

CERAMIC TILINGS, FINISHES WITH A FUTURE?

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ABSTRACT

On reviewing the main ceramic tile applications, an overview is given of the limitations and possibilities of ceramic coverings in current building construction, both with a high technological content and based on conventional construction methods. The former affords real market opportunities, especially in facades and non-residential flooring. The latter requires either pursuing quality in direct adhesion tile installation or addressing prefabrication.

The ceramic tile industrial sector should implement a deep transformation of its commercial structures with a view to adapting to industrialised construction. The offer of ceramic systems will need to break new ground amongst alternative materials designed for the same purpose, which compete in price and supply/installation logistics.

1 – INTRODUCTION

At least in the first world, the industrialisation of the building process is characterised by a series of tendencies, which in one way or another affect ceramic tiles. In cutting-edge building construction, objectives have been wholly adopted that prioritise functional, energy and environmental requirements, as well as low cost maintenance. Therefore systems, constructive models and suitable materials are adopted to meet these objectives. We refer to construction with a high technological content, in which prefabrication and specialisation in techniques and materials dominate the entire construction process, from planning to finishes. In this area, which still very minor at least with regard to residential architecture, any consideration of ceramic coverings is either the result of a direct intervention by the supplying industry or due to a coincidence, owing to functionality or compatibility of materials.

In conventional building construction, by which is understood the most widespread type of construction found, according to constructive models of the mid XXth century, where practically all ceramic tile production goes, factors are also converging that are not precisely favourable to achieving quality finishes with ceramic tiles. These include: drastic reduction in delivery times of finishes, excessive subcontracting with lack of professional skill in executing finishes, incorporation of materials (especially in partitions and enclosures) incompatible with traditional ceramic tile fixing with cement mortar, and absence of quality standards on tile installation technology. This situation is also shared by most of the major ceramic tile consuming countries (**Table 1**).

In both types of construction we can detect clear constraints on the expansion of the ceramic tiles, solely overcome in the last two decades owing to coinciding periods of growth in building activity and penetration into foreign markets. This positive evolution of production (**Table 2**), even with spectacular advances in some years, together with the start of ceramic tile production in countries that had hardly been present in the markets, is another source of concern in the current period of uncertainty.

TOP TEN TILE CONSUMING COUNTRIES		
Country	Population	Consumption ⁽¹⁾
Spain	39,200,000	7.00
Portugal	9,900,000	6.45
Italy	56,900,000	5.53
Taiwan	22,000,000	4.70
Greece	10,700,000	3.31
Czech Rep.	10,300,000	2.82
U. A. Emirates	2,300,000	2.70
Malaysia	21,000,000	2.33
Brazil	170,000,000	2.26
France	59,900,000	2.20
OTHER COUNTRIES: Germany 2.2; USA 0.68		
<small>(1) Consumption in m² per inhabitant/annum</small>		
<small>SOURCE: <i>Andare per Ceramiche</i>. Vilmy Montanari. Edition 2000</small>		

Table 1.

EVOLUTION OF WORLD PRODUCTION IN THE PERIOD 1980-2000					
Year	Production (in m ² /day)	% ⁽¹⁾	Year	Production (in m ² /day)	% ⁽¹⁾
1980	2,877,000	--	1991	6,370,000	-11.64
1981	3,154,000	9.63	1992	6,861,000	7.71
1982	3,224,000	2.22	1993	8,311,000	21.13
1983	3,402,000	5.52	1994	9,362,000	12.65
1984	3,597,000	5.73	1995	10,491,000	12.06
1985	4,078,000	13.37	1996	11,440,000	9.05
1986	4,210,000	3.24	1997	12,296,000	7.48
1987	5,058,000	20.14	1998	12,963,000	5.42
1988	5,879,000	16.23	1999	13,270,000	2.37
1989	6,456,000	9.81	2000	14,090,000	6.18
1990	7,210,000	11.68			

(1) Increase relative to the foregoing year

SOURCE: *Andare per Ceramiche*. Vilmy Montanari. Edition 2000

Table 2.

In the manufacturing sector we are not only witnessing a rise in production capacity and production, but it is also to be noted that worldwide, the technology process is shared between the top producers, even for the products with the greatest commercial repercussions (Table 3). If manufacturing technology ceases to be a clear competitive factor, production cost will discriminate between some countries, especially as regards manpower costs. Though a clear need remains for investigation, development and innovation in processes and products, the competitiveness of the ceramic industry is moving sharply toward non-technological intangibles.

When Cersaie'2001 was held, Sassi and other leaders of the Italian ceramic sector insisted on the necessity of reaching all the players involved in ceramic tiles, focusing innovation on the search for new applications as well as on assuring installation quality, with new communication modes and commercial strategies that include after-sales service^[1].

Possibly excessive production, worldwide economic uncertainty and the evolution of the construction sector, at least in the first world, set the framework for an investigation project that seeks to shed light on the future of ceramic tiles, and whose first approach is formed by the content of this report.

2 – CURRENT HABITAT AND COVERING MATERIALS

It is necessary first to address the duality already manifested between high-tech architecture and conventional construction. In our country, the former is limited almost exclusively to singular projects, mostly contracted by the Administration; in the latter, almost 300 million square meters of ceramic tiles go into new buildings and renovation.

TOP TEN TILE PRODUCING COUNTRIES															
Country	Production m ² /day	Annual production		PRODUCTION BY PROCESSES AND PRODUCTS											
		m ² x 10 ⁶ (1)	%(2)	Single fire		Twice fire		Porcelain tile		Terra cotta		Clinker		Mosaic	
				m ² /day	%(3)	m ² /day	%	m ² /day	%	m ² /day	%	m ² /day	%	m ² /day	%
Italy	2,162,580	713,651	15.35	1,413,800	65.38	252,400	9.85	431,300	19.94	34,280	1.59	29,800	1.38	1,000	0.05
Spain	1,962,560	647,645	14.17	1,607,000	81.88	172,650	8.80	91,400	4.66	32,860	1.67	58,650	2.99	--	0.00
P. Rep. China	1,541,500	508,695	11.13	889,300	57.69	240,050	15.57	363,600	23.59	1,900	0.12	--	0.00	--	0.00
Brazil	1,508,900	497,937	10.89	1,194,700	79.18	253,300	16.79	22,500	1.49	11,900	0.79	15,000	0.99	11,500	0.70
Turkey	577,600	190,608	4.17	370,000	64.06	171,800	29.74	35,800	6.20	--	0.00	--	0.00	--	0.00
Mexico	474,650	156,635	3.43	405,600	85.45	51,300	10.81	2,000	0.42	7,000	1.47	6,000	1.26	2,750	0.58
India	372,400	122,892	2.69	181,650	48.78	160,950	43.22	25,400	6.82	1,200	0.32	700	0.19	2,500	0.67
USA	291,650	96,245	2.11	207,450	71.13	13,900	4.77	22,200	7.61	17,400	5.97	28,350	9.72	2,350	0.81
Indonesia	284,400	93,852	2.05	196,500	69.09	52,900	18.60	30,500	10.72	--	0.00	4,500	1.58	--	0.00
Germany	280,150	92,450	2.02	101,750	36.32	50,800	18.13	19,300	6.89	650	0.23	99,150	35.39	8,500	3.03

