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REDUCING CONCRETE'S CARBON FOOTPRINT

USING FIBRES TO GO GREEN

IN THIS ISSUE:

46 Volumetric Mixing

REDUCING THE CARBON FOOTPRINT OF CONCRETE CONSTRUCTION

The use of fibre reinforcement in concrete not only improves durability; it also reduces the embodied carbon in the materials of construction.

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PHOTOS: COURTESY OF EUCLID CHEMICAL

It is no secret that concrete is one of the largest contributors to the emission of carbon dioxide around the world. To their credit, the concrete and cement industries have recognized that they must play a role in reducing their carbon impact. As such, the industry is exploring all aspects of a build, from adjusting the components in our building materials, to the choice of material components used in projects.

Cement manufacturers have been working on low-carbon recipes to help bring down the carbon levels produced through the manufacturing process for the core ingredient in concrete. Others in the industry have been doing research to bring down the carbon footprint of concrete projects as well, including through the use of recycled aggregate and even alternative aggregate materials. The use of fibre-reinforced concrete (FRC) is another industry innovation that holds the potential to make a sizable net-positive impact in the ongoing battle to reduce the carbon footprint of our projects.

Over the past several years, there has been a renewed interest in the use of fibre reinforcement in concrete pavements for parking lots, white toppings, bridge decks and roadways. As interest rises, various technical organizations such as the American Concrete Institute (ACI), American Concrete Pavement Association (ACPA) and the National Concrete Pavement Technology (CP Tech) Center have stepped forward with new guidance and recommendations on how to properly select and use fibre types in concrete.

MAKING THE GOOD BETTER

Despite some of the negative marketing and connotations, concrete is already one of the most environmentally friendly materials available when properly used. It is durable, cost effective, is made from locally sourced ingredients, is relatively easy to work with, has minimal waste, can be customized, and has a thermal mass that can be advantageous. It has a long history of use because of all its positive qualities.

To help address some of its less desirable traits, the construction industry has embarked on a pathway leading to sustainable concrete practices and technologies that can save energy, reduce CO_2 emissions, protect the environment and maximize economics. By taking a big-picture approach to the reduction of global carbon emissions, and focusing on embodied carbon, the use of fibre in place of steel reinforcing bars can indeed result in reduced CO_2 footprints for our infrastructure and other major projects.

ASSESSING THE IMPACT

Globally, it is estimated that the construction industry accounts for a quarter of total carbon emissions. Cement production claims about seven per cent of global emissions, and steel reinforcement accounts for 1.5 per cent of world-wide carbon emissions. With the large volume of reinforced concrete floors used worldwide, roughly 45 per cent of steel consumption is destined for concrete reinforcement. That's a lot of opportunity for improvement.

The energy required to produce one metric ton of reinforced concrete is 2.5 GJ/t. This compares with 30 GJ/t for steel and 2.0 GJ/t for wood. A study comparing the emissions of several different building materials per 1,000 kg found that concrete produced 147 kg of CO_2, metals produced 3,000 kg of CO_2, and wood produced 127 kg of CO_2.

When exploring ways to reduce carbon emissions, there appears to be some opportunity in exploring how floors, walls, roadways and foundations could be reinforced at a lower carbon cost.

With a focus on reducing environmental impact, the knowledge, testing and experience of using synthetic macrofibre-reinforced concrete continues to grow for use in infrastructure projects, and its successful use and benefits are now being realized through full scale and long-term demonstration projects.

With positive anecdotal case studies, many prospective engineers, architectural firms and clients are now requesting additional information as to the environmental impacts of using fibres in replacement of traditional reinforcement, or as an added material in concrete to improve durability and useful service life. The industry is working on environmental product declarations and other materials to officially qualify much of what has been observed via demonstration projects.

A BRIEF FRC HISTORY

Although FRC has been used since the 1960s, there has been little change to its use in North America for many potential applications, until recently. New developments in materials technology and the addition of field experience to the engineering knowledge base have expanded the applications of FRC to include design guides that are now material independent and recognized by the engineering community.

Over the past two decades, FRC technology has gained acceptance from industry bodies such as UL, Steel Deck Institute (SDI) and ACI thanks to multi-million-dollar research programs. Structural designs and software tools have been designed, and calculations for equivalent reinforcing options to allow for comparison to conventional designs have also been developed. As such, FRC is being used in high-profile projects, including applications where failure is not acceptable and where durability is key, such as in bridge decking and paving.

DIFFERENTIATING THE FIBRES

The physical characteristics of fibres varies, with each type having its ideal application. In general, the industry has accepted that steel macrofibres and older micro synthetic fibres (fibrillated, monofils, etc.) are not used under the same conditions.

Micro synthetics are generally used as secondary reinforcement, addressing plastic shrinkage only. Steel fibres are more suitable for industrial floor designs and can replace heavier reinforcing configurations.

Synthetic macrofibres can be strong, like steel fibres, but simply not made of steel. The physical characteristics of these fibres, such as their length, tensile strength and diameter, are all different when compared to traditional micro synthetics.

Synthetic macrofibre composites can be used to replace steel reinforcement or in conjunction with steel reinforcement to increase durability and extend service life. The contribution to sustainable construction through lowered environmental, social and economic impacts is currently being documented.

To ensure proper performance of the concrete, macrofibres dosages should be calculated based on the engineering requirements of the project. Since the fibres are worked into the concrete mix, significant savings may be realized in construction time, labour and overall costs.

Once placed, FRC has an increased resistance to cracking, impact and fatigue as the reinforcement is randomized and three-dimensional throughout the structure, rather than being provided along a more defined plane that exists with more traditional reinforcement components.

WHY FRC?

We are in the midst of a massive infrastructure deficit. A quarter of our existing roads, bridges and other structures will need to be repaired or replaced by 2030, and these projects need to be completed with a lower environmental impact. The use of innovative material substitutions, like fibre-reinforced concrete, can help with both the longevity of these structures and their carbon footprints.

The use of FRC has been found to reduce CO_2 emissions by more than 50 per cent compared to more traditional reinforcing means used in typical industrial floors and pavements.

And other materials, such as chemical admixtures, advanced cements and supplemental cementitious materials, can demonstrate additional significant reductions in overall upfront global warming potential (GWP) values.

We know that sustainability, or building better, needs to include a hard look at building practices, materials and long-term costs over time. If FRC lasts longer than normal concrete, is that not the exact definition of improving sustainability? ☐

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