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Innovative Materials and New Technologies: A Different Way to Use for Stone

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Abstract—*The pathways followed by technological innovation in the field of architecture, construction techniques and building products are difficult, often tortuous. Innovation is transferred from other fields of application (egg, aeronautical construction) and comes into construction as if it were second-hand. Yet these same innovations have begun to change the way of designing and building buildings. In the last thirty years took place an explosion of new materials, already existing or in the experimental phase, in architecture and design, as well as in the purely construction sector. Among these: milk-based fabrics, translucent wood, super light materials such as Boeing Microlattice, anti-pollution brick, rainfall facades, biocomposite materials, ceramic accumulating heat and releasing it on demand, thin film photovoltaic.*

However, in recent years, an in-depth study investigates the use in architecture and in the design of marble, granite or natural stone double or single curved panels, reinforced by the use of carbon fiber or glass fiber for the construction of ultra-light stone plain shells. With the help of technology, new prototyping tools, the two materials, although completely different, combined with each other, allow for the reduction of the thickness of the stone components up to a few millimeters and the achievement of great static strength performance of the new material. The project is the result of a collaboration between the researchers of Politecnico di Bari, the Ticino manufacturing marble and granite Generelli SA.

1. INTRODUCTION

The process of progressive lightening of the lithic construction, from stereotomic mass to coating leather, represents an ambition that has always accompanied man from antiquity: we passed from the doric order to the thinner ionic and corinthian order; during the Middle Ages, the walls of the cathedrals have been emptied, leaving the enormous stone skeletons of Gothic architecture emerging and so on. Making it lighter is a necessity of both the material and of the intellectual challenge of man aiming to combine material lightness and structural strength. After all , it is the very nature that suggests to concentrate material only where it serves, without leaving anything to chance. The imitation of nature in this sense has also materialized in architecture, starting with the first constructive applications of Hooke and Gaudì's catenary curve studies. However, this path towards the optimization of structures, to be built with compression-only resistant materials, undergoes a sharp interruption in the early twentieth century, when modernism puts in fact the ban on domes and vaults. [1]

2. THE EVOLUTION OF STONE

As you read in the catalog of the exhibition "The International Style" of 1932: " The mass effect, of static solidity, so far the main quality in architecture has completely disappeared; in its place there is a volume effect, or more precisely of flat surfaces delimiting a volume". [2] For stone architecture it is the origin of a long oblivion, lasting more than half a century. The Modern Movement will relegate the stone to the role of mere surface coating. However, over the last thirty years, the curved surface, the first exclusive prerogative of stone vault space, has come back to the fore. The New Fundamentals Research Group [3], for many years active in the upgrading of load-bearing stones masses, has set itself the goal of exploring the possibilities of use in architecture and design of thin, single or double curved, natural stone panels, reinforced by the use of carbon fiber or glass fiber, for the construction of ultra-lightweight natural stone shells. The research was also created thanks to the collaboration with the Ticino marble processing company and granite Generelli SA, holder of the European Patent, *Method of production of objects in stone and composite material.*

3. A CASE STUDY

The production of thin-fiber-reinforced natural stone panels is of relatively recent introduction.

The scientific literature on this subject is mainly based on a good number of patents that have occurred over time since the patent filed in Germany in 1995 by Gernot Ehrlich about natural stone sheets for cladding. It is possible to report that one of the first cases in which is was applied in architecture is the realization of the flooring of the Denver International Airport in 1993, later on, it should be pointed out the Studio Gang Marble Curtain project for the 2003 Masonry Variations exhibition, where glass fiber reinforced marble was used to withstand tensile stress rather than compression. [4]

Fibrorinforced panels represent the latest evolution of the multi-millennial use of natural stone as a coating, whose popularity has remained unchanged over the centuries. In particular, it can be noted that in the last two centuries both scientific research and industrial production as well as architectural practice have focused mainly on the development of this specific use of stone materials compared to other materials. In addition to patents, it is good to point out that the applied research on the subject of thin stone cladding is carried out above all by companies in the industry. At present, the production of thin stone panels is quite varied and a distinction can be made between fiber-reinforced folding panels and fiber-reinforced non- folding panels.

The design of architectural spaces characterized by free-form double-curvature surfaces has come back in vogue since the early nineties, with the introduction and dissemination of three-dimensional modeling tools. Even today, free-form surfaces are at the center of the interests of theorists, researchers and designers in many disciplinary fields.

The free-form panels made of non-metallic materials are generally made of composite stone variously armed; high performance concrete or fiber reinforced concrete, with the use of "liquid stone" dropped inside polystyrene, plaster or fabric molds. If the element to be manufactured through the use of molds is also modular, it is much cheaper because of its reproducibility and the consequent possibility of reusing the mold several times. However, the surface appearance obtained using these techniques is far from the aesthetic and performance qualities of natural stone, resulting more similar to cement-based composites. [5] It is possible to think of the use of this type of panels, even for structural applications, using specific structural morphologies resistant to shape (bows, vaults, shells, etc.) conforming the individual panels in such a way as to guarantee their intrinsic resistance.

The first panel prototype built according to this technique was presented by the architects of the New Fundamentals Research Group, at Zaha Hadid Architects in London in December 2015, a sphere formed by two-curved granite petals all alike; in the variation of the fiber-reinforced panel with the glass fiber it is possible to notice the translucency of the granite itself.

The fields of application of these panels can be schematically divided into two large families: structural panels and non-structural panels.The first ones are used in architecture for the creation of extroflective roofs tendentially assembled together without further support structures. For non-structural panels, the use of panels is carried out by a support structure. In this case, the carbon fiber layer is mainly used for safety issues, in order to prevent any stone breakage from causing damage to third parties. These panels can be used in architecture to create stone curtains, ventilated facades, roofs or suspended ceilings, or used for interior design. Another interesting aspect is the possibility of backlighting the panels, taking advantage of translucency due to their reduced thickness, through the application of LED strips and photoluminescent films, combined with the use of glass fiber in the back part.

REFERENCES

[1] D'Amaro, 2014, pp. 6-9.

[2] Hitchcock Johnson, 1982, pp.52.

[3] The New Fundamental Group, s a team of Italian architects and researchers coordinated by Prof. Giuseppe Fallacara.

[4] Kolarevic et al. 2008, pp. 81-83.

[5] It is good to emphasize the non-structural nature of these panels, not to be confused with the design philosophy of the monolithic and continuous thin shells constructed in solid concrete in the last century.