OTHER COUNTRIES PRODUCING OVER 1% OF WORLD TILE PRODUCTION:

Iran: 255,000 m ² /day (1.84%)	Malaysia: 222,100 m ² /day (1.60%)	Japan: 202,000 m ² /day (1.46%)
Thailand: 246,100 m ² /day (1.78%)	France: 212,050 m ² /day (1.53%)	Argentina: 186,900 m ² /day (1.35%)
Portugal: 242,200 m ² /day (1.75%)	Egypt: 207,000 m ² /day (1.49%)	Russia: 158,400 m ² /day (1.14%)
		Vietnam: 138,500 m ² /day (1.00%)

(1) Daily production x 330
 (2) Percentage relative to world production
 (3) Percentage relative to total production

N.B.: This production table is an estimation (e.g. Italy declared 631.8·10⁶ m² in 2000) [2]

SOURCE: *Andare per Ceramiche*. Vilmy Montanari. Edition 2000

Table 3.

However in high-tech construction, factors converge which in a few years will propitiate transfer of materials and technology toward conventional construction. Among these factors, mediated by stability in the real estate market, will be social pressure, which with more information and culture will be demanding QUALITY and respect for the environment in the biggest investment in the consumer's life: housing. This will involve quality, extended to encompass comfort and low use and maintenance costs, without forgetting the demand for an eco-label on materials and processes, besides knowing their service life.

The constant reference to the technological habitat is therefore warranted as a tendency that will transcend normal construction. Perhaps with greater progress than the Interior design proposals coming from the intellectual elite or scenes staged in company advertising, which are also discussed here.

For this we have chosen emblematic spaces where ceramic tile was or could be found.

2.1 – ENVELOPES AND ENCLOSURES

As a return to roots, architectural projection seeks a suitable skin for an ever-more agile and dynamic body. Modern enclosures are conceived as self-bearing envelopes, lightweight, multilayer and assembled by a dry method. Although there are precursors from the mid XIXth century, it was Rationalist Architecture which pursued those objectives based on the availability of materials and the first civil engineering. The Modern Movement mythicised geometric reason, seeking objectivity through a geometry of right lines and abstraction, as well as the autonomy and emancipation of what is natural. It was to be a process lasting decades, in which the availability of materials and their adaptation to construction technology would condition the projection of the envelope system as the lightest possible closure: small thickness, small weight and multiple specialised layers separated by a layer of air.

From the Citrohan house of Le Corbusier (1922) and the fibrecement walls filled with pressed cork 6 cm thick, of Walter Gropius (Weissenhof house, Stuttgart, 1927), to the competitive materialisation of the lightweight facade in the last decades of the XXth century, materials and constructive techniques have been tried, yielding *lightweight facade*

system^[3], based on principles of specialisation and the division of functions: the *panel* or closing element, which with the joint, determines the final appearance of the facade in its main attributes (tension, lightness, order, colour, texture, etc.); the *union between elements*, between structure and auxiliary structure, and between this and the panels, technologically resolving all the problems stemming from dynamic and static stress, environmental conditions and, perhaps the most complex, the fit between two different construction methodologies (structure and auxiliary structure); finally, the lightweight auxiliary structure, as element transmitting the stresses of the envelope to the resistant, bearing structure.

If the lightweight facade is made with single and multilayer metallic panels, also using new generation materials, the already experienced technology in auxiliary structures and unions is transferred to heavy enclosures, with the purpose of taking advantage of all the functional benefits, now using panels of natural stone, prefabricated concrete elements and other composite materials seeking to lighten the enclosure. In fact, natural stone cutting and handling technology will also contribute to this objective. The stone industry will supply large panels, even solving the limited resistance owing to lack of thickness by aluminium threshing on the back or introducing reinforcing inside the piece. It is in this context that ceramic tile represents an option for the future.

In fact, since the 1980s different fastening systems and ceramic facade system configurations have been tried, until reaching the current panorama (Table 4).

Ceramic Facades	
CERAMIC TILE INSTALLATION IN EXTERIORS	<ul style="list-style-type: none"> • By direct adhesion with cementitious adhesives (floating and buttering) or cement mortar • By mixed fixing: adhesion + clips • By mechanical fixing
MECHANICAL FIXING MODES	
<ul style="list-style-type: none"> ➤ Visible fastenings without auxiliary structure ➤ Visible fastenings with auxiliary structure <ul style="list-style-type: none"> • All-glass and vitrall systems • Visible perforation system (<i>System ATK 100 Minor</i>)¹ • Visible profile system (<i>System ATK 106</i>)¹ • Visible clip system (for 4 tiles) (<i>System ATK 100 KL</i>)¹ • Visible clip system (4 per tile) (<i>System ATK 102 Minor</i>)¹ ➤ Hidden fastenings without auxiliary structure <ul style="list-style-type: none"> • Various systems adapted to natural stone by the edge • Top and bottom fastening • Side fastening ➤ Hidden fastenings with auxiliary structure <ul style="list-style-type: none"> • Side grooving² • Back grooving (4 oblique grooves per piece)³ • Back grooving and profiles S-7⁴ • Back-drilled perforation⁵ • Adhesion⁶ 	

1 BWM Dübel + Montagetechnik GmbH

2 Floor Gres System

3 SACMI, SICOF, MECANOTUBO, .etc. Systems

4 MECANOFAS KARRAT S-7 System

SOURCE: TAU CERÁMICA documentation [4]

5 ZYKON FZP (Fischerceram) System
KEIL System

6 KerAion Hydrotect Quadro System
(AGROB BUCHTAL)

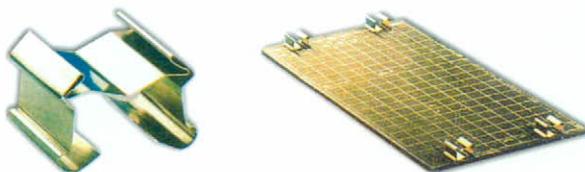
Table 4.

