APPLICATION OF GRC - GLASS FIBER REINFORCED CONCRETE IN BUILDING REHABILITATION

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ABSTRACT

GRC - Glass fiber Reinforced Concrete is a suitable material in rehabilitation. It is very economic when applied to architectural items, where is necessary reproducing fine details, copy the old finishing, or give a completely new design.

The possibility of making complex shapes with a minimum increase of cost, associated to a lightweight panel, but made of concrete, so, stiff enough and strong enough to build exterior façades is a major advantage

Properties such as fire resistance (class M0, non combustibility), ultra-violet light resistance (non degradable), put GRC panels in the front line of the suitable materials.

An example, is the rebuild façades of a building made of ceramic tiles, no more available in the market, that were reproduce in GRC sandwich panels.

Another example is the rehabilitation of the “Vila de Este” urbanization (about 2,200 dwellings), to give a new modern aspect, increasing the affectivity of the inhabitants.

Key words: Rehabilitation, GRC, Social Building, Light, Versatile.
Introduction

In Portugal efforts have been made in the last few years to build new residential areas, whereas in contrasts little efforts have been made to retrofit the existing buildings. [1]

According to the Euroconstruc-daei statistics for construction works, Portugal occupies a relevant place as far as investment. The building sector is concerned, but in the last place when it comes to retrofitting/maintaining the buildings it represents only 6 % of total investment. To reach an average value of over 30 % in retrofitting it will be needed a great development in building rehabilitation in the following years.

In this document we point out GRC, this composite material allows a technical rehabilitation of buildings maintaining the “element” of architecture when necessary. In one of the cases - “Mota-Galiza”-, the use of GRC was important to preserve the aesthetics of the building, and in the others two cases - “Valongo” and “Vila de Este” - it allows to improve the performance of the buildings.

GRC

Glass Reinforced Concrete (GRC or GFRC) is a composite material consisting of a mortar of hydraulic Portland cement and fine aggregate reinforced with alkali resistant glass fibers. Within this broad definition, variations are possible in mix constituents and proportions, and manufacturing method, such as to produce materials with differing properties.

The material properties, component design and method of manufacture of GRC products are interrelated. The properties of GRC depend on a wide range of variables. These include method of manufacture, mix formulation, fiber product type, length and orientation, admixtures used, etc.

A GRC material may therefore be tailored to meet the particular requirements of a specific application. The information given in this guide mainly refers to GRC materials having an aggregate: cement ratio of up to 1:1, incorporating AR glassfibers in the range 2 - 5 % and made by the spray and premix processes.

The GRC may contain additional filler materials and admixtures. GRC materials have been widely used for a number of years and their properties and characteristics studied extensively. GRC is a family of composite materials that combine the high compressive strength properties of cement mortars with significantly increased impact, flexural and tensile strengths imparted by the fiber reinforcement.

GRC is a composite with reinforcing elements randomly distributed throughout the matrix, unlike reinforced concrete where the reinforcing steel is placed primarily in tensile stress areas, at a predetermined distance from the surface to give the steel
protective cover. This means that for practical purposes GRC is designed as a homogeneous material. GRC products are safe, have good chemical resistance and will not rot or corrode. GRC is made of inorganic materials, will not burn and has negligible smoke emissions. It gives excellent stability and integrity resistance to fire.

However, due to the thin nature of panels, it requires additional material to satisfy insulation requirements. In some circumstances GRC is made containing polymer materials which may slightly affect some fire performance properties. GRC is normally of relatively thin cross section, with thickness commonly in the range 10 mm to 15 mm. This gives a low component weight which allows savings in handling, storage, transportation, and installation compared with traditional concrete products. There are two main methods of manufacturing GRC, namely:

- Spraying the fiber and slurry simultaneously onto a mould, by manual or mechanical means, with subsequent compaction by roller and trowel. Typical products made using the spray process include architectural cladding panels, channels, tanks, facade elements, ducting and permanent formwork.
- Premixing pre-chopped fiber in a mixer after thorough mixing of other components and then processing the mixture by vibration casting in a mould, extrusion to produce the end product form. This method of production is very versatile and is ideal for producing small items of architectural product in short periods of time, by using multiple moulds.

GRC is a composite material that combines the fine advantages of concrete durability and resistance to the slightness and the plasticity/flexibility of forms and textures usually adverse to concrete.

