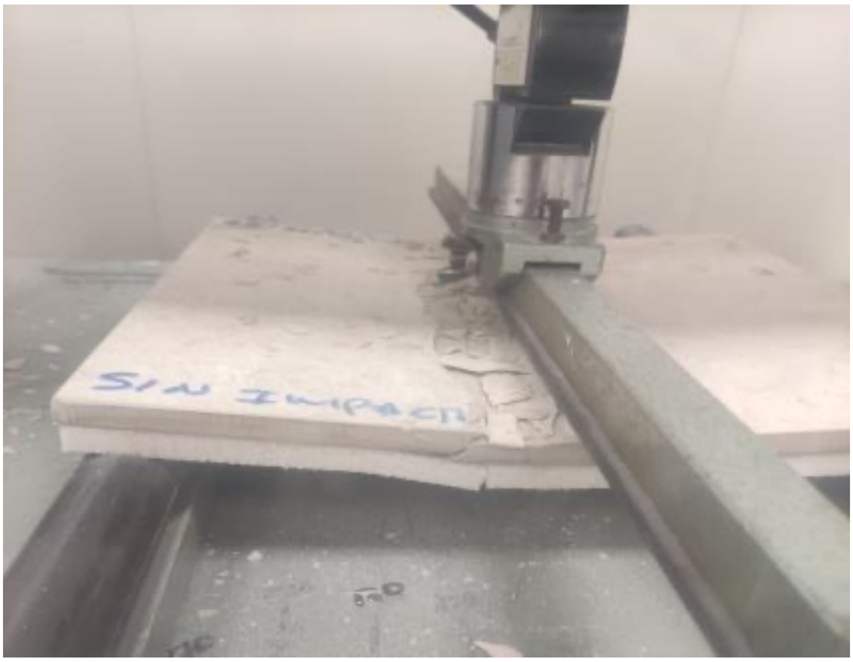


Figure 15. *Sample of raised technical floor*

Figure 16. *The system's breaking strength is higher than that of porcelain tile*

One can see how failure occurs in the porcelain slab while the structure of the ceramic sandwich panel is preserved.

2.8 FASTENING STRENGTH TEST OF A BATHROOM FIXTURE

A further test was performed to measure the fastening strength of a bathroom fixture, according to the principles of standard UNE 67100.

The intention was to see how bathroom fixtures on a ceramic sandwich panel behave, when the panel is used in dry building work or in industrialised construction.

The idea was to renovate a wall with ceramic sandwich panel using dry building work to create a blank wall where different items can be fixed, such as towel rails, mirrors, shower screens, etc.

The aim was to demonstrate the results achieved when no other materials such as cement, gypsum or bricks are installed behind the ceramic panel.

For the test, a ceramic sandwich panel with 6-mm porcelain slab and 20-mm-thick core with 80 kg/m^3 density was used. The test was performed on four samples.

A common bathroom fixture of a leading brand in sanitation was used for the test, and the samples were drilled with two holes for 5x25 mm wall plugs and 3.5x30 mm screws.

A weight of 10.4 kilos was attached to the fixture (i.e. more than twice the weight required by the standard) and left hanging from the fixture on the various samples for 24 hours.

Standard UNE 67100 requires a weight of 5 kilos for 24 hours.

Figure 17. *Photograph of the ceramic sandwich subjected to constant weight.*

Figure 18. *Photograph of the ceramic sandwich subjected to constant weight.*

All four samples passed the test. No movement of the fixture was seen, nor of the screws or wall plugs, and as there were no breaks or cracks in the porcelain slab, the system passed the test successfully.

2.9 SOUND ABSORPTION TEST USING AN ALPHA CABIN

This test was carried out to demonstrate the sound absorption capabilities provided by the PET panel and therefore the improvement to the ceramic sandwich panel as a whole, according to the following test standards:

- UNI EN ISO 354:2003 – Acoustics — Measurement of sound absorption in a reverberation room (deviation from the standard).
- UNI EN ISO 11654:1998 – Acoustics. Sound absorbers for use in buildings. Sound absorption classification (deviation from the standard).
- ASTM C423 – 09a – Standard test method for sound absorption and sound absorption indexes using the reverberation room method (deviation from standard).