As the ventilated facade system with open joints is the most appropriate for the functional requirements of current construction, especially in cold regions, where it is so important to avoid thermal bridges such as condensations in the enclosure, the ceramic alternative as a panel material, with superior technical characteristics to other alternative materials and with limitless formal possibilities, can have an assured future if it takes advantage of all its technological and commercial potential. To be considered in this respect:

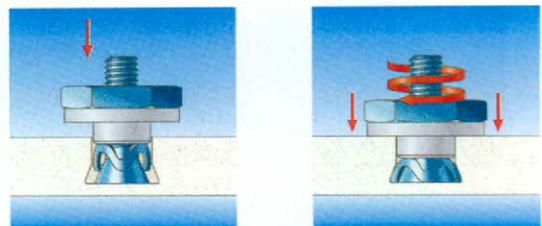
- Current commercialisation of porcelain tile in large sizes, especially from 60 x 90 cm and 90 x 120 cm sizes on, which enter into the modular play of panelling.
- Continuous advances in the semi-dry pressing process. We no longer speak of optimised compaction for making products with 0.01% water absorption and bending strength exceeding 500 Kp/cm², but of double and triple charges, with in-press monitored design, allowing reproduction of the colour, texture and relief, depth and heterogeneity of effects of the entire Mineral Kingdom. With the added possibility of green tile modulation (co-ordinated sizes) and combination customised to order. By way of example may be mentioned the promotion at Cersaie'01 of the *Twin Press* system, fruit of the collaboration between Sacmi and Cerdisa



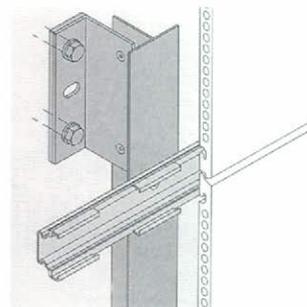
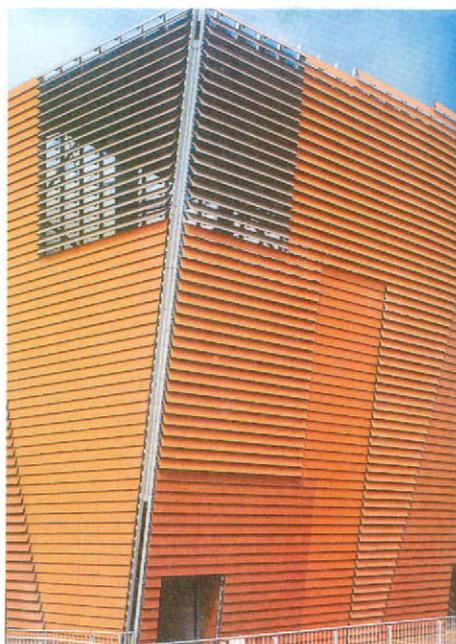
Execution process of a ventilated facade with polished and natural porcelain tile (Dolphin and Coconut series), under the MECANOFAS KARRAT S-7 ® system of auxiliary structure and hidden fastening.
SOURCE: TAU CERAMIC documentation.



System of rear grooving to hold 4 stainless steel clips per piece.
SICOF SPIDER CLIP System
SOURCE: SICOF, S.R.L. catalogue (FOCCHI GROUP).



System of hidden fastening by back-drilled perforation. FISCHER ZYKON FZP fastening, without expansion pressure.
SOURCE: FISCHERCERAM catalogue.



Extruded clinker tile at the service of the semi-heavy envelope.
Rear grooving for hidden fastening with clips. AGROB BUCHTAL® KERATWIN K3 system.
SOURCE: "Programa di produzione. Ceramica per grandi progetti.
Ceramica per facciate" catalogue. AGROB BUCHTAL. Cersaie 2001.

- The possibility of using hydraulic cutting, widespread in floor tiles and wall tile trims, to enrich and diversify facades in rhythm and colour, while also incorporating the curved line in the joints.
- The potential involved in achieving the *light envelope* objective in a facade, the incorporation of compacting (or rather packing) technologies that allow making sheets of 90 x 270 cm with 3 mm thickness (6 kg/m² weight), with the added property of a certain deformability. We refer to proposals such as *Sinterflex*^{1 [5]} or *Lapitech*², together with the widely found Buchtal precursor *KerAion*. These sheets, fixed on lightweight panels that provide enough resistance to the pressure of the wind and are dilatometrically compatible, can attain the essential objectives of the ventilated, open joint, lightweight facade.
- The necessity to incorporate *technical marketing* into the promotional activity of ceramic tiles for exteriors, even in comparison with competing materials in panelling lightweight and heavy envelopes, also with materials for cladding conventional enclosures.
- Jointly with the supply sectors of auxiliary structures and joining elements, the ceramic industry should define, try out and promote the most appropriate envelope systems for ceramic tile, even with functional proposals (acoustic and thermal insulation) at the rear of the envelope.

With regard to the specifiers, the technological parameters of ceramic tile are the best argument against alternative products for the same use. These are properties such as life cycle (exceeding that of the building itself), behaviour with fire, inalterability on exposure to light, air and water, inorganic and non-metallic easily recyclable nature, inert behaviour

1 Process patented by System

2 Breton S.p.A. proces

and use as immobiliser of other recycled materials; even references to special properties such as the self-cleaning capacity, by photocatalytic reaction, of some glazes that contain TiO₂ are also sales arguments.

We insist on the need for active participation of the ceramic industry in the promotion of ceramic coverings in exteriors, in a twin approach, by offering competitive construction solutions for *ceramic facade systems* and by disseminating their technological suitability for that concrete application. We should like to contribute to this with a concise reference to a full comparative study based on different cladding materials^[6]: porcelain tile with different finishes, marble, recrystallised limestone, granite, wood for exteriors, laminated plastic, painted aluminium on intermediate rubber and concrete slabs for exteriors. **Table 5** lists the studied parameters and **Table 6** compares the materials.

