ARCHITECTURE AND TECHNOLOGY OF CERAMIC FACADE TILINGS IN HIGH-RISE BUILDINGS: THE CASE OF THE TERRA BRASILIS BUILDING IN RECIFE, BRAZIL.

Bruno Ferraz [1] **Jonas Silvestre Medeiros** [2]

[1] Architect. Partner-Director of B'Ferraz Arquitectura Ltda. Brazil
[2] Civil Engeneer. Partner-Director of Inovatec Consultores Associados Ltda. Brazil

Bruno Ferraz earned his degree in Architecture from the Federal University of Pernambuco – in Brazil in 1985, and is partner-director of B'Ferraz Arquitetura Ltda, a Brazilian company devoted to planning and consultancy in the area of Architecture and Town Planning, intensely engaged in the real estate market for more than 20 years in the city of Recife, in the State of Pernambuco, in North-Eastern Brazil.

The company resume includes numerous enterprises, in both commercial and residential spheres with the development of tens of projects for the major builders and developers of the region. In the residential real estate market, the building Terra Brasilis is a landmark, with its 46 floors, 132 m height, 200 parking spaces and 300 m^2 privative area per dwelling unit, amongst several other undertakings of the same scope.

He was awarded the Gold Medal in the Global Forum of Young Architects at the International Biennial of Brazil (1994) and participated in the International Exhibition of Architecture of Brazil (1997), in Beirut – Lebanon. Jury member in National Architecture Competitions in Brazil and outside assessor on a number of student Graduation Work boards of the Faculty of Architecture at the UFPE (Federal University of Pernambuco).

He is currently National Vice-president of IAB (Institute of Architects of Brazil – North-East Region) and President of IAB/PE (Institute of Architects of Brazil, Department of Pernambuco); he is also Vice-president of CREA/PE (Regional Council for Engineering and Architecture of the State of Pernambuco); Coordinator of the Special Chamber for Architecture of CREA/PE; Consultant of CCU (Commission for Urban Control of the Recife City Council); and Professor of the Course on Architecture and Town Planning of UFPE (Federal University of Pernambuco); he was also on the Scientific Committee of the XVIIth Brazilian Congress on Architecture, held at Rio De Janeiro in 2003.

Jonas Silvestre, Civil engineer, M.Sc. and Ph.D. in Construction Engineering from the Polytechnic School of the University of São Paulo - EPUSP, where he was a researcher and lecturer in the area of construction technology.

He studied Concrete Masonry Technology at the Besser Research Center in the USA in 1991 to complete his Master's dissertation on Structural Masonry of Concrete Blocks.

His Ph.D. thesis on the Design and Execution of Ceramic Facade Claddings and his subsequent work has led him to become a member of the Technical Committee of Qualicer – the World Congress on Ceramic Tile Quality.

He was adviser of class organisations and, for the magazine Arquitetura & Construção, created the Doubt Solution section for readers via the Internet.

He has authored 43 national and international articles, delivered tens of lectures and courses on masonry pathologies and coverings, structural and envelope masonry technology, design and execution of coverings with mortar and ceramics.

In recent years he has implemented and managed the Department of Covering Systems Technology of the ceramics manufacturer Portobello S.A.

At present he is invited postgraduate lecturer at the Federal University of Santa Catarina and technical director of Inovatec Consultores Associados Ltda, a company that provides consultancy, projects, materials developments and their applications for the building construction sector.

> *'I admire the poets: what they say with two words, we must express with thousands of bricks'*
>
> *Vilanova Artigas, Architect*

The Brazilian architect Vilanova Artigas thus expressed in that so peculiar way of his the great paradox of architectural work, always on the threshold between poetry and technology. In addition, architecture, as an artistic genre, contrary to the other arts, finds in space an extended variable in its finite and limited dimension, because if the building contemplates rules and immutable properties, the architect changes these according to his desire.

