

12 Mobile Home (Maxi-Caravan) in GRC

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The Sviluppo GRC International company is developing engineering projects abroad and in Italy using GRC in the field of light prefabricated buildings.

In this session of Congresso 2011 I would like to present a GRC utilisation experiment in a particular field: a mobile home (maxi-caravan) entirely constructed in GRC without any steel structure (Fig. 1 - Photo 1 maxi-caravan).

I have worked in the GRC field for many years and maybe some of you might remember me: particularly with regards to the Manstricht conference where I received the GRCA award for the first robotised installation.

I became interested in box constructions and similar units in 1997 that were used as cabins for the storage of telecommunication equipment.

These box constructions had reduced dimensions and were constructed in a single piece without joints using a system that was patented in my name and the Managing Director of a Portuguese manufacturing company.

They substituted the same type of prefabricated building or those in fibreglass or in reinforced concrete.

The advantage of GRC over the other two materials was that it was less heavy than reinforced concrete (bearing in mind that the telecommunication antennas are often located in positions that are difficult to reach) and not inflammable like fibreglass (bearing in mind that they are often located in zones that cannot be controlled against vandalism).

This experience was important for me to design the first mobile home entirely constructed in GRC.

The first consideration was that the telecommunication box system was not adaptable to mobile homes of much greater dimensions of box unit.

The moulds to produce the shell in a single piece were too complex and heavy.

The necessity to construct various models of mobile home with different dimensions meant producing a series of moulds even more complex and costly, although the idea of a self-supporting shell without a steel structure was kept in mind.

This time the idea was to construct a box unit in panels and build it using adhesive suitable for a GRC shell.

The first series was designed in 2001 and manufactured in 2002/2003.

As a consequence of this experience acquired with the previous series, Sviluppo GRC International started studying two new series: one series entirely in GRC with 45mm panels that were no longer sandwich, but lightened using a GRC and steel structure.

Let's return to the description of the first series, which is the most interesting because of the difficulties encountered and the future developments of the material.

The first problem that presented itself was determining the type of sandwich panel and the insulating material that formed the sandwich.

The thickness of the sandwich of the two walls is 45mm whilst the insulating material is fibre orientated mineral wool: the thickness of the two sides in GRC is theoretically 15mm from the external face and 10mm from the internal face, whilst the mineral wool is 30mm thick.

The second and more difficult problem to confront was defining the type of fixing between the various pieces of the GRC.

The solution to be explored was gluing the pieces together.

The adhesives on sale nowadays cover the most varied of requirements and application technologies.

In the end, the four walls, the floor and the ceiling were glued using epoxy adhesive (Fig. 2 - Design 4/29).

Before defining the adhesive material to be used, tensile tests were carried out on the pieces to be glued.

The result referring to the material adopted was such to convince me that there would be no problem. The breaking point occurred inside the glued pieces and not the adhesive material. Obviously, the necessity of not allowing the adhesive to work under shear stress conditions was kept in mind during the planning stages.

The advantage obtained with the solution of gluing only the GRC panels without any steel structure utilising continuous gluing without pins with structural tasks to do, does not make the variations of temperature and humidity inhomogeneous in the parallelepiped constituting the mobile home maxi-caravan.

The floor is a particularly type of sandwich. The total thickness including the joists is 195mm. Seen from underneath, it is like the coffer ceiling of a church or a medieval palace of the 13th century (Fig. 3 - Design 5/29).

The upper part is 45mm thick, whilst the joists are 150mm and constitute the load-bearing part of the entire shell.

The shell is composed of the two sides in GRC of 12mm thickness and formed of a light polystyrene-cement mixture with a density of 600 kgs/m³.

The wheels and towing unit are connected to the joists of the floor.

The floor panel has considerable rigidity longitudinally and permits the walls that operate as wall beams to not suffer such stress that exceeds the stress limits of the tensile part in the upper part of the wall at the joint where it meets the roof.

The panels were realised in ready-mix with 3% fibreglass and 2 fibreglass meshes of 130 gr/m² with mesh openings of 50 x 50 mm.

The layout of the habitation unit is L-shaped and is formed in two parts; one with a dimension of 2.5m x 7.5m and the other 2.5m x 3.5m (Fig. 4 - Design 9/29).

Both parts have their own wheels and are positioned in an L-shape.

The dimensions in length of both parts have been designed to be loaded onto one articulated vehicle.

The assembly was carried out inside the factory in a section isolated from the rest of production in which the panels were assembled to form the mobile home, complete with utility service installations and furnished (Fig. 5 - photo maxi-caravan 2).