TECHNICAL CHARACTERISTICS OF MATERIALS FOR FACADES	
Technological Parameter	Test method
Dimensional deviations	UNE-EN ISO 10.545-2
Mass/surface ratio	--
Bending strength	UNE-EN ISO 10.545-4
Dimensional variations	(¹)
• Moisture expansion	UNE-EN ISO 10.545-8
• Linear thermal expansion	
Durability on exposure to atmospheric agents	BS431 Appendix A
• Permeability to rain (proper face of the material)	UNE 112017 (ISO 9227)
• Corrosion resistance in saline mist	UNE-EN ISO 6988
• Behaviour in SO ₂ atmosphere	UNE-EN ISO 11341
• Resistance to solar radiation (accelerated ageing test)	UNE-EN ISO 10.545-12
• Frost resistance	
Durability on exposure to external agents	
• Cleanability of stains produced by impregnation	(²)
• Cleanability of stains produced by filming action	(³)

(¹) Dimensional variations after immersion in water for 7 days at ambient temperature
 (²) Own test method. Staining agent: rhodamine 0.1 g/l
 (³) Own test method. Staining agent: indelible black felt-tipped pen
 SOURCE: TAU CERÁMICA documentation^[6]

Table 5.

COMPARISON BETWEEN CLADDING MATERIALS FOR EXTERIORS													
Characteristic	Porcelain tile						Marble	Limestone ⁽⁴⁾	Granite	Wood	Plastic	Painted aluminium	Concrete
	Natural	Polished	Glossy	Satin ⁽¹⁾	Alpax ⁽²⁾	Mitica ⁽³⁾							
Dimensional characteristics	High						High	High	High	High	High	--	--
Bending strength	High						High	High	High	High	High	Low	High
Frost resistance	High						High	High	High	High	High	High	Low
Permeability	High						Medium	Medium	Medium	Medium	Medium	High	Low
Mass/surface ratio	Medium						Low	Low	Low	Medium	Medium	High	Low
Moisture expansion	High						High	High	High	Low	Low	--	Medium
Linear thermal expansion	High						High	High	High	Low	Low	Low	Medium
Stain resistance	High	High	High	Medium	High	High	Low	Medium	Low	High	High	Medium	Low
Saline mist corrosion	High	High	High	High	High	High	Low	Low	High	High	High	High	Low
SO ₂ atmosphere	High	High	High	High	High	Medium	Low	Low	Medium	Medium	High	High	Low
Solar radiation ageing	High	High	High	High	High	High	Low	Low	Medium	Low	Medium	Medium	--

(1) Partial polishing with hardly any material removal

(2) Glazed porcelain tile (metallised glaze)

SOURCE: TAU CERÁMICA documentation^[6]

(3) Double press charge, with spray-dried glaze materials

(4) Slabs of recrystallised limestone

Table 6.

This active stance of the ceramic industry toward high-tech architecture, which entails important changes in its commercial structures, can be extended to conventional construction where, in the short term, the use of ceramic tiles can be widened if tile installation is appropriately performed, from the planning phase to the execution. Direct adhesion tile installation technology has been sufficiently tried and tested to assure end quality ^{[7][8]}. Fair face brick and continuous coverings with single-layer mortar are the main constraint, together with tile fixing, for the diffusion of ceramic tilings. Some of the main points dealt with in this section are summarised in **Table 7**.

THE STRATEGY OF THE CERAMIC SECTOR
<ul style="list-style-type: none"> ➤ Continuity and promotion of R+D+I programs for high performance exteriors claddings and floorings ➤ Incorporation of new materials, with technological transfer from advanced ceramics ^[9]
TOWARD HIGH-TECH BUILDING CONSTRUCTION
<ul style="list-style-type: none"> ➤ Establishing themselves as suppliers of systems: facades and raised floors. Technical assistance on site ➤ Solving deliveries, specially gaps and changes of plan, in ventilated envelopes ➤ Fostering technical marketing toward the specifiers ➤ Establishing collaboration programs with the fastening and auxiliary structures industry
TOWARD CONVENTIONAL BUILDING CONSTRUCTION
<ul style="list-style-type: none"> ➤ Providing the specifier with technical information on the tile installation ➤ Contributing to the process of quality assurance in finishes, foreseen in a voluntary way in the L.O.E. regulation. ➤ Addressing prefabrication as an alternative to tile fixing by direct adhesion

Table 7.

2.2 – FLOORING IN INDUSTRY AND ARCHITECTURE ACCESSED BY THE PUBLIC

In both destinations the ceramic flooring is a very minor option compared to continuous flooring of different types. Acquisition and installation costs, degree of complexity in the execution of the flooring and the requirement of skilled labour have worked against the ceramic tile in Spain.

Malfunctions and pathologies deriving from the incorrect selection of ceramic tiles and faulty installation, detected in large surfaces, have acted as the greatest constraint on their consideration by the specifier.

In industrial building construction, ceramic tile does not account for more than 10% of the covered surface and that percentage comes from the food sector and some minor applications in other activities. Continuous cementitious floors are the major flooring owing to low cost (60%), followed by thin-film or multilayer epoxy (20%) and polyurethane (10%) floor coverings.

Besides the economic and technical considerations of the materials, including suitability in use and life cycle, the installation process and good initial performance are decisive. Industrialised installation, with a high output, which can be put into service fast is critical for a material to be considered.

The ceramic industry should not only supply complete systems for industrial flooring (from non-slip, small and medium size tiles, of different thicknesses, with easy mechanical cleaning, to the whole range of fitted pieces, including drainage pipes), but also assist in the installation, including the actions to be undertaken on backgrounds and waterproofing. The life cycle of the ceramic flooring must coincide with that of the industrial construction itself, even under the toughest service conditions.

If we consider the offer of ceramic systems for industrial flooring, there are fewer than twelve companies in the whole European Union that compete in this technical application, and possibilities for growth exist if the eco-culture spreads. Unlike Central Europe, where there is an experienced technology and tradition in the industrial use of stoneware clinker floor tiles, in other countries the consideration of this application has coincided with the commercialisation of porcelain tile, but planners will only think of ceramic products if tile installation problems are solved.