Modern architecture cannot be denied, because we understand that it cannot communicate with a society in an ephemeral and spectacular way. The structure must be simple and functional, with cultural content and mounted in a

symbolically expressive facade, if we may put it like this. And the architect, as a creator of places, essentially his inner space, with all his stereotomic values of light, shadows, noise, silence, temperature, smells and colours, who makes us reflect that although every space includes an envelope, a box, a volume, a solid, a plastics, what should be valued and judged is what is enclosed within the architectural sculpture: its atmosphere.

And the fascinating and admirable thing is that we make people believe, and I say I believe, that as architects we are able to control systems of demands over which we have no power, non-representative values like gestures and attitudes, the architect as modeller of spaces and of human behaviour and, as Umberto eco says, *'condemned to be the last humanists of contemporary society'.*

On the other hand, the interests of man as an individual do not always coincide with those of that same man as a collective being; it corresponds then to the town planner to try to solve, as far as possible, this fundamental contradiction. And this is our legacy as architects and (or) town planners, and it would also seems to be the great paradox that we need to solve as designers and planners of the non-invented cities composed of self-affirmed dwellings in a world blinded by the cult of individuality and by spectacular architecture, where what has never been seen before is confused with originality, novelty with quality architecture and simplicity with lack of talent, as our colleague Edson Mafhuz has said so well.

After this conceptual introduction, we come to our object of study: the *Terra Brasilis* Building. A residential building is involved, made up of 39 standard floors and one duplex deck, three storeys for parking and leisure, totalling 46 storeys with a 'helipoint' at its termination. The living units have an area of 300 m^2, with 4 suites, front terrace, home office, home theatre with private terrace, barbecue and individual sauna in the apartment.

Its leisure area consists of an aquatic park with a swimming pool for adults, children's pool and semi-Olympic lane of 25 m. There is a tennis court, footing track, football pitch, sauna, relax room, game room and gymnasium, changing rooms, dance hall, office and washing sink. Each living unit has 5 parking slots, totalling 200 parking places for vehicles spread over a two-storey car park. It is located on a 5000 m^2 area of land, of which 50% has been reserved as a green zone, softening the constructive impact. This 'social club' characteristic of the building's leisure area is the reflection of a society that tries to protect itself from the insecurity of the urban space of our city, by moving as little as possible and concentrating its social and leisure activities in the place of residence.

The technology used in the application of the outer tiling, the architectural aspects, the cultural practices, that interactive undertaking of engineering and Brazilian architecture in a vertical residential building of great altitude, will be presented and dealt with in the debate.

Terra Brasilis has been constructed in Recife, the State Capital of Pernambuco, in North-eastern Brazil, an important metropolis with a population of 1.500.000 inhabitants in the city area and 3.500.000 in the metropolitan region. With an area of approximately 220 km^2, it is the second smallest State Capital of Brazil in territorial extension. About 68% of its territory consists of hills, 10% is marshy and 22% corresponds to plains able to absorb the growth of the city. This small area of flat land has led to a vertical

evolution of its built mass, characterised by the predominance of high-rise residential buildings, at the moment, up to about 30 floors.

This verticalisation process started in the 1960s, with projects not exceeding 15 floors, concentrated in the Boa Vista district and the southern area of the city, specifically in the Boa Viagem district. In the 1970s, the process had already intensified in the southern and bordering areas by the proximity with the town beach, with works already surpassing 20-floor heights. In the 1980s, the northern area of the city was already constructing its built mass when the works reached 25/30 floors. In the 1990s, the barrier of 30 floors was broken, at present exceeding 40 floors.

The architectural production of Recife is rich in examples produced in an intense way by the real estate market in the last 40 years, forming extensive study material for the ceramic tiling industry.

Tiling which, necessarily has had to accompany all that vertical constructive evolution, both in technological and aesthetic aspects. Thus, we can observe the qualities and intrinsic characteristics of the tilings in their tendencies, the chromaticism, textures, materials, in an evolutionary process from wall tile to porcelain mosaic, passing to ceramics, granite stone and, at the moment, porcelain tile.

It is important to note that our architectural inheritance, stemming from the Dutch and the Portuguese, with clusters of houses of doors and windows featuring facade tiling, established the cultural concept directly linking the ceramic tiling of the facade to the noble standing of the building. The greater or lesser detailing of this material at the beginning of century was a determining factor in the degree of excellence of the building.