Another feature of the project was the particular type of finish of the wall panels: the mixture was poured with the side constituting the inside of the mobile home on the formwork base and therefore with the part exposed to the outside of the mobile.

To remedy this inconvenience, the panel was finished with a 2 to 3mm “fresh on fresh” layer of sand cement mixture reinforced with 0.5% of high dispersion chopper strongly fortified with acrylic sprayed using a plaster spray gun with a “droplets” effect.

Using this system, the panel came out of the mould finished on both sides with a smooth formwork inside face and an external face with a finish like plaster worked as droplets.

(Fig. 6 - photo maxi-caravan 3).

What are the advantages that can therefore be utilised by constructing a mobile home in GRC?

What are the advantages for the user (the manager of the camping village)?

The use of mobile homes is expanding always due to those camping tourists who do not want to leave home with their own vehicle and prefer to rent a mobile home (Fig. 7 - photo maxi-caravan 4).

To be classified as a mobile home (and therefore not a fixed construction that cannot be positioned on land used for tourist facilities), it must be able to be moved at any moment.

It is therefore not necessary to be particularly light.

It was thought to utilise a medium/light wall.

A wall like the one proposed with a weight of approximately 60 kg/m².

The 2.50m x 6.50m unit weighs approximately 8,000 kg.

What is the advantage of a sandwich wall in GRC?

To heat up the mass of approximately 60 kg/m² of a GRC wall, 5 times more calories are needed as opposed to heating a wall in steel/polyurethane of an ordinary mobile home weighing 12 kg/m².

A more favourable trend of the day/night curve is achieved and a corresponding greater wellbeing inside.

Surfaces in steel or aluminium have a strong conductivity and a narrow thickness therefore everything is transferred to the insulation that transmits a residual part of the heat to the inside wall that is also made from strongly conductive material and functions as irradiating surfaces.

In the GRC sandwich there is a first obstacle of the mass of approximately 30 kg of the external face having a thermal conductivity coefficient less than steel or aluminium.

The residual calories that pass to the internal face after passing through the insulation find a surface with a mass of approximately 20 kg that absorbs another part of the energy before irradiation starts inside the unit.

The GRC of the internal face also has irradiation qualities that are less than a metal surface.

The result is a more comfortable habitability of the mobile home.

There is also less energy consumption for air-conditioning in summer.

Also the maintenance of external parts is facilitated by the type of material that in particular only needs repainting on the outside.

There are also psychological considerations for which a home in cement, even mobile, appears more “refined” than a mobile home made from metal.

I believe this experiment has been of great interest to me and could be interesting for use in the GRC field; it is a successful attempt of utilising the engineering qualities of GRC and the materials that are available; particularly fibreglass mesh resistant to alkalis.

The meshes utilised in this case were expressly manufactured for this project with the openings as required by the design planner.

For this design project, I took advantage of the experience acquired in the research financed by the European Union denominated Structa GRC in which I participated as a researcher. Many parts of the research were addressed to studying the reinforcements of the GRC using fibreglass mesh.

I believe that, in the case of flat moulds, whether they are monoskin or sandwich, the use of fibreglass mesh has not been completely explored from the industrial point of view and it is still possible to make progress in the industrialisation in the field of GRC products, advancing the use of the synergy between ready-mix and fibreglass.

For this reason I have written these brief notes about my experience of the construction I have described above, believing it to be useful in the planning and realisation of new GRC components.

During the study and experimentation of the various wall panels, a particular mixture was formulated that gave place to a further mobile home project.

It is a lightened panel with expanded glass 45mm thick with particular characteristics of resistance and insulation.

We are still at prototype level on this type of panel and mobile home maxi-caravan.

From a cost point of view it seems interesting because the realisation of single panels requires less labour, although it does have the disadvantage that it cannot be utilised without the support of a metal structure. In particular, the floor in the new series has been redesigned incorporating metal reinforcements.

This new series on which we are working will be more flexible than the previous series along the longitudinal axis and the problem will be to resolve the fixing of the panels and joints capable of absorbing the dimensional variations.

My experience with the planning project carried out for the Italiana Costruzioni company of Rome has helped me a lot in this project regarding beams in GRC in the MAXI museum of Rome of Zaha Hadid.

The slabs 1.5m high and 12m in length with a thickness of 15mm are suspended from a steel beam of the same 12m span with non-rigid attachments to absorb the bending stress of the steel beam to which the slab is fixed.

I am continuing as consultant for Sviluppo GRC International in this field in which the developments and eventual progress that could interest the majority of associates I hope to be able to recount to you at the next conference.