The existence of specialised subcontractors in industrial ceramic flooring, who can present a quote for complete execution based on an installed deck, is a key factor that should be stimulated by the ceramic industry.



*Clinker tile at the service of industrial flooring with high mechanical performance, chemically resistant and chemical proof.
SOURCE: KlinkerSire per l'industria. KLINKERSIRE.
Catalogue, September, 2001.*

In architecture accessed by the public, the situation is quite similar, though the promotion of porcelain tile is starting to include ceramic flooring in small or medium surface areas that present no particular constructive problems. In public building construction, the planner systematically avoids ceramic tiles and prefers latest generation continuous flooring. At the dictates of the Administration on the hotly debated *sustainability* issue, criteria are adopted in materials selection involving durability (apparent), ease of installation, constructive simplification and economy.



Continuous flooring at the Guggenheim Museum in Bilbao
 Photo: Eugeni Pons
 SOURCE: ON DISEÑO, n.º. 186, páge. 148.

Continuous cement-based floorings, flexibilised with fibres and resins, also treated with resins to make them non-absorbing and improve mechanical strength and chemical resistance, and finishes with different degrees of polishing (from rotary systems to the terrazzo polishing machine), are found in a large part of the big projects of recent years. The absence of joints, deformability and adaptation to any type of background by means of the application of self-levelling mortars, are significant technical reasons that lay the basis for fully industrialised execution at competitive prices even for the most complex projects.



Large slabs of terrazzo and continuous flooring at Bilbao airport
 Photo: Baltanás, Sánchez
 SOURCE: ON DISEÑO, n.º. 221, pág. 374.



Continuous agglomerate flooring. INYETPAVI® system .
 SOURCE: INYETPAVI SYSTEMS.
 BETTOR MBT catalogue.

A formal contribution has also entered these continuous cement or resin-based floors. This ranges from the availability of quartz, glass and marble of different colour and grain size, to a wide palette of colours for the binder (cement or resins), with the added possibility of creating designs, by separating the materials with aluminium and brass joints.

In interior design, besides natural stone and artificial agglomerates, ceramic tile competes with a new generation of flexible materials, sheets and slabs which provide reliable performance and connect better and better with eco postulates. Reversible unions and easy installation are also arguments of weight when it comes to selection in public and service areas, of medium traffic. Mixed sandwich laminates contain thermal and acoustic insulation, with which they meet basic functional requirements^[10].

The response of the ceramic sector should be multiple: promoting modularity as a surface enriching element against continuity, disseminating the exclusive properties of ceramic tile that link up with health and the quality of the habitat in public areas; but also providing solutions and technological answers in installations in immature structures, decks with high expected movements, badly installed decks, insulation requirements and the aspiration of *reversibility* for finishes and layouts. Leaders of the Italian sector pointed in Cersaie'01 to superseding current raised flooring by multilayer floating floors, or by floors executed with self-levelling materials on which ceramic tiles or panels are mechanically fastened, already fitted with insulation.

2.3 – PARTITIONS AND INTERIOR CLADDING

Although partitions continue to consist mostly of brickwork, the problems deriving from their faulty execution and of those with gypsum plastering have led to growing use of dry partitions, particularly with sheets of plasterboard. The greater demand for this type of walling encourages the growth of the number of subcontractors specialising in this type of installation, which has led to a sufficient level of quality, service and assurance to make this option worth considering in all its variables, including the economic/productive evaluation in industrialised construction.

Furthermore, sheets and slabs enable approaching the postulates of current construction: easy assembly and disassembly, reversible unions, accessibility to the rear, flexibility and adaptability of the inhabitable space with the changing needs of contemporary life. Also fewer stockpiles and less waste.

This type of materials has led to a substantial change in their consideration as backgrounds for tile installation; sometimes because of the material (e.g. tensioned board non-resistant to moisture), and at other times because of the deformability and vibrations of these partitions. Tile installation with rigid cementitious adhesive has resulted in widespread detachments, even with small-size tiles and tilings with tile-to-tile joints.

But another danger lies in wait for ceramic tiling. Some of the available materials have finishes that require no subsequent treatment, and play the right formal game for current interior design proposals, for housing fixtures and furnishings. Quartz compacts become the standard for worktops; other compact agglomerates with polyester resins are

an alternative for terrazzo and ceramic tile; plywoods with phenol resins provide noble wood finishes; and mixed sandwich laminates containing sheets of rock wool or fibreglass provide acoustic absorbency, thermal insulation and act as firebreaks.

When problems of supply and installation are solved, they become competitive when their higher price is compensated by a reduction in manpower, and even more so if they also provide shorter execution times, with the elimination of constructive processes and materials.

These supply sectors are also dynamic in investigating the new performance characteristics and new finishes of their materials, while at the same time progressing in environmental aspects, both with regard to production and recycling.

There is one more section; the one intimately linked to the bathroom, kitchen and residential flooring, which should be actively attended by the ceramic sector, even allying itself with prefabrication.



*Prefabrication at the service of the bathroom and kitchen. Extruded closed cell, high density, "Styrofoam"® polystyrene boards covered with fibreglass mesh and cementitious adhesive.
SOURCE: WEDI GMBH catalogue.*

Housing: present and future

Once again, we need to refer to the duality between the proposals from the intellectual and economic elite, and the current housing models for common mortals. Already in 1996, at Cersaie in Bologna we attended a futurist staging of the housing, or rather habitat concept. TopStar has provided the best three-dimensional representation of ceramic tiles performed by the ceramic industry in the last two decades. Water as the main character, its rhythmic surrounding sound, domotics at the service of comfort, the bathroom as a hydrothermal spa, the kitchen as a gastronomic laboratory and the common areas connected with nature. The ceramic tile occupied its fair place on a

technological and futurist stage. Some of the ceramic tiles presented there have marked the direction of the interior design offer of the last five years. As in the fashion branch, ceramic interior design repeats tendencies cyclically, but in this case great advances have been made in the offer of systems for each application, in the symbiosis with other materials, in the modular potential of the tile, underlining the joint with multiple coordinated sizes. Large slabs of porcelain tile are found together with mosaics, be they stone, glass or ceramic. A cultured decorative offer linked to tradition is united with avant-garde designs obtained by combining materials, on three-dimensional pieces or using hydraulic cutting technology to make of the ceramic tile a marquetry of materials, textures and colours ^[11], [N.A. ^[16]].

