



15 GRC - The Next Generation - Future Manufacturing Developments

Trevor Gregory
Can Build Group, China

In Prague, I provided an insight into the use of Architectural GRC as Permanent Formwork on a Residential Development in Hong Kong, using the '*Outside-In System*'.

This system combined the use of GRC and precast facades to form the entire external envelop of the building.

The external envelop, the *Outside*, for each floor was erected first and subsequently the structure, the *In-side*, was poured using the external facade as permanent formwork.

The final building has become a distinctive landmark in Hong Kong.



This year I am describing the future manufacturing developments of the '*Outside-In System*' and the increased use of GRC within the system.

Since Prague, the interest in the benefits of the *Outside-In System* has seen several projects undertaken utilizing the *System*.

In this paper, I will feature a small selection of projects which show both the development of the *System* as well as developments in the next generation of GRC used in modular facades.

MASDAR

Masdar Institute of Science and Technology, Phase 1A

Masdar City, is being built around pedestrians, where open public squares intersect with narrow shaded walkways and connect to homes, schools, restaurants, theatres and shops. The architecture of the city is inspired by the traditional medinas, souks and wind towers of the Arab world.

Considerable effort was expended in the design of the overall facade unit to attain a low carbon footprint, whilst generating a cool living environment to combat the extreme heat of the desert location.

GRC was employed on this project, for the full height of the external facade encompassing the balconies, staircases, ventilation shafts and link bridges.

The facade was originally designed utilizing GRC, by Foster+Partners, to be partially constructed by the *Outside-In System* and partially by cladding panels. Constraints in the on-site construction methodology, however, saw the facade cladding panels develop into a prefabricated GRC façade module that was prefabricated completely off-site and then bolted on to the pre-aligned brackets cast-in to the concrete structural frame.

By providing flexibility in the use of GRC and pro-actively providing solutions relating to buildability, the external prefabricated GRC façade modules were able to cater for the principal designer's characteristic complex shapes, whilst providing an integral finish for both texture and colour, with no externally applied finish being required.



The GRC façade has been designed as a series of curved balconies in a wave pattern that alternates on each floor so when the balcony on one floor is convex the balcony immediately above is concave.

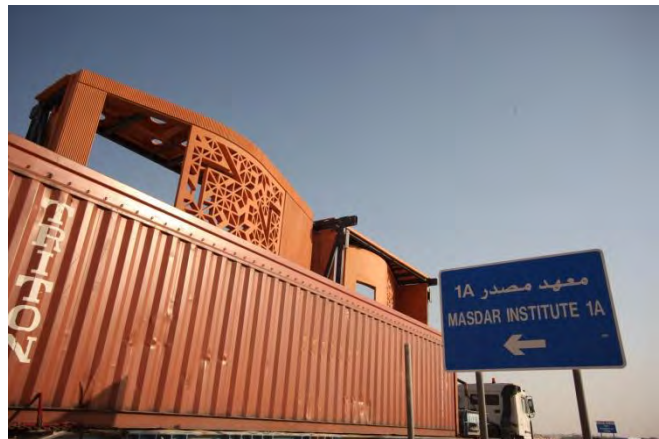
The colour scheme follows local traditions and other complementary materials combine with the GRC facades to create the whole balcony effect.

When the GRC supply contract was originally tendered, the scope included for only the design and supply of the GRC panels themselves: some to be used in the *Outside-In System*, whilst other panels would need to have been delivered to site, individually lifted to the building and fixed to the steel structure forming the curved balconies. This is the traditional manner of fixing cladding panels to the structure. The various interfaces between construction trades would have been numerous, requiring large amounts of workers, access scaffolding and lifting equipment. The Main Contractor would have had to co-ordinate all of these.

Through discussions with the Client, the Main Contractor and the design team, the original scope was developed to create a fast-track solution for the facades to the Residential units in which several individual GRC panels were combined to create larger sized panels, thereby reducing the number of moulds and joints between panels.

These larger GRC panels were then installed on to a steel frame, which was coated with corrosion and fire protection, off-site in our factory and delivered to site as 'one-piece' units utilizing 40ft open-top containers.

One whole Residential balcony unit (two balcony units combine to form the external façade of one Residential unit) is then simply lifted and bolted on to pre-installed brackets which had been lined and leveled.



Erection of these balcony units originally would have taken up to 10 days for each Residential unit but subsequently the GRC facade modules were fixed in place in only 2 hours.