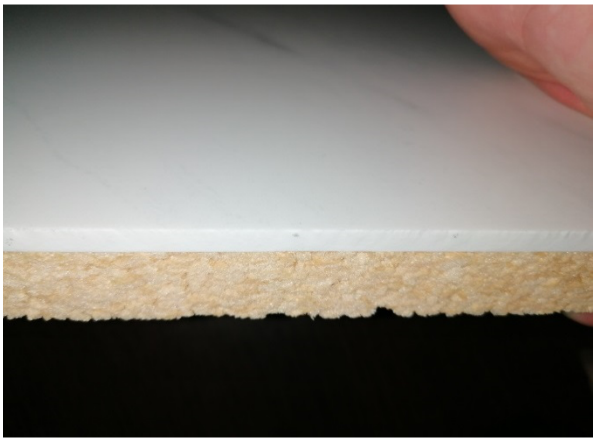


Figure 19. *Photograph of a test piece*

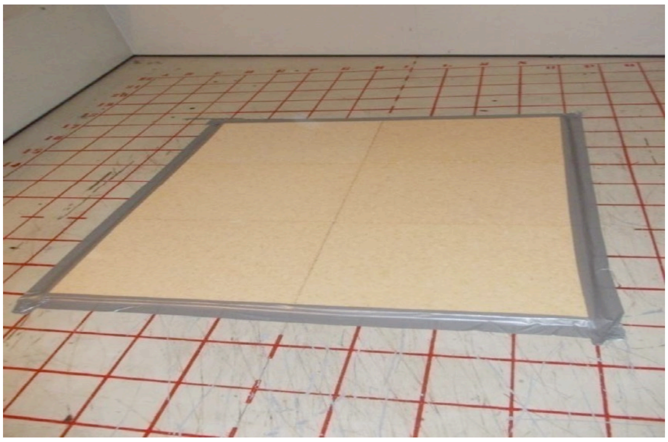


Figure 20. *Photograph of the test*

For the test, a 10-mm thick PET core of 100 kg/m^3 density was used on a surface of 0.72 m^2.

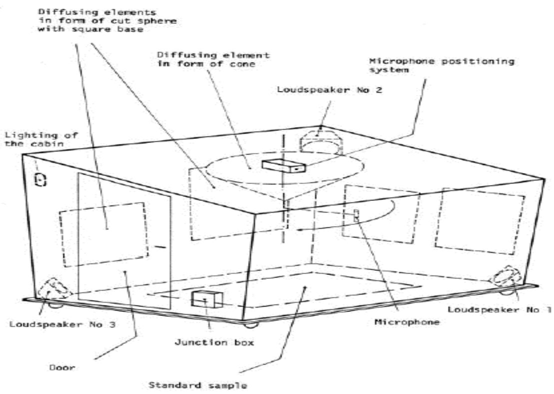


Figure 21. *Diagram of the test in the Alpha cabin*

CALCOLO SECONDO UNI EN ISO 354:2003 / *UNI EN ISO 354:2003 DATA PROCESSING*

VALORI DEL COEFFICIENTE DI ASSORBIMENTO ACUSTICO α_s (IN BANDE 1/3 DI OTTAVA)
SOUND ABSORPTION COEFFICIENT α_s VALUES (ONE-THIRD OCTAVE BANDS)

Hz	500	630	800	1 k	1,25k	1,6 k	2 k	2,5 k	3,15 k	4 k	5 k	6,3 k	8 k
α_s	0,25	0,38	0,57	0,68	0,68	0,75	0,69	0,64	0,60	0,59	0,61	0,58	0,61

VALORI DEL COEFFICIENTE DI ASSORBIMENTO ACUSTICO α_s (IN BANDE 1/3 DI OTTAVA) - GRAFICO
SOUND ABSORPTION COEFFICIENT α_s VALUES (ONE-THIRD OCTAVE BANDS) – GRAPHICAL PRESENTATION

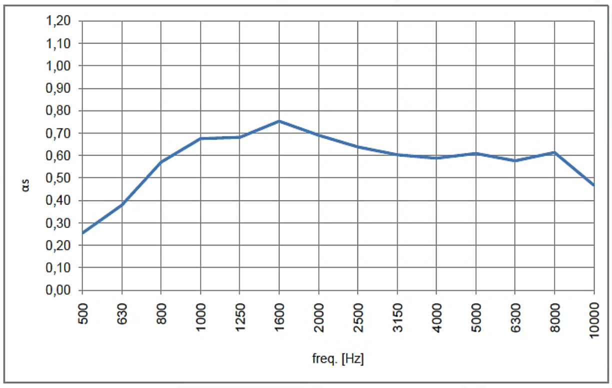


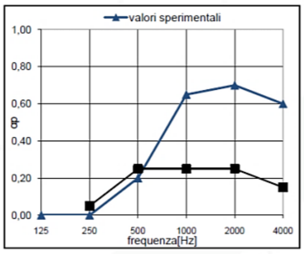
Table 09. *Test results.*

CALCOLO SECONDO UNI EN ISO 11654:1998/ *UNI EN ISO 11654:1998 DATA PROCESSING*

VALORI DEL COEFFICIENTE DI ASSORBIMENTO ACUSTICO PRATICO α_p (IN BANDE 1/1 DI OTTAVA)
PRATICAL SOUND ABSORPTION COEFFICIENT α_p VALUES (OCTAVE BANDS)