At Construmat 2001 we attended a futurist proposal under the title *Casa Barcelona*, another current staging of preoccupations and proposals which reflect present sensitivities concerning the concept of the dwelling. In the first place, there were all the issues relating to health and comfort, even with oriental references, such as Feng Shui, with a view to taking advantage of the energy of the elements that surround us through better spatial organisation. Thus, models are proposed that on one hand attempt to achieve maximum surrounding comfort, understood as a favourable atmosphere for spiritual recollection and physical health, and on the other, to achieve protection from outside elements. But the dwelling also needs to be transformable and perfectible, through lighting adjustments or changes in the furnishings, fixtures and definition of spaces.

This whole metaphysical discourse is evidenced by latest generation materials, following more or less defined currents. In almost all of them, ceramic tiles are missing or reduced to their minimum expression, where there is an indispensable hygienic-sanitary function or where an ecological link is to be established with nature, through terra cotta. The phenomenon of *loftism* and many post-minimalist stagings point in this direction.

In contrast we have the traditional dwelling, compartmentalised in fixed, unmoveable areas, done with traditional materials or adapted to a traditional construction. This is where most of the offer in ceramic tiles moves, focusing on the three classic destinations: bathroom, kitchen and residential flooring. Especially in renovation, but also in new work, materials are selected, first, on the basis of economic motivation and in the second place, on logistical motivation. A study carried out by Sigfried Dörr and presented at the V International Congress of the Ceramic Technician^[12] gave us some of the keys to the selection of materials in Central Europe:

- Ceramic wall tile has an eminently sanitary and decorative value in very concrete spaces.
- Greater purchasing power leads to considering ceramic floor tiles rather than alternative products (carpeting and elastic materials in general) for reasons of a sanitary and ecological nature, and because of formal expression.
- The issue of tile installation is extremely important in selecting a material. First because of the availability of the services and, in the second place, because of the impact of the cost of the tile installation on the total cost. According to the source mentioned above, the installation of ceramic floor tiles represents 55-60% of the total cost (compared to 15-35% in the case of carpeting, linoleum, sheets of PVC or laminates). The cost of the installation of ceramic floor tiles is, in every case,

higher than the price of acquisition, and this can be extended to the situation in Spain, where in some regions it triples the sales price of the product.

- In renovation, another important factor appears: clean materials are selected that present the least inconvenience in installation, especially when the installation does not involve short times.

In a certain way and at a general level, it can be said that the advance of wooden flooring and its derivatives has taken place at the expense of carpeting and elastic flooring, owing to reduced installation cost (even facilitating DIY) compared to the ceramic tile installation, with higher installation costs and inconveniences.

In the case of Italy, where statistics are available on materials consumption, both for flooring and wall cladding^[13], ceramics remains practically stable in the period 1993-2000 (79.5% for ceramic floor tiles and a slight increase in the case of wall tiles, from 57.6% to 64.9%).

Although in traditional housing there is a constant assignment to ceramic tiles, a reduction is detected in square meters by the proposal of environments that combine ceramic tile with other materials or reduce the installation surface area. Perhaps the reduction of square meters is compensated by a more qualified consumption of ceramic tile, from the use of special fittings and trims to the arrangement of floorings and wall claddings and their combination with stone materials, wood, and continuous coverings.

However, besides the cultural identification with ceramics or aesthetic criteria in selection, the tile installation factor is fundamental, even in the most traditional applications, to keeping ceramic tilings from losing ground compared to other materials that present no installation problems and which can also be reversible without requiring building work.

In the case of Spain, deficient tile installation is limiting, even in specification, the use of rigid and thin modular floor tiles outside domains with reduced surface areas, such as the bathroom and kitchen. Cracking with polygonal tendencies and detachment of ceramic tiles is restricting the expansion of ceramics in housing and can pave the way for the use of alternative materials, such wood products^[14].

The bathroom domain

Precisely on the occasion of Cersaie 2001, the Fair Organisation invited a group of designers, stylists and prominent people from the world of art and culture to define this space according to their personal perception. As a common denominator, the bathroom is a domain capable of evoking suggestions linked to eras and places, while it also has a specific relaxing function tied to the spa culture. The bathroom needs to be able to convert itself for a time during the day, however short, to a domain of sensual delights, where one can think alone, with the gratifying idea of wishing oneself well^[15]. The participants included Alberto Alessi, Mario Bellini and Alessandro Mendini. The first defines it as one of the most interesting domains of domestic imagination; Bellini conceives it as an open space, awash with natural light, which favours mental concentration and psychological well being; while Mendini raises it to the category of the living room, as a jewel case for the body and water.



*Proposal for bathroom design by ALESSANDRO MENDINI
Exhibition "La stanza da bagno, personaggi tra rito e design". Cersaie'2001
SOURCE: CERSAIE Press Office.*

In all these proposals ceramics is present in the sanitary ware and in the tiles if they accompany a targeted interior design atmosphere. In fact, one of the proposed stagings did wholly without ceramic tiles, connecting the hydromassage bathtub with a tropical landscape through a raised wooden parquet floor. It was in fact the proposal of Mariuccia Mandelli, who has worked as a ceramic designer for the firm Edilcuoghi.

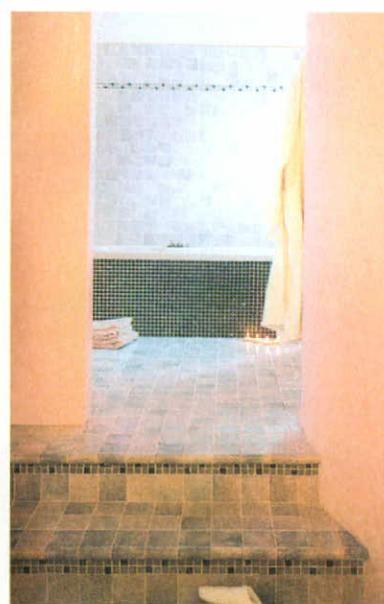
These projects for the future point to the clear separation between the hygienic function (a concise space with a WC and bidet) and the hydrothermal function. For the first space the survival of ceramic cladding can be predicted, but for the second other materials can be used of reliable behaviour, although their cycle of life is not known, if what prevails is a stage setting, comfort in the installation or reversibility of the domain.



