Introduction

Background: The durability of concrete is a key indicator of the long-term performance of reinforced concrete structures. Enhancing durability can reduce maintenance requirement and will have positive effects on whole-life costs, material demands and usage and thus the environmental impact of the structure itself.

One of the primary drivers of damage to, and deterioration of, reinforced concrete is the ingress of moisture through cracks and pores inherent in the material. It has been found that materials composed of hydrophobic particles, when used as admixture within concrete, can improve the concrete’s ability to impede water ingress and one such material is Recovered Toner Powder (RTP).

In recent studies, carried out at the University of Dundee, further to its initial application as a pigment for concrete, RTP was found to increase the water resistance of a concrete mix. As a waste material, RTP can be reclaimed and utilised to help the aims of the construction industry in terms of enhanced service life and sustainability of reinforced concrete structures and consequently national infrastructure.

ImPLICATIONS FOR DESIGN

Improvements in the Key areas of Durability:

It was found that RTP concrete has the potential to be adopted to allow specification of concrete with high levels of durability performance in the areas of water penetration, chloride diffusion, carbonation depth, electrical resistivity and sorptivity with. It may allow designers the ability to specify a lower strength concrete that exhibits the durability performance of concretes with lower w/c ratios and higher strength. If the outcomes from the research can be replicated and reproduced consistently in the field, there may be scope for consideration of codifying the use and specification of RTP admixtures within the design standards.

Cost, £/m³

This allowed comparison of RTP mixes to the properties of conventional mixes and mixes containing commercially available waterproofing additives. The project also sought to determine the potential use of RTP to reduce the required cement content in a mix to achieve a comparable durability performance in the key areas, alongside investigating the potential of RTP to reduce the reliance on increased cementitious material and increased cover specifications to improve the durability of a mix in design.

The effects that RTP has on these factors was used to determine impact on cost and sustainability of concrete.

Conclusions

It was discovered that RTP as a waterproofing admixture can impact upon the compressive strength of a concrete but can notably improve the durability of a mix in the key areas. A balance then must be struck between the strength of a concrete and its short and long-term durability performance when specifying RTP admixtures. RTP can be said to have potential for designers when performance and durability are of primary concern.

Carbon dioxide emissions from concrete and its embodied carbon dioxide are directly proportional to the cement content (CEM I) in a mix. With the RTP admixture reducing the need for increased cementitious materials whilst maintaining and often improving the performance of the concrete, this admixture offers clear savings on both the monetary costs and eCO₂ of a concrete.

RTP has potential to be adopted to improve durability performance in the areas of water penetration, chloride diffusion, carbonation depth, electrical resistivity and sorptivity with. It may allow designers the ability to specify a lower strength concrete (eg in precast concrete elements where strength may not be the driving factor) that exhibits equivalent durability performance of concretes with higher strength.

Adoption of design and specification in line with the use of such recovered/recycled materials can only help contribute to the reduction of the substantial environmental impact of concrete production and utilisation.

Future Work

This project focused mainly on using RTP in conventional in-situ, CEM I type concrete mixes. Further work could be carried out in these areas:

• Concrete mixes which contain sustainable cementitious materials such as GGBS and fly ash could be used. These materials often improve the strength of concrete and thus the durability and are already in use within the industry.

• Further research could be undertaken on the potential whole-life cost savings that any reductions in the need for maintenance that a more durable RTP concrete mix would offer.

• Work could be carried out on precast concrete samples to analyse the benefits of using RTP in this way. In precast, non-structural members where the long-term durability is of primary importance to the manufacturer and designer, the strength of the concrete may be of secondary concern and so any reduction in such by the RTP admixture may not be as significant.

Acknowledgements

The authors wish to acknowledge the help and funding from the CSIC and the Institution of Structural Engineers.