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Incorporation of waste plastics as fine aggregates in reinforced concrete beams

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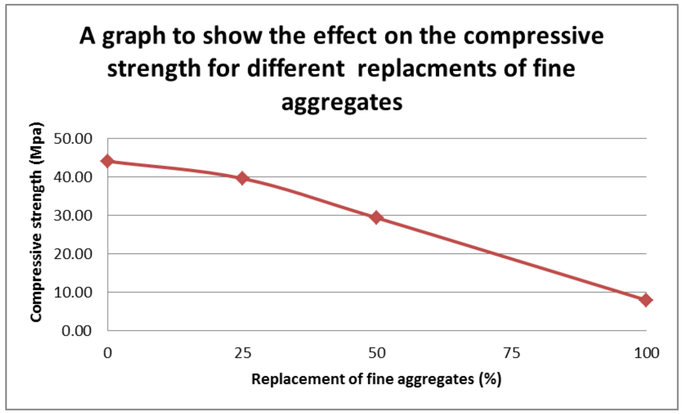
Abstract

Management of waste material is major concern in the world for the present and future. There is an increasing awareness about waste material due to the fact that there is major environmental problems, reduced space for landfilling and highs costs involved. Therefore, there is a greater appeal to reduce the disposal of theses waste materials and use them in the production of other materials. Many research studies have been carried out on using waste materials in the production of concrete but very little research has been undertaken on reinforced concrete beams. Not only would it reduce the costs in the production of concrete beams and the disposal of the waste material, but it can also increase the performance. Plastic is a waste material which is heavily used in the world today. Efforts have been made to use waste plastics in the production of concrete which is very important to the plastic recycling industry and concrete production industries as the performance of the material can be enhanced.

Aims

- Reduce environmental issues caused by waste plastic
- Incorporate waste plastic in the production of concrete
- Achieve the structural performance of waste plastic concrete as model concrete



It can be seen from the graph on the left that the replacement of fine aggregates with plastic had a dramatic effect on the compressive strength of the concrete. As the percentage of plastic replacement increased, the compressive strength decreased significantly. This was due to the plastic particles not being able to create a strong bond with the cement paste.

Testing undertaken

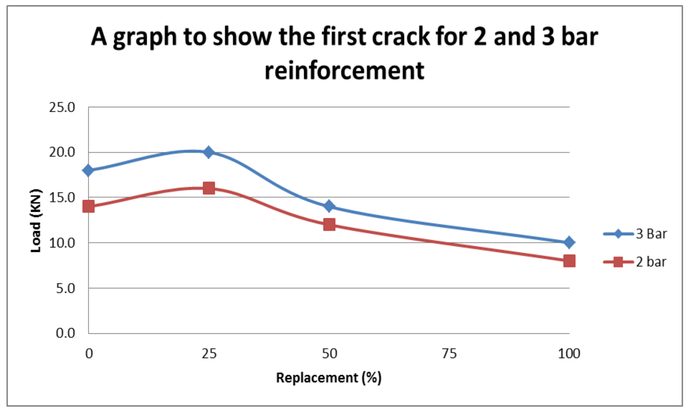
A variety of tests were performed on concrete cubes and reinforced concrete beams. The workability was tested using a slump test shown in the image below when the mixture was first created, whereas all other tests were performed on concrete cubes and reinforced concrete beams after 28 days curing at room temperature.

- Workability
- Dry density
- Ultrasonic pulse velocity
- Compressive strength
- Beam failure mode
- Cracking behaviour
- Load at first crack
- Ultimate loading
- Central deflection
- Strain

Plastic particles used in testing

The image below shows the plastic particles used in the investigation. It can be seen that the particles are very fine meaning that it was possible to replace sand aggregates with this material.

It can be seen from the graph on the right that the replacement of fine aggregates with plastic had a large effect on the load at which the first crack appeared on the beams. For the 25% replacement, the load at first crack increased for the 2 and 3 bar reinforcement compared to the control. However, for replacements greater than 25%, the load at first crack decreased rapidly for both reinforcements.



Material	Positives	Negatives
Plastic	Reduces cost of Landfill	May reduce structural performance of concrete
	Reduces toxic gases being released into the atmosphere	Some plastics have low melting points
	Very good insulator of electric and heat	Some plastics can release harmful gases when heated
	Lightweight	
	Chemically unreactive	
	Waterproof	
	Odourless	
	Very long life span	
	Low production costs	

The table shows that there are a larger number of positives compared to negatives in incorporating waste plastics in concrete production. The main concern about adding waste plastic to concrete is that the strength of the concrete could be heavily reduced. Also, the release of toxic gases could be harmful but this negative could be eliminated by selecting plastics which don't release harmful gases and ones which have a high melting point.

Scope for further study

Research in using recycled or waste plastic in the production of reinforced concrete beams is a very new topic and a lot of extra research is needed before this material can be used. Lots of research has been carried out on the replacement of aggregates in normal concrete whereas very little research has been carried out on replacing aggregates in reinforced concrete beams. Following from this research, investigations should be focused towards replacing fine/coarse or both types of aggregates in reinforced concrete beams or investigating with different water/cement ratios as found from this research, some plastics absorb water which can have a large effect on results.

Main conclusions

1. The workability of the mixture generally decreased for an increase in plastic aggregates.
2. The increase in plastic aggregates reduced the density and compressive strength for an increase in plastic material.
3. The increase in plastic aggregates increased the ultrasonic pulse velocity for all replacements.
4. The failure modes of the reinforced plastic beams were very similar compared to the control beams except for the 100% replacement which failed due to shear.
5. For an increased percentage of plastic aggregates, there was an increased number of cracks which lead to smaller lengths and widths of cracks developing compared to normal concrete beams
6. The load at first crack and ultimate loading increased for 25% replacement of fine aggregates but decreased for 50% and 100% replacement of fine aggregates.
7. The central deflection increased for 25% and 50% replacement whereas the 100% replacement incurred very little central deflection due to the beam failing by shear.
8. The increase in reinforcement from 2 bars to 3 bars in the tension zone had similar results on the beams behaviour but the properties of the beams were enhanced.
9. The increase in tension reinforcement increased the loading at which the first crack occurred and ultimate loadings compared to the two bar reinforcement.
10. It was found that the analytical data predicted 50% of the experimental values for the ultimate moment. Also, lower values compared to the experimental values were under estimated for the central deflections.