*The bathroom in its traditional setting
Staging by
FRANCESCO DI MAIO,
Cersaie'2001
SOURCE: CERSAIE Press Office.*



*The bathroom of our time.
SOURCE: JASBA catalogue.*



*Interior design à la cart in the
bathroom domain Series BREZZE®
"Oltramino" blue by COTTO
VENETO. SOURCE: "Cottoveneto,
oltre la materia" catalogue.*

In the conventional bathroom, ceramic floor and wall tiles are more assured (especially wall tiles) in view of certain functional and aesthetic patterns demanded by most of the population. Even so, if the tile installation fails other materials with reliable performance can progress.



More than just tiles in the bathroom setting
SOURCE: "Selezione atmosfere" catalogue 01/2001. COTTOVENETO.

The kitchen, between food function and living space

With the large-scale incorporation of women into the outside labour world, social habits in the dwelling have changed and the roles of its members are also beginning to change. The kitchen area has gone from being a closed service room, assigned exclusively to women, to an open space in which all or some members of the family unit should participate actively in an organisation (of presence and cooking equipment), with some itineraries that allow cooking and serving food in a short time.



The traditional ceramic kitchen: a luxury within reach of the very few?
SOURCE: "Ceramic di Vietri" catalogue FRANCESCO DE MAIO. Cersaie' 2001.

The culinary function can be concentrated, leaving as day area the rest of the space assigned in the past to the dining room, or both spaces can be integrated to create a unit for life together and participation, which will take care of a fast breakfast as well as the single meal that is usually cooked with serenity, namely dinner. Also, a certain reversibility will be demanded at least for the non-fixed furnishings, as well as the most favourable ambient conditions, if there is no second residence for the free time.

This new conception of the kitchen domain allows the use of ceramic tiles if there is a cultural bias toward ceramics; otherwise it will reduce this to a minimum expression, if for economic, supply or installation reasons, other more affordable materials are sought.

The same conclusions apply here as for the bathroom domain:

- Promoting technical marketing with regard to suitability for use, sanitary and ecological properties and the extensive life cycle of the ceramic tile.
- Linking ceramic tilings to a cultural model that highlights the modularity of the surfaces compared to continuous materials, underlining their expressiveness in texture and colour, even emphasising three dimensionality. It is necessary to achieve the consumer's cultural complicity.
- Attending to tile installation technology as a service integrated in the promotion and sale of the ceramic tile, proposing solutions for the different types of tiles and tile installation backgrounds to be found in current construction. Special mention deserves to be made of the promotion of ceramic floor tiles in association with floating screeds (to avoid the malfunctions produced with unstable backgrounds or poorly executed levelling layers), as well as functional insulation requirements (mainly, acoustic insulation) and in relevant cases, floor heating. This can be decisive in renovation.
- Establishing the collaboration routes with the industry supplying prefabricated elements for partitions and worktops, for the ceramic tile to be associated with actions linking it with prefabrication and the elimination of traditional building work
- Both in the bathroom and in the kitchen, the ceramic skin is a system, all of whose components should be offered. For obvious reasons, these components will also be ceramic (an added value for the marketed system), but the combination with other materials that provide technical solutions or contribute to formal enrichment should not be discarded. This becomes the most specialised interior design offer for the future.



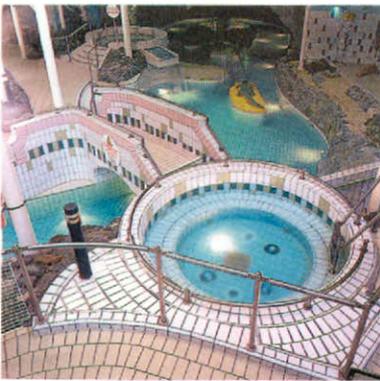
The modularity of ceramic coverings
 SOURCE: COTTODAVID catalogue. Cersaie'2001.

2.4 – HYDROTHERMAL APPLICATIONS

The greater purchasing power in the first world and the greater availability of free time have not only brought about a renaissance of spa facilities, but they have opened the door to large aquatic facilities where sport, relaxation and amusement are found together. The ceramic systems for these spaces have been available in Central Europe for decades, but it is a very specialised offer by a reduced number of companies. There also, just as in industrial flooring, are standards, quality assurance and an installation technology that solves all the functional problems of a hydric domain, from surfaces submerged in water to auxiliary facilities.

Behind a hydrothermal installation, with its complete ceramic system, there is a sophisticated technology that ranges from the waterproofing of the basin to all the insulation and functionality requirements of the space, with floor heating and a multiplicity of specialised areas of use. The tile installation is usually carried out with deformable, quality cementitious adhesive, grouted with reaction resins that assure chemical resistance and watertightness. The technology has evolved with time, incorporating grouts with better properties than the epoxy resins (for example, the cementitious silicate compounds), while also pursuing joint deformability.

It is evident that in these applications the main problem is not the supply of the ceramic material but the material's correct installation.



*Aquatic park Talford Waterworld Stoke-on-Trent
(Staffordshire, GB).
SOURCE: General Catalogue n.º. 5. KLINKERSIRE
October, 2000.*



*Salt water therapy and rehabilitation swimming pool.
Carnac talasotherapy (France).
SOURCE: "Keramik ist kompetenz" catalogue. Sydney,
2000. GAIL INAX.*

In Spain, lack of knowledge and completely erroneous professional practices have led to numerous pathologies in wet facilities. The use of glass mosaic has not produced good results owing to the use of conventional mortars for tile installation and grouting, when non-absorbent materials are involved. Apart from this, the ceramic system is expensive because of the required special pieces, which in some cases such as bottom coving were not provided with the appropriate curvature radius for using automatic cleaners, which need to be able to ascend the walls of the pool.

Ceramic coverings are at a crossroads: there is quite a complete, quality offer of ceramic systems for pools; however, their growth is limited by a lack of qualified fixers.

2.5 - URBAN FURNITURE

At least in the countries of the Mediterranean Basin, glazed architectural ceramics has a cultural significance that transcends any consideration of economic, projection or aesthetic nature. It is part of our personality, being more pronounced where the Moorish influence has been greatest.

