48 Percent Carbon Reduction using 75 Percent GGBS in Structural Concrete

RESPONSIBLE BUSINESS | ENERGY AND CARBON | RESOURCE EFFICIENCY

Innovation

PROJECT NAME
Harwell EPAC

BUSINESS UNIT
1113 - Public Sector Construction

POINT OF CONTACT:
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Overview

- The EPAC project is using 7,500m3 of structural concrete with a composition of 75% GGBS (Ground Granulated Blast Furnace Slag), and Slag cement replacement (blast furnace bi-product), in place of 100% Portland Cement.
- The concrete design was based on its radiation shielding properties, high density aggregates & reduced cement content to reduce the risk of thermal cracks. Specifying this concrete mix enabled the site team to maintain control of the curing temperature to ensure minimal cracking and achieve the specified oven dry density for shielding purposes.

Benefits:

- **Sustainability:** By using 75% GGBS the project generated a 48% carbon saving. They would have used 2867 tCO2e with 100% Portland Cement, compared with 1494.5 tCO2e with 75% GGBS. The offsetting saving by using 75% GGBS would be ~£11,000 (assuming a moderate cost of £8 per tonne to offset).

Key challenges

Due to the nature of the project (essentially a concrete box to house super-bright lasers to produce state-of-the-art 3D X-rays in just 40 seconds), a huge volume of structural concrete is required (7,500m3) in large pour sizes.
Concrete is the most widely used man-made material in existence. Whilst cement - the key ingredient in concrete - has shaped much of our built environment, it also has a massive carbon footprint. Cement is the source of about 8% of the world's carbon dioxide (CO2) emissions. Not only does the production of Portland cement involve quarrying - causing airborne pollution in the form of dust - it also requires the use of massive kilns, which require large amounts of energy. The actual chemical process of making cement also emits staggeringly high levels of CO2.

Our solution

The EPAC project specified 7,500m3 of structural concrete with a composition of 75% GGBS (Ground Granulated Blast Furnace Slag) in place of 100% Portland Cement. OTB (Outside the Box), the concrete consultant, and Hansen's technical department collaborated with Mace on the final mix design. Installer: J Coffey.

Outcomes & benefits

Sustainability:

- We inputted data into the One-Click LCA tool to calculate the carbon saving which is a bench marking guide. By specifying 7,500m3 of structural concrete with a composition of 75% GGBS, EPAC generated a 48% carbon saving compared with 100% Portland Cement. The project would have used 2867 tCO2e, compared with 1494.5 tCO2e with 75% GGBS.
- The client held an open event at the Harwell Campus that the staff & local community were invited to attend. We had been advised that staff may question the environmental impact of the project and what Mace are doing to reduce / offset the large volume of concrete required. We therefore calculated the carbon savings & presented this to gain public approval.

Cost:

- The purchase of the concrete mix at 75% GGBS is about £3/m3 more expensive than standard. As a result, it cost the project a ~£25,000 premium.
- The carbon offsetting saving by using 75% GGBS would be ~£11,000.
- Overall, using 75% GGBS increased the project cost by ~£14,000 (total project value is £31m for reference). In this case, this specification was necessary due to the nature of the project, as a concrete mix with high density aggregates & reduced cement content was required to reduce the risk of thermal cracks.

Performance:

- It is structurally sound – studies have found that concrete containing higher GGBS have higher values of flexural strength than OPC concrete when cured under the summer curing environment rather than in winter (which is what took place at EPAC)

Appearance:

- GGBS is off-white in colour and substantially lighter than Portland cement. This whiter colour is especially seen at CEM I replacement levels of 50% and above. The more aesthetically pleasing appearance of GGBS concrete can help soften the visual impact of large structures.

Lessons Learnt

- **Strength:** The concrete composition was suitable for the EPAC project, but it wouldn't be suitable for every project. The overall full-strength curing time is increased for compositions with higher GGBS content.
  - Typically, the 7-day strength of a 70% GGBS concrete will be 35% of the 28-day strength compared to 70-80% for a similar Portland cement CEM I concrete.
  - The reduction in early strength will be more noticeable at high GGBS levels and low temperatures.

- The concrete strength spec called for C30/40 which has been achieved without issue, the use of GGBS on EPAC had no effect on the strength required.

- **Programme:** Under normal circumstances, the striking times for concretes containing up to 50% GGBS do not increase to the point of significantly affecting the construction programme. However, concretes with higher levels of GGBS will not always achieve sufficient strength after one day to allow removal of vertical formwork, particularly at lower temperatures.
  - The programme was not impacted at EPAC as we had allowed for sufficient shutters to be able to leave them in place for an extra couple of days. Once on site & following the pour of the first large wall section, it became evident that if we were able to stand the prefabricated rebar before moving the shutters in place, we could maintain the programme duration between each pour. We then designed the temporary works required to do this & flipped the sequence (rebar installation before standing the shutters). As a result, we improved the overall programme by ~6 weeks.

Mace info handling: Not confidential – internal

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