Innovation Case Study – Rotherham to Kilnhurst Flood Alleviation Scheme

Introduction

In collaboration with Breedon, Jacksons Civil Engineering (JCE) used 180m^3 of C30 grade Earth Friendly Concrete (EFC), an Ultra-Low Carbon Concrete (ULCC) consisting of Ground Granulated Blast Furnace Slag (GGBS) and a geopolymer binder in place of Ordinary Portland Cement (OPC), on the Rotherham to Kilnhurst Flood Alleviation Scheme. Typically, substituting OPC for EFC binder can reduce embodied CO_2 by 55-70%, and the concrete itself requires similar aggregate proportions in mixing and the same production, delivery, placement and compaction infrastructure as OPC-based concrete. The EFC C30 grade mixture used in this project had 76.5kg/m^3 of CO_2e, as opposed to a typical OPC C30 grade mixture with 320.2kg/m^3 of CO_2. Therefore, 44t of CO_2 was saved in using 180m^3 of the EFC C30 grade mixture instead of an OPC mixture.


Figure 1 – A model render of the new canal barrier (JCE, n.d)

Background

Following flood events in Rotherham town centre in 2007 and 2019, Rotherham Metropolitan Borough Council (RMBC) identified the need to upgrade the flood defences and canal barrier along 5km of the River Don. This led to the development of the £17m Rotherham to Kilnhurst Flood Alleviation Scheme to reduce the risk of the River Don overtopping into the canal and flooding Rotherham town centre and the Central Railway Station. Jacksons Civil Engineering Group has been commissioned to complete the central part of the scheme on Forge Island, which consists of installing a new multi-million-pound canal barrier – a guillotine-style gate leaf within an architectural statement superstructure – and constructing flood walls and abutment supports and extending tow paths.

JCE saw potential in this development to use EFC, instead of OPC-based concrete, on lower risk elements in the scheme to reduce the overall carbon footprint of the project. Cube compressive strength test results showed this C25/30 EFC mix reached 21.5MPa and 36.6MPa, 7 days and 28 days after pouring, respectively.

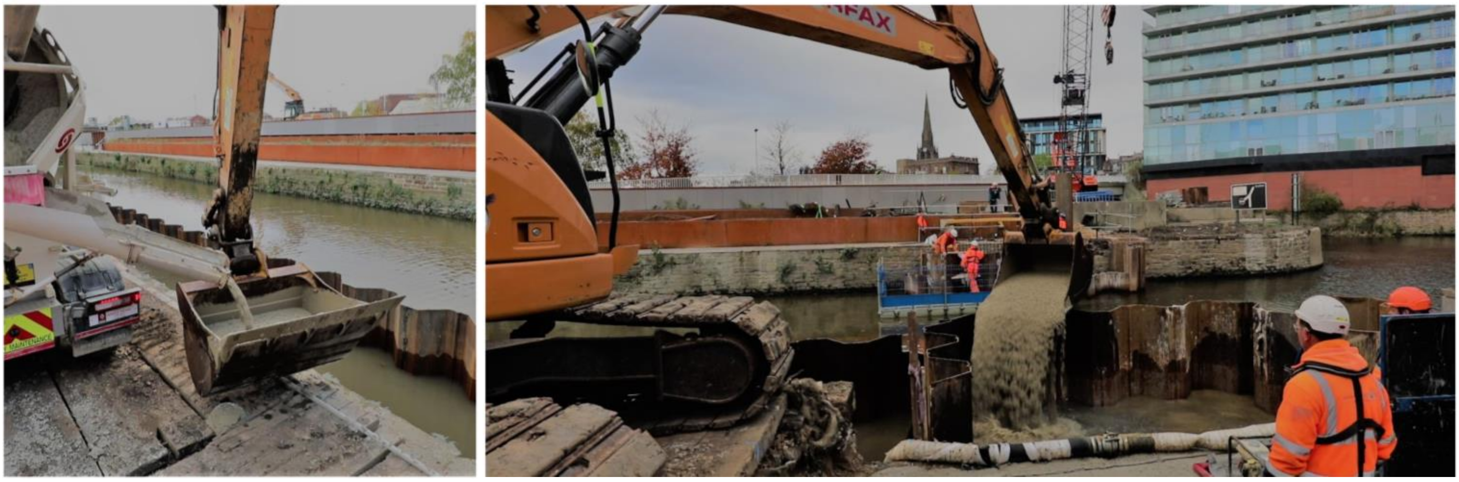
Solution – Using 180m^3 of EFC C30-grade concrete in the sub-structure