Even today, the tiling material represents one of the greatest symbolic values of the degree of nobility of a building, together with noteworthy technical aspects in the selection and specification of the product by the architect, such as moisture expansion, resistance to cracking, thickness, flatness, water absorption, stain resistance, abrasion resistance, bending strength, coefficient of thermal expansion, coefficient of wear, and others.

The technical characteristics are fundamental elements in the architectural conception process of the high-rise buildings in Recife. It is important to note our climatic variation, which oscillates daily from 20 to 32 degrees Celsius. And in the pleasantness of the sunny tropics creating shade, moving back walls, emptying walls, protecting windows, opening doors, continuing spaces, building with few items, coexisting with nature, and making leafy constructions are already rules of our architectural repertory.

In the case we are dealing with, the *Terra Brasilis* Building rises as a landmark picture in the urban landscape of the city with its 46 floors and 132 metre height; and the ceramic facade tiling was always one of our greatest concerns as designers. It was essential to assure the necessary safety in a tremendously vertical building work and, at the end of the process, ceramic tiling was understood as the most appropriate cladding for our specification.

The choice fell on glazed ceramics of the stoneware type, measuring 7.5 x 7.5 cm, across the whole extension of the facade and on polished and rectified porcelain tile of 30 x 30 cm in the details protected by the gaps, and which, from an aesthetic point of

view, assured a break in the final reading of the built work. The cost-benefit ratio was also an important variable in view of the magnitudes, with over 10,000 m^2 surface area to be covered. There was further the fact that to the external observer the small size piece presents a continuous plane, enabling compensation of movements of a thermal and hygroscopic origin of the tiling, of its layers and also of the base, mainly in the vertical. It was known beforehand that the greatest number settling joints would be crucial for relieving the stresses induced by these movements.

The proposed colouring was deliberately classical and formal from the point of view of the architectural composition, and predominantly monochrome (beige) from the point of view of assuring the maintenance of technical features, such as low thermal absorption in comparison with dark colours, again significantly reducing the cyclical expansion and shrinkage of the construction and improving the inner thermal comfort of the living units.

The excessive chromaticism of present facades, with a great variety of materials, colours and textures, jeopardises in a certain way the unity of the work, as a function of the different techniques, processes and mortars to be used, overloading the work in the execution, as well as the final result and the understanding of the architectural work.

It is also important to emphasise the value of the balconies or terraces in the project. By definition and location, these are free open spaces, for transition between the outside and the inside, and thus projected, characterised as wet areas and, consequently, equipped with drainage systems (evacuation), naturally presenting horizontal movement joints in the facade composition. They perform the important function of modelling space (shades) of the facade, and are also smoothing and control areas of elements like the sun and rain. Nor may we forget the capacity of the shaded and open areas to control and filter the outside light, mitigating its excesses before it reaches the inner ambients with natural and suitably comfortable luminosity.

In the tradition of North-eastern Brazil, the houses of the old plantations and haciendas had such shaded places: balconies running round the building and along the main facade. Modern architecture with its pure volumes cut short that evolution, reaffirming the bordering band that hides the roof and creates flat facades, true cubes exposed to the sun and rain, representative and recognised by the users as low-quality architecture. And that tradition helps us extraordinarily as professionals to fight with the vertical movements of building construction.

The living rooms and dining rooms of *Terra Brasilis* have been designed and planned to fulfil their basic functions without needing to add values and spaces of other ambients, beyond the possibility of adding a home office, forming a wide social space far above market standards for this type of construction. This set of living environments culminates in the terrace facing the river, which performs the complementary function of an open space for enjoyment and interaction with the natural landscape.

The architectural form of the *Terra Brasilis* building and, mainly, of its facade facing the river have been conceived as strictly tied to the foundations set out previously; therefore, equipped with a certain autonomy to respond to the requirements of valuing and appreciating the aesthetics of the building as a whole.

