Flexural performance of RC beams containing a novel, lightweight aggregate

The Institution of Structural Engineers

UNIVERSITY OF WOLVERHAMPTON
KNOWLEDGE ▪ INNOVATION ▪ ENTERPRISE

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1.0 Background

The use of a lightweight, recycled novel aggregate in concrete has the potential to improve functionality and sustainability. This is due to:

•Reducing a members self weight, the consequential size requirement of further structure to support it is reduced.

•The recycling of waste material for use as aggregate reduces the quantity of quarried natural resources and reduces landfill waste.

•Reduce energy usage heating spaces due to better insulation properties.

It is estimated that quarrying removes 300 million tonnes of material per year for use as aggregate in the UK alone. (BGS 2012)

It is estimated that 300,000 tonnes of waste EPS is produced in the UK per year, because it is so light, the volume of landfill space it takes up is considerable.

The use of polystyrene as an aggregate in concrete has been researched previously. The findings revealed issues including segregation and poor strength of hardened concrete. Attempts to find a solution to these issues, focused solely on “high technology” methods, such as chemical coatings and latex treatments which are expensive and not readily available in third world countries.

The aim of this research is to investigate the properties of concrete containing a novel aggregate. The aggregate production is “low technology” and is required to make lintels in low cost housing production. It should not segregate during mixing and should be of a structural grade.

2.0 Aggregate Production

The aggregate called Stabilite, is produced by Parry Associates by the following procedure:

1. Waste Expanded Polystyrene (EPS) is fed into a shredding machine.
2. Clayey soil lumps are crushed to a fine powder.
3. A wet cement mixture is produced
4. The outputs of steps 1 & 2 are combined, followed by the output of step 3.
5. The mixture is left to harden.
6. The product of step 5 is re-crushed into finer particles.

Waste Polystyrene

1. Shredding Machine

2. Clay Crushing Machine

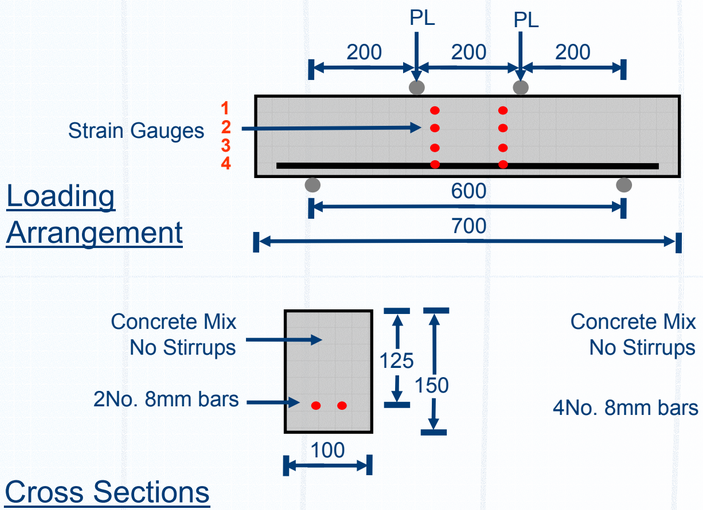
3. Cement Mixing Machine

4. The Finished Product

The aggregate was found to be 2.67 times lighter than normal aggregate. Mix proportions that were used contained coarse aggregate replacements with Stabilite from 0% to 45% by volume. The values were derived from previous research, in order to produce a structural grade concrete without the use of superplasiticisers, which would be unsuitable for developing countries. Shear links were omitted in order to reduce the cost of production, despite its potential strength improvement.

3.0 Methodology

The fresh concrete was observed for segregation whilst mixing. Two beams per mix were tested, each containing 2no. or 4no. 8mm reinforcing bars (f_y=275N/mm^2), all containing no shear links. The strain was recorded at 4 depths and deflection was recorded at mid-span as the load increased to failure. Various hardened concrete properties were also tested to give reason for performance changes, such as compressive strength of concrete.



