Trent Brick Panel: innovative envelope system designed according latest UK national fire and energy performance regulations

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Abstract. In November 2018, following the Grenfell Tower tragedy in London, the Ministry of Housing, Communities & Local Government (MHCLG) introduced an amendment to the Building Regulations 2010, which outlined stricter rules banning the use of combustible materials defined by the new Building Regulation 7(2). This change had a significant impact since early 2019, on the materials and systems that can be used in the construction sector. In 2020, the global pandemic caused by the diffusion of the COVID-19 virus represented a new challenge for the industry, with implications on programme certainty, material procurement, workforce management, moving towards offsite manufacture. The development of the Trent Brick Panel is set against this historical and social context. The envelope prototype is the opportunity for innovation that follows the turn of events. The offsite manufacturing of glass-reinforced concrete panel, mimicking several finishes, is the result of a design investigation carried out with the market-leading actors: developers, main contractors, subcontractors, engineering consultancies, architects, local authorities and warranty providers. The research aims to give an overview of the design principles, sequence and buildability study, assessed weathering performance according to CWCT Sequence B test and fire performance.

1. Introduction
New systems are needed to address the most recent UK Building Regulations. Interest in offsite manufacturing has risen dramatically over the last years in the construction industry, following the Grenfell Tower tragedy and the spreading of the COVID-19 disease. Designers have been called upon to answer the new requirements.

2. What is Glassfibre Reinforced Concrete
The Glassfibre Reinforced Concrete (GRC) is a composite material containing cement, fine aggregates, alkali-resistant glass fibres, and additives. Relatively new in the UK construction industry, the oldest
sample would not have been built over 10 years ago. The material can be used in several applications for architectural and façade components as well as civil engineering products. Three different grades of GRC can be designed. The sprayable grade selected for the Trent Panel contains a high alkali-resistant (AR) glass fibre content which can be sprayed into a mould to form any shape, texture or feature required by the specifier. It provides higher tensile strength and is more ductile than the other grades. The strengths are identified by the Modules of Rupture (MOR), the highest stress on a strain plot during a flexural bending test, which is defined by the International Glassfibre Reinforced Concrete Association (GRCA) as a value of 8, 10 or 18, the higher the figure, the stronger the GRC [1].

2.1. Manufacturing, curing and testing
The spray production method uses calibrated specialist equipment that allows the simultaneous deposition of known quantities of cementitious slime and glass fibre. Completed moulds should be stored according to the following procedures: GRC components should be cured at controlled temperature and humidity, with a minimum of seven days at 20°C and 95% RH; temperatures between 5°C and 40°C are generally acceptable; moulds must be stored on a level surface and supported to avoid any deformation, bowing or twist; products should not be exposed to drying winds or excessive heat for a minimum of two days [2]. The alkali-resistant glass fibre content shall be determined in accordance with either the “GRCA Methods of Testing Glassfibre Reinforced Concrete (GRC) Material Part 1” or BS EN 1170-2. The Limit of proportionality (LOP), defined as the elastic limit, is the stress in a flexural bending test where the strain plot deviates from a straight line. LOP and MOR may be determined at 7, 14 or 28 days in accordance with either the “GRCA Methods of Testing Glassfibre Reinforced Concrete (GRC) Material Part 3” or EN 1170-5. The 7 and 14 day results must only be acceptable if they already exceed design requirements.

3. Trent Brick Panel
A GRC cladding component is normally used as a rainscreen panel for naturally ventilated façade and open joints systems, where the weathering performance is achieved with a membrane engineered to protect the build-up from water ingress. The Trent Brick Panel (TBP) introduces the principles of unitized glazing façade saddle gasket design on a GRC element. Bespoke EPDM and TPE gaskets have been designed to manage horizontal and vertical movements. The 20mm horizontal joint can accommodate a range of +15mm and -12mm, the 10mm vertical joint a range of +5mm and -4mm. A first and second line of water and air defense is provided horizontally with bubble and rainscreen gaskets, vertically with lip and bullet gaskets. The gaskets are installed on metal trays and cast-in channels as part of the GRC panel. Once two panels engage, they perform for water tightness and air permeability. The weathering capability is now on the external line of the build-up, behind the GRC, hanging off a thermally broken secondary steel frame, mineral wool insulation.

3.1. Midgard Advanced Building System, buildability and sequence
The Midgard Advanced Building System (MABS) consists of installing, while building the reinforced concrete frame, a light gauge steel frame panel (LGSF) made offsite and finished with
cementitious particle board, breather membrane and metal edge shutter on top. The system allows to watertight the building at an early stage, progressing with the M&E installation and internal fit-out. A scaffolding system is required to complete the works related to the external envelope, cladding, glazing elements and brickwork installation. The TBP eliminates the need for scaffolding, the brick and several finishes can be mimicked, procurement time compressed, the glazing elements can be installed within the panel, offsite, in a controlled environment. The MABS sequence can be replicated with the TBP, with the advantage that no additional works are required once the system is in place.

Figure 3. Section and ISO view for the TBP. The system is delivered on site with edge shutter and edge protection. PHASE 1: panel erected on a given floor and restrained with Push&Pull arms. PHASE 2: formworks completed on the level above, rebars installation. PHASE 3: concrete pouring and floor completion, cycle completed. PHASE 4: installation of the panel above, start of a new cycle.

3.2. Fire performance, energy performance and CWCT Sequence B Test
Following the Grenfell Tower Fire, a decision was taken to restrict the use of combustible materials in defined buildings with a storey 18m or more above ground level containing a sleeping risk (defined for hotels and hostels that have higher level of fire detection, however residents are generally less familiar with their surroundings than in their own residences). Known now as ‘relevant buildings’, they are defined by the new Building Regulation 7 [3]. Exclusions apply for seals and gaskets due to negligible fire loads, the only combustible materials within the panel. Therefore, the system will comfortably meet the above standards when assessed under the European fire classification system.

The hygrothermal assessment and energy performance demonstrate a centre pane U-value equal to 0.18 W/m²K, according to BS EN ISO 6946:2017, showing that the system can comply with the latest 2013 edition of Approved Document L1A for new dwellings. Target Fabric Energy Efficiency rates (TFEE) were specifically introduced for façade components to sit alongside Target Emission Rates.

Since September 2020, the panel went through a cycle of CWCT Sequence B pre-tests. The test has been finally passed on January 2021, with minor modifications at the metal trays, cast-in channels and gasket design. The test proved the panel performances on air permeability, water tightness, wind resistance, water penetration in dynamic conditions, impact resistance, vertical and lateral sway.

4. Conclusions
The design and engineering flexibility that the GRC offers, combined with the new construction method and sequence, represents a competitive option in terms of planning, procurement and offsite manufacture. Subsequently, the success in the weathering test, the research will progress with an already scheduled fire performance test. The system would be likely optimized and finally adopted on a live project later this summer in Reading, UK.

References
[1] The International Glassfibre Reinforced Concrete Association (GRCA) 2016 Specifiers Guide to Glassfibre Reinforced Concrete
[2] The International Glassfibre Reinforced Concrete Association (GRCA) 2017 Specification for the Manufacture, Curing & Testing of Glassfibre Reinforced Concrete (GRC) Products
[3] The Building Regulations 2010 Approved Document B: Regulation 7(2) Materials and workmanship 2013 edition, List of amendments November 2018 volume 2 part B4