The fact of concrete being armed with fiber glass leads to a significant reduction of thickness and makes possible designs of sections that would be very difficult or even impossible but also very useful in non-structural coverings. These advantages benefit rehabilitation.

Appliance of GRC in Buildings Rehabilitation

To exemplify the advantages of the use of GRC in buildings rehabilitation, we have selected 3 examples located in the north of Portugal; 2 of them are already executed - “Calvário, in Valongo” and “Mota Galiza, in Porto” - and the last one - “Vila de Este, in Vila Nova de Gaia” - still an ongoing project.

Calvário - Valongo

The “Calvário” set of buildings was constructed in the 80’s and is constituted by 144 dwellings.
All the buildings of “Calvário” revealed a high set of anomalies as we can verify from the following figures.

*Figure 2: Fissures and dirty façades*

*Figure 3: Fissures and fall of elements in external walls*

*Figure 4: Degradation of pluvial water drain pipes*

*Figure 5: Fissures in external wall, view of the interior side of a room*

*Figure 6: Fissures of a internal wall*

*Figure 7: Condensation in a room*
The deepest analysis of the exterior wall demonstrated that a deficient structural support existed. (Figure 8).

![Figure 8: cut of the exterior wall with the slab](image)

It was determined to make the buildings rehabilitation attending to the following principles:
- Appliance of thermal isolation;
- Appliance of a covering over the thermal isolation with no contact with the walls (some had fallen and others were about to fall);

It was determined to use GRC panels; the settlement would be made on the top of the slab concrete. These panels had about 3 meters of length and an height corresponding to an habitation.

![Figure 9: GRC panels (front and back view)](image)

One of the main difficulties was related to the match with existing windows, but using metallic plating the problem was solved (figures 10 and 11).
With the use of the GRC panels, new drawings of the entrances and of the lateral façades were introduced (figure 12).

In conclusion, the use of GRC panels represents significant advantages:
- Reduction of the construction work time;
- Reduction of the workmanship time in about 50 %, with less disturbance the inhabitants
- There was no need for maintenance ten years after the work was done.

Mota-Galiza - Porto

“Mota-Galiza” is a luxury building, with commerce and apartments that presented a lot of fissures and also the fall of the covering (figure 13).
The solutions for the problem consist in eliminating the cause remaking the lateral façades. Such was only possible with the full dismount of the walls and its replacement with convenient expansion joints. This solution presented the difficulty of replacing the covering material - ceramic tiles, no more available in the market.

Consequently, it was decide to use the GRC panels to remake the covering.

These panels of GRC of large dimensions where anchored in the structural elements, beam and pillars, reproducing the existing covering.

This way the problem of infiltrations and covering was solved much faster than it would be in a traditional way and the architecture was maintained.

It was obtained an intervention sufficiently faster than the traditional one to decide the problem of infiltrations, and covering fall, keeping the original aspect.

Vila De Este - Vila Nova De Gaia

The “Vila de Este” set of buildings was constructed in the ends of 80’s, beginning of 90’s. It is constituted by 18 blocks and about 2100 apartments. The buildings have 8/9 floors and most of them have “Tunnel framework” structure.

The rehabilitation of this set of buildings will be supported using external thermal insulation composite systems. GRC panels will also be used to give a modern look to ground floor and entrances zones.

In the following figures some details of the GRC panels liaisons with the remaining covering are presented.

These joints, in rehabilitation, are very important to obtain quality of the intervention.
In the following figures we present 2 hypotheses of coverings using GRC panels - entrances with white or grey color and ground floor with green or red color.

Because it is a project in development, we show two figures, one representing the current state and the other simulating the buildings after rehabilitation.
Conclusion

As conclusion we can emphasize that with the GRC, building rehabilitation, more than its technique rehabilitation, either thermal and/or acoustic isolation, is also able to include a significant improvement in the architectural point of view of the intervention.

This possibility is so much more important the bigger the intervention, giving a new identity to the existing buildings, correcting eventual errors of conception or simply valuing more the existing one.

This type of intervention with this composite material is a resistant intervention to the aggressions for vandalism and also resistant and durable to the aggressions of the environment, as aggressive as they can be.

The levels of annoyance and insecurity during the intervention time, for the inhabitants, are reduced because there is no need for permanent scaffold in the work place and also because the time required for this intervention is usually reduced.

In economic terms this is a similar option comparing with the existing ones.
References