The set of terraces and, particularly, the finishing termination (roof), are defining elements of the complex and responsible for the dynamism and plastic enrichment of the building.

All these aspects of the architecture needed to interact harmoniously with the materials to be used in the execution, so that a final tiling would result that met the minimum requirements of safety, durability and quality.

The execution of the facade tilings is a complex process that involves an important series of different requirements and criteria. The control and responsibility of the production process in this phase demand the attention of designers and builders, and, often, need the participation of specialists. This process ranges from specifications of the materials to the training of the executing labour force, while always needing to observe the issues relative to the technical standards and performance of tests.

Although applied in a conventional form, the tiling of *Terra Brasilis* has required special technical attention, in which the specification and execution detailing phases are to be noted.

The concrete structure made in situ of *Terra Brasilis* is one of the five highest in the country, and features a singular slenderness. On one of the sides, the relation between total height and width has a value close to 10, thus subjecting the building to significant movements due to the action of the wind, which in the region has a basic speed of 30 m/s. These singularities have made the execution of the facade tiling a technical challenge, since reference parameters were practically unavailable for comparison.

For the storeys, ribbed decks of 20 cm height were devised, supported on beams with a span of 7.7 m and height of 0.70 m. On the perimeter, the beams of the structure had a uniform height, a fundamental condition for the appropriate installation on the same level of the horizontal movement joints. The windows have their gaps aligned at the top with the beam seats, so that the movement joints are interrupted and close to the ideal position for controlling the appearance of any possible fissures.

The specification and appropriate execution of the parging-render combination also needed particular attention, since the stability and safety of the adhered ceramic pieces depended on this.

The adhesion, surface strength and deformability of the mortar layer were the subject of evaluation by the designer and materials suppliers. For the parging-render combination adhesive strengths were specified for the base of at least 0.3 N/mm^2 with a mean value of 0.4 N/mm^2. For the surface strength the accepted minimum value was 0.7 N/mm^2 with a minimum strength of 0.9 N/mm^2 in all the analysed samples throughout the work.

If, on the one hand, in this structure high-strength concrete (> 35 N/mm^2) was used, which made it less deformable, on the other, this same concrete displayed a surface porosity that made adhesion of the parging-render combination difficult, so that it required special preparation.

The adhesive strength values of the courses of ceramic blocks reached adequate values. A greater difficulty was the obtainment of the strength prescribed in the reinforced concrete elements, which needed to receive special preparation to allow anchorage of the parging-render combination that would subsequently serve as substrate for the application of the ceramic tiles.

The courses of ceramic blocks of *Terra Brasilis* were fastened to the pillars of the structure by means of metal mesh specially conceived for this purpose. No movement joints were necessary between the walls of the insulation courses and the elements of the structure.

In relation to the bedding of the ceramic stoneware, two different single-component cementitious adhesives were specified: one for the lower floors (up to the 20th) and another for higher floors (from the 21st to the 46th). The cementitious adhesive of the lower floors had a tensile adhesive strength above 1.0 N/mm^2 – measured with the own ceramic stoneware – whereas that of the upper floors provided an adhesive strength exceeding 1.5 N/mm^2.

For the bedding of the porcelain tile just one two—component cementitious adhesive was used with acrylic adhesive latex, with an adhesive strength of 2.0 N/mm^2 – measured with the own porcelain tile. The flexibility of this mortar, measured by means of the transverse deformation test of the European standard, exceeded 15 mm. The porcelain tile was fixed entirely by means of the buttering and floating technique.

To fill the joints two different mortars were used: a special one for the stoneware and another one for the porcelain tile. All the mortars were supplied by the manufacturer of the ceramic stoneware tiles and the porcelain tile himself, and had been specifically developed for the use of these products on the facades.

In the tiling project the points that exhibited the greatest likelihood of crack formation and the areas of stress accumulation, for the installation of hot dipped zinced wire mesh reinforcements and movement joints, were taken into account. Horizontal movement joints, 15 mm in width, have been applied between the beam seat alignment and gaps on all the floors. A high-performance, durable polyurethane sealant was used for the treatment of the movement joints in accordance with the American ASTM standards.

