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NEW DEVELOPMENTS IN TILE CLAD EXTERIOR BUILDING FACADES

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Adhesive technology has opened up an entire new world of aesthetic and technical possibilities for cladding of exterior building facades with ceramic tile. Direct adhesion of tile offers the architect tremendous design flexibility with a material that otherwise would be unsuitable as a cladding material for facades. Building owners benefit from more efficient and environmentally sensitive use of materials, and the construction process is made more efficient by lightweight, pre-finished materials, or from pre-fabricated wall components, both of which reduce construction time and costs.

However, tile-clad exterior building facades have been slow to gain widespread acceptance, due primarily to a lack of understanding of the specific requirements and behavior of construction adhesive technology, as well as the unique attributes of ceramic tile cladding and tile installation material technology. This situation is about to change dramatically, the result of a unique confluence of social, economic and technological factors.

This article will explore examples of several new developments, such as Sustainable ("Green") Building Technology and Building Information Modeling (BIM), all of which will likely have dramatic affect on the use of ceramic tile as a building cladding material. Some of these developments may seem as far-fetched as the prediction several years ago of having a mobile hand-held computer that would allow access to an entire world of information. However, these developments are certain to have an impact on emerging technologies such as tile-cladding of exterior building facades.

A detailed examination of the myriad of technical considerations for design and construction of tile-clad exterior building facades is beyond the scope of this article. The book titled "Direct Adhered Ceramic Tile, Stone & Thin Brick Facades" by this article's author, can provide much more comprehensive technical information on this subject than can be afforded by a short article; the book and excerpts are available at the following website: www.proconweb.com

CHANGES IN TECHNOLOGY – SO WHAT ELSE IS NEW ?

Rapid technological change is now commonplace; it is the astonishing advances that are both sublime and frightening at the same time. Dramatic changes are also being driven by socio-economic factors such as protecting the environment and dwindling

and costly energy resources. So how do these changes affect attitudes toward the use of ceramic tile as an exterior cladding material for buildings ? First and foremost, we now have the cost effective technologies that allow us to understand adhesive technology behavior, and ultimately design and construct adhered tile veneers with confidence. Second, we are at a critical crossroad with respect to finding new building technologies to sustain our environment and conserve energy. And lastly, technology-driven development of new materials and products will result in dramatic changes in perception of tile as a building cladding material. The following are three new developments that will drive the future direction of tile-clad exterior facades:

- Building Information Modeling
- Sustainable ("Green") Building Technology
- New Tile Product Technology

BUILDING INFORMATION MODELING (BIM)

Building Information Modeling (also known by the acronym BIM) is a method of design and construction which utilizes information generated from computer digital simulation of a building's design to coordinate, quantify and even assemble building elements. BIM provides far more information than can be practically or physically provided by an architect's construction documents.

BIM has been used extensively and successfully in the automobile industry for years, although the economies of mass-production has, until recently, justified the enormous investment and cost. However, ever expanding technological capabilities, combined with reduced costs of software and hardware, have now allowed BIM to filter down to the building design and construction industry.

The emergence of building information modeling in the building design and construction industry is a significant new development for tile-clad building facades for many reasons. The most important aspect of this development is that the success of the BIM process requires collaboration between architects and contractors both during design and construction, similar to the design-build process. This approach is critical to more widespread acceptance and success of tile-clad building facades, as proper design is very much dependent on a thorough understanding of construction means and methods, and likewise, construction is very dependent on an understanding of design performance and need for quality control of a tile installation on a building exterior using adhesive technology. I can speak from experience that the most successful exterior tile facades are typically the result of an extensive collaborative effort, and BIM will facilitate and drive this process as it has in other industries.

Another benefit of BIM is that the fluid nature of adhered ceramic tile veneers can be utilized to create complex façade configurations that otherwise can not be designed and constructed in a cost and time effective manner. For this reason, the use of ceramic tile-clad surfaces for large-scale complex building façade configurations has historically been limited.

The most significant development, though, is that building information modeling can now provide the information to allow engineers to conduct cost-effective finite element analysis (FEA). Finite element analysis is a computer-based analysis of structural behavior of an assembly, such as an adhered ceramic tile veneer, that has mathematically complex or indeterminate reactions to stress. This is a breakthrough development for tile-clad building façade technology, as we can now more accurately

predict structural behavior of adhesives and design accordingly, rather than cross our fingers and hope for the best.

A good example is being able to understand the thermal movement behavior of compound curvature that is possible with tile-clad surfaces, and design appropriate movement joint patterns or use particular materials or techniques at those locations.
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Figure 1 – Building façade designs can take advantage of the fluid nature, color and texture unique to ceramic tile-clad building facades

Figure 2 – Building modeling information (BIM) can be used to predict behavior of compound curvature in ceramic tile-clad building facades and aid in proper design of movement joints