Since the Modern Movement, Spanish architecture has rejected all the symbols of the last crafted architecture whose greatest exponent was Modernism. There are technological reasons behind this; there are constructive models that condition or make the use of certain materials more expensive, but there is also a snobbish stance toward foreign architectures, which becomes scornful toward everything making up the long trajectory of the only architecture that could be classified as national in the Kingdom of Spain: MUDEJAR architecture.

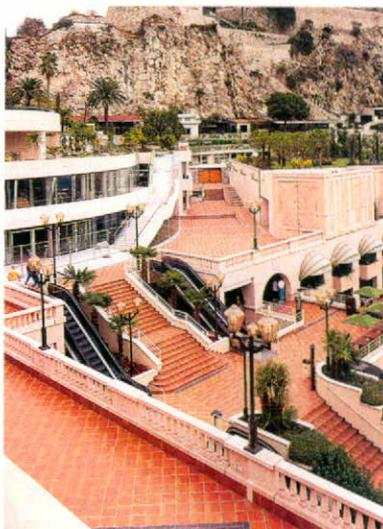
In the first decades of the XXth century, also because of the different events of the time, different interventions occurred in public works and town planning; in many of these, architectural ceramics are present as cladding and as furniture, besides their wide use in public and private construction. Perhaps the Ibero-American Exhibition of Seville in 1929, in the context of the regionalist architecture of the time, was the last great ceramic expression in the urban environment (M^a Luisa Park and Plaza de España), although during the IInd Republic, unique urban undertakings proliferated over the whole geography, where ceramics was dearly present.

Many decades have passed, and time and the hand of man have swept away that way of understanding the public space. Hydraulic tiles and terrazzo became the lords of flooring, without caring if they were stainable or slippery. Concrete, omnipresent concrete, covered walls and the combination of vegetation and water made way for impersonal furniture that left forums, parks and squares as empty spaces, spaces to be crossed toward individual consumption. The current situation is not very different from that of two decades ago; the shapes and furniture have changed but ceramics with all its expressive potential is merely anecdotal, when it exists, on the scale of a sculpture or mural insert in large surfaces where grey cement products predominate.



Clinker tiles on a promenade.

SOURCE: "Arredo Urbano" catalogue, of LARIA CLINKER. Cersaie'2001.



Shopping centre "Les Terrasses de Fontvieille" at Montecarlo (France).
SOURCE: "KlinkerSire per locali pubblici e arredo urbano" catalogue. KLINKERSIRE. July 2001.

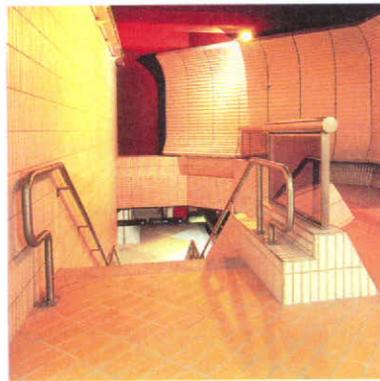
Only the offer coming from extruded stoneware, which has already been discussed in the section on industrial flooring and architecture accessed by the public, is found in public applications when the budget allows, and there is a true vocation for incorporating design and colour into collective spaces.

In this section of applications, there are at least two routes that would vastly facilitate extending the use of ceramic tiles. One would be based on the traditional Dutch street paving, with the help of spacer tiles, installed dry. We would be speaking of solid bricks that could contain recycled materials of the ceramic industry itself, or from other branches, manufactured in a process that minimised their cost but assured good mechanical strength, as well as good stain and slip resistance on wet and dirty surfaces. With these premises, a few co-ordinated sizes and a concise palette of plain inks, could provide expressive and functional play for a wide range of applications in pedestrian flooring or for moderate vehicular traffic.

The other possibility, which is more complex from the point of view of design and production, would be the offer of ceramic systems for furniture based on porcelain tile, recapturing in a current version all the potentiality of ceramics applied to benches, fountains, balustrades, perrons, etc. This proposal would be the result of a complex design process, enabling creation of combinable items that would become the raw material of the planner on defining furniture in urban applications. For example, each fountain could be different by inclusion or not of a part of the system, or by a change in colour or size.



“Castellane” station of the Marseilles underground.
 SOURCE: “KlinkerSire per locali pubblici e arredo urbano” catalogue. KLINKERSIRE. July 2001.



“Jules Guesde” station of the Marseilles underground.
 SOURCE: “KlinkerSire per locali pubblici e arredo urbano” catalogue. KLINKERSIRE. July 2001.

3 – CONCLUSIONS

The ceramic industry is entering the new century in a context of economic uncertainty that could shortly affect building activity. An annual production exceeding 4500 million square meters based on a manufacturing technology shared by all the producing countries shifts competition toward non-technological intangibles, including technical marketing and after-sales service to assist in correct installation of the ceramic tiles.

However the ceramic sector should decide on a deep transformation of its commercial structures to enable recovering for ceramic tile, applications that it used to have, to make ceramic tilings competitive against alternative products for the same use, and to promote a *culture* of ceramic flooring and wall cladding, associated with ecological, functional and aesthetic values: lasting beauty respectful of human beings and the environment, which can form the epidermis of our habitat.

Having reviewed the main applications of ceramic tiles, we may infer that the ceramic industry:

- Should assist, inevitably and directly, in the ceramic tile installation process, based on the latest available technology. It should propitiate the synergy with the adhesives and tile installation equipment sectors and, principally, with the trade that executes the tile installation.
- Should investigate, experiment and promote ceramic systems that constitute an alternative to tile installation by direct adhesion, which meets all the functional requirements and are competitive in cost and supply/installation logistics with alternative materials. The ceramic industry will need to extend the industrial design of the piece to that of systems, including in that projection activity materials and techniques that are not its own, and should provide on-site service.
- Will also have to think of *prefabrication* as an alternative to conventional tile installation *in situ*, and associate with other industrial sectors that provide goods and services to an ever more technologised building activity.
- Will diversify the investment in R+D+I toward ceramic systems that solve current construction problems and which can become serious economic/functional alternatives to non-ceramic systems. Technology transfer from “technical” ceramics toward the ceramic tile could contribute to achieving this objective.

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- [16] **Author’s note:** The analysis of the direction and tendencies of the offer in ceramic tiles, a result of the field work done at Cersaie’2001 on a universe of 77 manufacturing companies, is not included in this paper for reasons of length. The analysis conducted has enabled deriving a table of opportunities for the ceramic industry based on current building construction.