The deployment of state-of-the-art GRC materials and spraying techniques enabled the GRC to be produced with an optimum percentage of fibre in the mix, resulting in a reduction of its carbon footprint. As part of this process, even the materials and process used for moulding of the panels were assessed to ensure the lowest possible carbon footprint. As an example of this, silicone was used as a liner to form the voids, to create the decorative pattern in the panels. The silicone was able to be re-cycled for use in other moulds.

These issues were fundamental in the approval process for the use of these GRC panels for this phase of the project.

The whole manufacturing process was developed and implemented within a short time frame, aided by the use of samples, prototypes, mock-ups and full size mock-ups.



These balcony units are highly complex with the GRC units including openings for lighting; GRC permanent form panels to receive the screed for the in-situ balcony floor above; built-in GRC slatted soffits and ceilings (to look like timber slats, which were originally to be manufactured from renewable source timber); curved GRC panels; and curved GRC screens, all to millimeter accuracy.

Flourosilane sealer was applied to the face of the GRC to provide a waterproof surface that also proved successful in reducing the unsightly visual effect of sand adhering to the facade after sand storms.

The overall visual effect is a GRC façade that meets the client's and the designers' requirements, fixed in place to the optimum programme.



Rambatan Road, Singapore

This 5 storey residential building has a light weight structural steel frame and the façade was planned to be constructed from lightweight block work, cement board, render, paint and joint sealant. The developer, however, appreciated the benefits of GRC and changed the specification, after commencement of the project, to utilise a GRC *Outside-In System* solution for the balconies, architectural GRC permanent form wall panels with a structural concrete backing and GRC cladding in other areas.



Even though this was a relatively small project, the benefits to the project were such that the developer has designed his forthcoming projects using a concrete frame with GRC utilizing the *Outside-In System* for the whole façade.





Tai Po TPTL 187, Hong Kong

The development, consisting of 43 tower blocks, is based around the concept of lagoons, so each of the sites celebrates water at the heart of its masterplan, integrated with the design of the clubhouses. The water of the lagoons at the heart of each site cascades down providing the calming effect of falling water with wonderfully illuminated pools and landscape by night.

For this project, we believe for the first time ever, we are constructing a building for which the external façade is totally GRC (excluding the windows and window frames) that is not a cladding system.

This means that the external face of the building is 100% GRC (except windows) which is white in colour and incorporates a sparkle effect. The design architect has, therefore, completely eradicated the use of external formwork (plywood or steel), external working scaffold, render, wall tiles, paint, steel bracketry and joint sealant and in doing so, has created an environmentally friendly façade, which is erected quickly with low maintenance requirements.



The GRC façade units are very significant in size with balconies up to 9.3m long and 2m wide, bay windows up to 5m wide and 2.8m high, as well as other sizeable units, such as box frames and other special feature panels.



The facade and bay window units have precast concrete to provide the structure behind the GRC skin which in turn provides the desired architectural finish.

This also reduces the overall cost of the façade as there is no requirement for any other external finishing work.

The wall units are erected, supported on the structural slab below and are stitched together by the internal insitu walls poured behind the façade.



The balconies are aligned together with the internal formwork used for the floor slabs to enable a homogenous floor slab to be poured.

The Main Contractor's programme is 9 days per 9 towers. Each day, therefore, effectively the facade of one level of each tower block is erected.

Once erected no further work is required to be undertaken to the external facade.

This creates substantial savings in labour and materials, together with a significant reduction in the overall construction programme which leads to further cost savings, conforming to the adage: *Don't Build Cheap, Build Cheaply*. These developments have also enhanced the use of GRC as an inexpensive alternative and/or complement, to curtain wall options.

In addition to direct cost savings, there is also less waste generated in the construction process and thereby greater environmental credentials. This is leading to the increased use of GRC as a green option for use in highly complex innovative facades.

I believe the above indicates that GRC already is and will continue to play an increasing part to improve the quality and buildability of projects in the future.

Future Projects

Continued development of the *Outside-In System* and the utilisation of GRC as part of a curtain wall system has seen a wide variety of projects being undertaken, and planned, that employ best-fit solutions to cater for varied requirements. Some examples of which are shown below:

Multi-storey Commercial and Residential Complex, Singapore



GRC has been designed for this forthcoming project. The intent is that GRC will be employed for use internally to the main lift lobby, the lift cores to each floor and externally for the planter boxes, utilizing the *Outside-In System*.

Commercial, Retail and Hotel Complex, Vietnam



Staying within South East Asia, a major development is being constructed in Hanoi.

GRC had been adopted for use in the facades, where the GRC will be installed using both the *Outside-In System* in the structural concrete areas and as cladding panels within the curtain wall system.