The execution phases were strictly controlled by hiring a company for technological control to verify periodically whether the projected strength was being obtained throughout the building work.

We may conclude with the termination of the construction and handover of the *Terra Brasilis* building, in which the execution details, materials employed and constructive practices used have led to the materialisation of a project that has given the city of Recife a new symbol of modernity and audacity in the construction of residential buildings. The facade tiling of the imposing 46-floor tower is the result of the combined effort of a contextualised architecture and of the correct ceramic tiling application technology, which has contributed directly to the beauty of the building, doing justice to the city in which it rises.

Finally, we cannot but attest that in *Terra Brasilis* we identify a building work of differentiated characteristics and qualities in the urban space of the city of Recife, which has engaged professionals and companies that have planned and constructed an object, not just of singular economic value but also of symbolic value, with an image that is indissociable from the collective heritage.

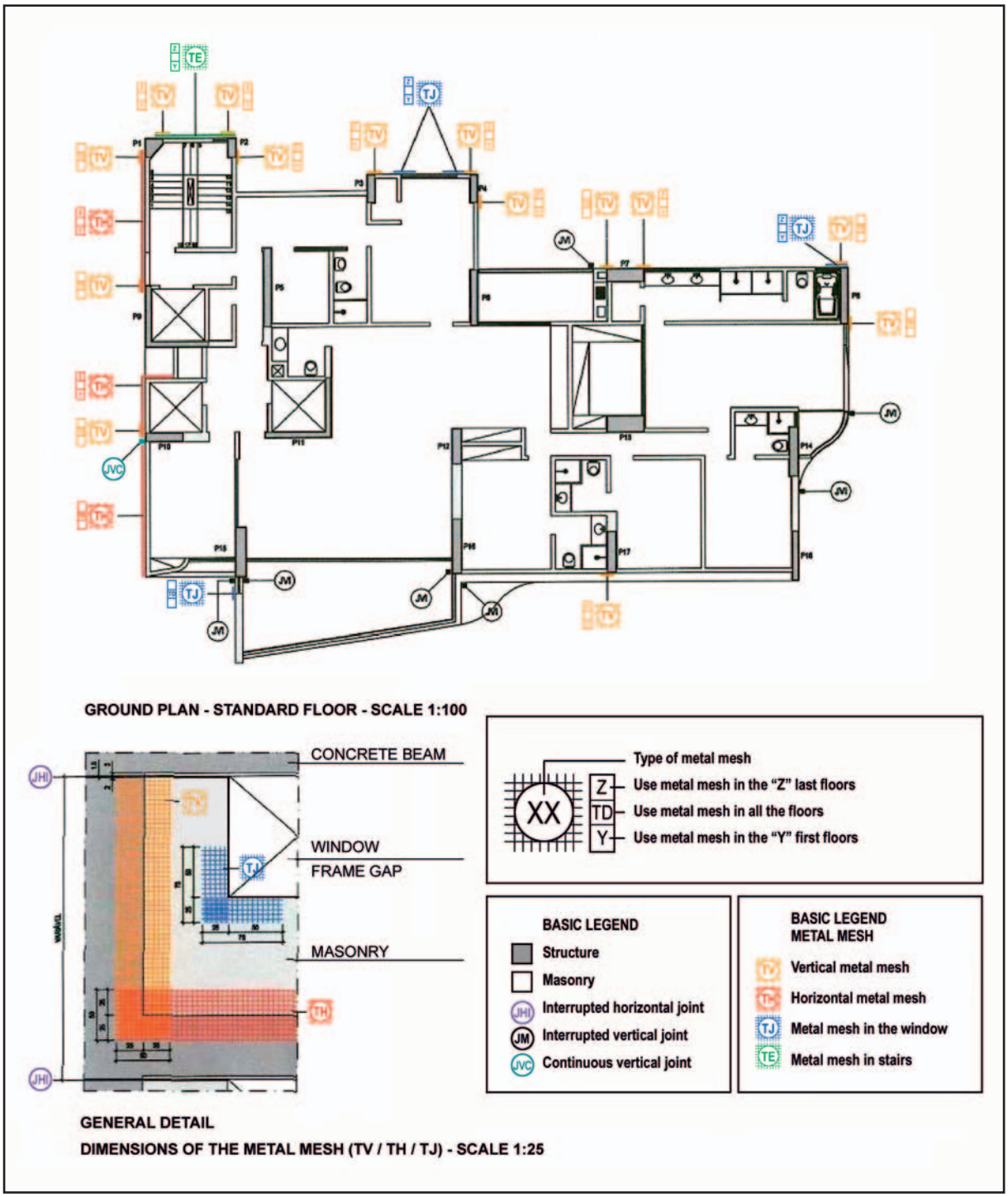