Hz	125	250	500	1000	2000	4000
α_p	/	/	0,20	0,65	0,70	0,60

VALORI DEL COEFFICIENTE DI ASS. ACUSTICO PRATICO α_p (IN BANDE 1/1 DI OTTAVA) - GRAFICO
PRATICAL SOUND ABSORPTION COEFFICIENT α_p VALUES (OCTAVE BANDS) – GRAPHICAL PRESENTATION



RISULTATI DELLA PROVA – INDICI DI VALUTAZIONE STANDARD
TEST RESULTS – STANDARD INDEXES

α_w	0,25 (MHH)	Coefficiente di assorbimento acustico ponderato / *Weighted sound absorption coefficient*	UNI EN ISO 11654:1998
NRC	0,40	*Noise Reduction Coefficient*	ASTM C423 – 09a
I risultati espressi nella presente tabella sono puramente indicativi a causa della deviazione dallo standard (in cabina alfa i risultati al di sotto dei 500 Hz non possono essere ritenuti attendibili) / **The results and indexes shown in the table above are only indicative** due to the deviation from standard (in alpha cabin results below 500 Hz are not reliable).			

Table 10. *Test result.*

The results of the tests show the improvement achieved by the porcelain sandwich with the PET core, thanks to the sound absorption properties that the PET panel affords the entire system.

Depending on the requirements, the density and thickness of the PET core can be adjusted to produce a fully customised sandwich panel.

3. RESULTS

A wide range of tests were performed to verify the improvements we claim are afforded by the ceramic sandwich panel in the materials and applications stated. All the tests considered necessary to do so were passed successfully, thus demonstrating the projected ceramic sandwich panel's suitability in the various proposed uses.

The results of the tests show how the sandwich panel improves the properties of a 6-mm porcelain slab compared to porcelain tiles of the same thickness with no sandwich panel system.

In the test performed on the raised technical floor, the results were very good, even though some of the slabs were broken because they had been used in earlier impact tests. The system remained intact without failing, enabling the tiles to be changed without any danger of the floor collapsing.

The fastening strength test on a bathroom fixture was aimed at demonstrating its worth in dry building work and industrialised construction, and the results were again highly satisfactory.

From the acoustic tests performed, the improvements that can be afforded by using the sandwich panel in house renovations or new-builds are clearly evident.

For some tests, the standard had to be adapted because it does not include specific rules for the materials and uses at issue.

The aim was to provide the necessary results for slim ceramic thicknesses to be used in the various applications detailed in the Abstract.

4. CONCLUSIONS

The various tests validate the use of ceramic sandwich panels with slim porcelain slabs (thickness of 3–6 mm) as an alternative to 12-mm or thicker tiles. In addition, they can also be used in different types of applications with the guarantees of success that these tests have been able to demonstrate.

Thanks to a hybrid combination of materials of a different nature, used in other production sectors, improvements have been achieved in porcelain slabs, a construction material that can be used for decoration, furniture, dry building work and industrialised construction, among other uses.

Ceramic is a material that is very resistant to wear and discolouring, which withstands a wide range of temperatures, resists moisture and chemical agents, and can have anti-bacterial properties, among other characteristics. All these properties mean that the ceramic sandwich panel can be used to compete with other materials, which till now have dominated the decoration and furniture sectors with phenolics, laminates, or the entire range of products from the world of carpentry or even of compact quartzes.

ENVIRONMENTAL ADVANTAGES:

- Reduced carbon footprint, so important for all processes today.
- The use of slimmer porcelain slabs with similar results to thicker tiles helps to reduce emissions to the atmosphere in the manufacturing and firing process.
- As they are considerably lighter in weight, CO_2 emissions during transport are reduced.
- In rehabilitation projects, it is no longer necessary to remove existing coverings, thus reducing the energy consumed in removing them, along with CO_2 emissions from transport and recycling processes.
- Thanks to its dry installation in which no buttering and floating of cementitious adhesive is required, it saves the emission of polluting gases in the manufacture of those materials.
- Using PET cores made of recycled materials helps recycle waste materials and enhances the circular economy.
- The thermal properties that the sandwich incorporates mitigate emissions into the atmosphere from gas heaters, consumption of electricity, etc.
- With their soundproofing properties, these panels reduce noise pollution in old buildings rehabilitated with this system.

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