Gauge	Depth from top surface
1	25mm
2	62.5mm
3	87.5mm
4	125mm

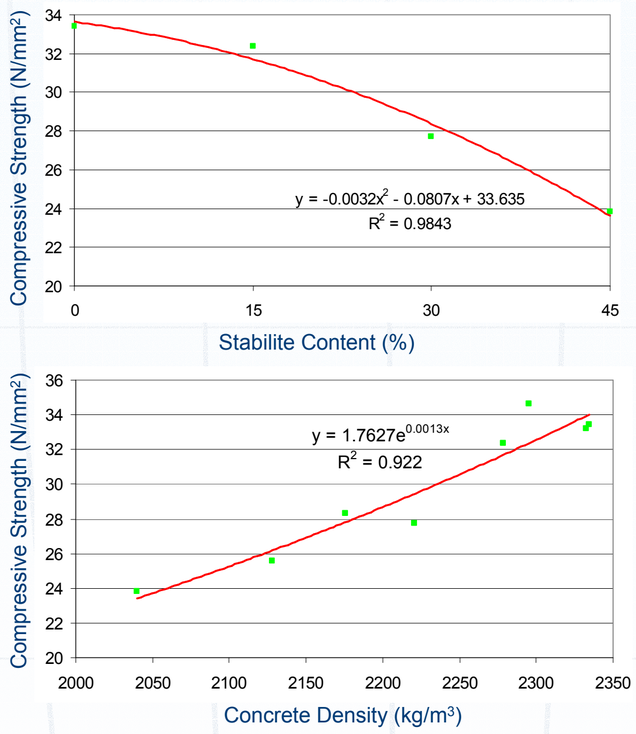
4.0 Results

4.1 Segregation

From the observations, no EPS particles floated to the surface of the fresh concrete during mixing. The photograph shows a cross section of a beam containing 45% Stabilite following failure, showing an adequate, uniform distribution of Stabilite particles throughout the depth of the beam.

4.2 Hardened Concrete Properties

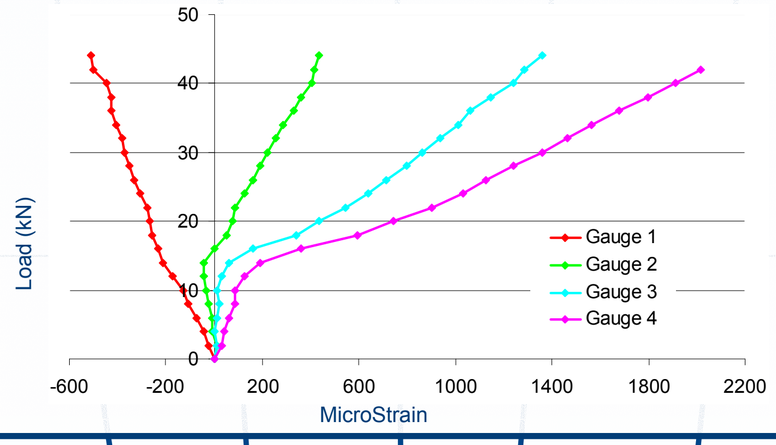
The results showed that increasing Stabilite content reduced the compressive strength and density of the concrete. A relationship was found between the compressive strength and the density of the concrete, as shown by the graph.

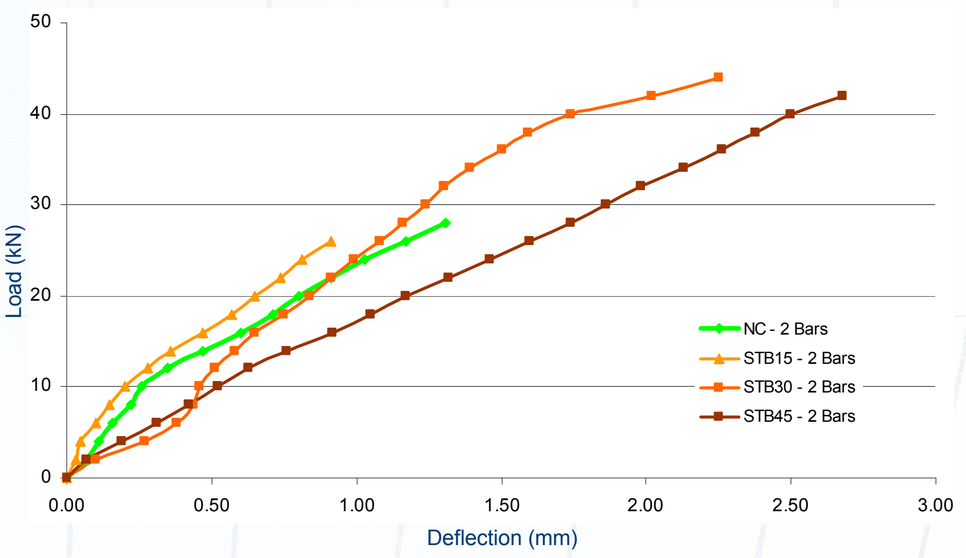


4.3 Flexural Performance

As predicted for beams containing no shear links, the beams failed through typical flexural shear, shear/ bond or diagonal tension failures.

The graph showing typical strain behaviour shows the rise of the neutral axis as the green line initially sees compressive stress, however as the load increases its turns to tensile.





As Stabilite content increased;

•The compressive strength of the concrete reduced, due to a reduction in aggregate strength.

•Deformation before failure increased. This could have been caused by a reduction in the overall stiffness of the beam as a result of a reduction in the stiffness of the aggregate.

Increasing the steel content reduced deflection, however the beams failed in shear before the full tensile strength of the bars could be utilised.

A relationship between concrete compressive strength and density, as presented in the graph.

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