Figure 1. Designs of the Facade Tiling Project of Terra Brasilis. The ground plan shows the reinforcing metal mesh in the areas subject to fissures. The general detail on the bottom right shows the areas of use for the mesh. Alongside, the legend shows the types and areas of movement joints and mesh used in the project.

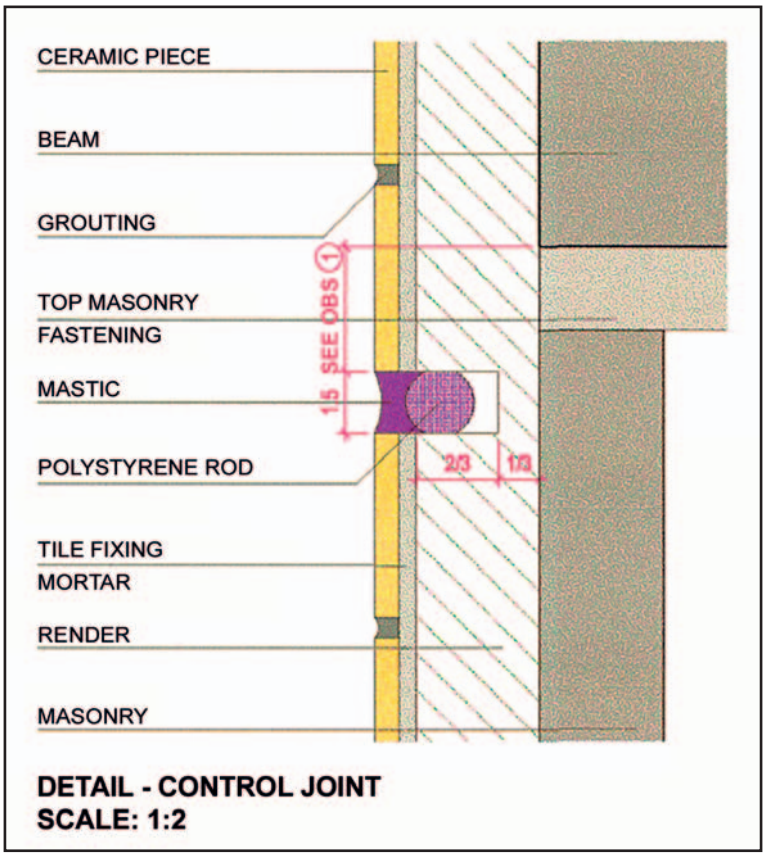

Figure 2. Detail of the horizontal movement joint. Note the non-alignment with the resulting perimeter beam seat at the end of the window gaps. The joints are not cut in all the thickness of the render so that a second barrier is formed against water penetration.

Figure 3. Detail of the tiling with pieces of stoneware-type tiles of 7.5 x 7.5 cm in the area of the horizontal movement joint. The cavity must be free and clean before the introduction of the joint back-up rod.

Figure 4. Appearance of the facade during the execution of the render, with access by means of suspended scaffolding. Note the movement joints already installed on all the floors.

Figure 5. Detail of the horizontal bottom course that enables fastening the vertical reference wires to assure alignment of the pieces throughout the height of the building.

Figure 6. Facade of the Terra Brasilis building with its 46 floors, which stands as a landmark in the urban scenario of the city of Recife in Brazil, concluded in August of 2005.