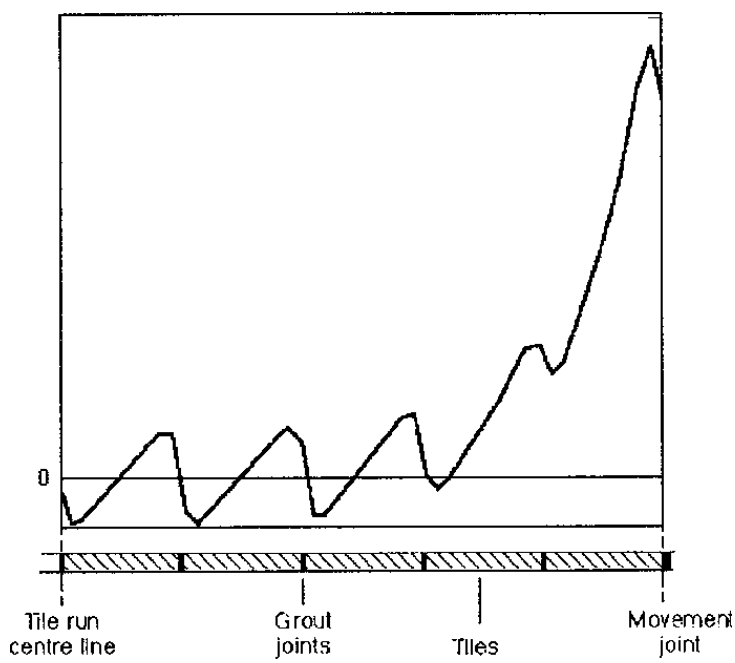

Figure 3 – An example of a graph of Finite Element Analysis revealing adhesive shear stress resulting from thermal expansion at the tile surface in an exterior wall. Note the high shear stress adjacent to movement joints, requiring careful attention to both design and installation of tile in this area

Figure 4 – model of porcelain ceramic tile mosaic façade and roof deck with compound curvature; building information modeling can be used to design, quantify and assemble components of the tile assembly

SUSTAINALBLE "GREEN" BUILDING SYSTEMS AND PRODUCTS

The demand for sustainable building design and construction has created an entire new market for environmentally sensitive or "green" building materials. In addition to market demand, the requirements of the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) program has accelerated research and development of new products that qualify as environmentally sustainable building materials. You can get more information on the LEED program by visiting the Council's website at: usgbc.com

Ceramic tile and the ancillary products that are used to install tile assemblies have historically provided many environmental benefits, despite the energy required for tile manufacturing. However, there have been recent advances that have significantly increased interest in ceramic tile as a sustainable and environmentally sensitive building façade cladding material.

Polymer technology has developed to the point where most tile installation adhesives and waterproofing products utilize water-based technology with low volatile organic compound (VOC) content and anti-microbial technology that now perform in the most extreme environments, such as a building façade. Recent developments of water-based products with high flexibility and good adhesion to a variety of surfaces, including metal, will greatly improve the performance of tile-clad facades.

Ceramic tile, cementitious tile adhesives and even cement backer board tile panel substrates often contain re-cycled content that is available locally, such as reactive fly-

ash aggregate, a by-product of coal combustion plants. Fly ash is also a lightweight filler mineral, and improves the strength and workability of cements and resin-based products.

It is likely the popularity of glass tile will lead to significant investments in research, resulting in development of large format glass tiles using recycled content that will be technologically robust for use as exterior building cladding in ways that are not possible or too costly with glass curtain wall technology.

Figure 5 – A textured porcelain stoneware tile-clad building façade results in a durable and stone-like appearance, with environmental benefits such as weight and volume reduction of building components, without reduction of performance, such as wind resistance in hurricane-prone areas

NEW CERAMIC TILE AND TILE INSTALLATION PRODUCT TECHNOLOGY

Nanotechnology is the most exciting and promising new development in ceramic tile and tile installation product material technology; this technology should figure prominently in increasing the popularity of ceramic tile-clad building facades. The term nanotechnology is derived from the measurement called a nanometer, which is one-billionth of a meter, 1/75,000th the size of a human hair; a nanometer comprises around four individual atoms. Once we are able to effectively manipulate the basic building blocks of materials, we will literally be able to create the desired characteristics of a material, and likely see thinner, stronger, tougher, lighter and more resilient ceramic tile in the near future. Nanotechnology is already being used to create ceramic tile and glass products with a microscopic layer of repellant nano-particles that can make surfaces virtually scratch and maintenance-free.

There are porcelain tile products already on the market that are 1/8 inch (3mm) thick and available in flexible panels up to 1,000 x 3,000 mm that can be assembled in a composite panel assembly with a protective security layer, similar to laminated safety glass, and applied to building facades with adhesive technology. The potential to laminate "smart" building technologies such as photovoltaic cells, into or between such panels presents some very interesting future possibilities, similar to LED (light emitting diode) curtain wall façade panels currently used in state-of-the-art buildings.

Developments in resin-based adhesive technology have resulted in high-strength, relatively flexible adhesives that are now approved by regulatory agencies to provide equivalent performance to metal mechanical anchors currently used to construct thick dimension stone curtain wall building facades. The significance of this development is that tile, which is typically not suitable for installation using concealed metal anchors due to its limited thickness, can now be installed safely and efficiently installed on a building façade using spot adhesive attachment that is engineered by building information modeling and finite element analysis.

Another development which should figure prominently in improving efficiency of ceramic tile-clad facade construction is cementitious adhesive and board products which incorporate re-cycled glass sphere aggregates to reduce weight of construction by over 30% without sacrifice in performance.

CERAMIC TILE-CLAD FACADES – AN EMERGING BUILDING TECHNOLOGY

The ceramic tile industry is uniquely positioned to take advantage of the confluence of social, economic and technological factors that will lead to a fundamental change in the way we design and construct the exterior envelope of buildings. The real challenge, though, is to apply all the tools and resources at our disposal, as the tile industry needs to develop more practical and specific information for the design and construction of exterior tile-cladding in order to instill more confidence in building owners, architects and contractors in this emerging building technology.

Figure 6 - Adhered tile veneers used in sustainable “green” buildings as an environmentally sensitive alternative to conventional thick masonry or dimension stone construction

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Mr. Goldberg's book titled "Direct Adhered Ceramic Tile, Stone and Thin Brick Facades" is available at the website **www.proconweb.com**