JCE investigated the feasibility of using an alternative low-carbon material in the sub-structure of the development in conjunction with their supply chain partner, Breedon. The EFC product that had recently been trialled between JCE and Breedon looked to be an ideal material to use. Through continuous liaison between JCE and Breedon, an EFC mix design was developed and submitted to the project design team at Pell Frischmann to ascertain the viability of using the product in place of the designated standard OPC mixture for lower risk elements of the sub-structure. Once the use of EFC was agreed in, RMBC were contacted to confirm if there was an appetite for incorporating EFC into the project. RMBC were interested in the use of EFC as using it aligned with their Net Zero Carbon targets and ambitions.

JCE developed a production and delivery programme with Breedon and scheduled the pours that were to take place in the coming 6 to 8 weeks. A bespoke batching set-up needed to be created at local batching plant, which is approximately 3 miles from the site, to ensure that the large volume pours could be supported. This created challenges, as the chemical activators required being kept at a temperature of 25ºC in insulated tanks during delivery and storage, prior to incorporating into the mix.

Further complications arose nearer to the pour window as there was no way to fully de-water the pour point, therefore requiring a plan to remove displaced water. After pouring, JCE also found that the surface of the EFC concrete remained wetter for longer, unlike an OPC concrete surface that cures more rapidly. Despite all this, the pours were carried out with little issue and both large volume pours were supported fully in good time.

The collaboration between JCE, Breedon, Pell Frischmann and RMBC allowed for part of the sub-structure and surrounding landscape to be constructed utilising approximately 180m^3 of C25/30 grade EFC-based concrete in a mass concrete foundation and capping, which saved the project 44t of CO_2. As the design of the sub-structure was comprised of lower risk, non-structural elements, JCE's Project Manager saw the potential in using an alternative, lower-carbon concrete, which defines the innovation behind this project.



Figures 2 and 3 – De-watering the pouring points (behind the sheet piles) using an excavator (JCE, n.d.)

Concrete cube samples were taken to measure the compressive strength development of the EFC. The results from compressive strength testing showed compressive strengths of 21.5MPa and 36.6MPa 7 days and 28 days after pouring, respectively. Therefore roughly 72% of the concrete's compressive strength was gained after 7 days.

Benefits

- Substituting EFC for OPC achieved ~76% reduction in CO_2e by using EFC instead of OPC in the delivery of lower-risk non-structural elements, which is a CO_2 saving of 44t.
- EFC can gain the majority of its C25/30 grade strength in 7 days and exceed the target strength in 28 days.
- Key public relations advantage in showing the use of innovative carbon saving measures.
- Normalising the use of products that can be seen as 'niche'.

Key lessons learned

- Early assessment and engagement with suppliers and clients was vital to using this technology.
- The product itself can be treated exactly like an OPC-based concrete and requires no additional facilities or specialised equipment is required for storing, placing, compacting or curing the concrete.
- A standard C30 OPC-based mix costs roughly £82-£85/m^3 whereas the EFC mixture cost roughly £150-£160/m^3. The cost-to-benefit analysis requires a forward-thinking client as EFC currently costs roughly twice as much as OPC-based concrete. Increased usage of EFC will drive down cost.
- The mix activators needed to be kept at a consistent temperature above 25ºC prior to mixing with EFC.

- If concrete pumping is to be used, it must be noted that specific grouts must be used to line the pump and these grouts cannot be washed out into the pour, therefore requiring separate discharge areas.

Where can I get further information?

For further information, see:

- YouTube video about the project
- Ultra low-carbon concrete used on Rotherham canal barrier scheme (jackson-civils.co.uk)
- Pell Frischmann Appointed Onto Flood Alleviation Scheme - Excellence Through Innovation - Pell Frischmann
- Work begins on new town centre flood defence – Rotherham Metropolitan Borough Council

For details on the case study please email: andrew.powell@environment-agency.gov.uk