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# Effect of the Fibre Geometry on the Flexural Properties of Reinforced Steel Fibre Refractory Concrete

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**Abstract**

Steel fibres are commonly used in refractory industry to reinforce high temperature concretes. Little information is available on the effect of fibre geometry on the refractory concrete and in particular to thermal shock. Eleven different melt extract fibre geometries were investigated with fibre lengths of 10 mm, 25 mm and 50 mm and aspect ratios varying from 14 to 108. Beam specimens made from a proprietary dense hydraulically bonded castable, reinforced with 5 % by weight of steel fibre, were cyclically heated and colled on one face in a specially designed spalling furnace to condition them in a simulated service environment Flexural tests were conducted at service and room temperature to obtain toughness indices. The relationship between fibre geometry and toughness indices is discussed.


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*Keywords:* Refractory concrete; Fibre; Thoughness; Temperature

## 1. Introduction

The performance of refractory concrete reinforced with short discontinuous steel fibres randomly oriented in the mix is influenced by many factors. Fibre geometry is one factor which may have a significant influence on the

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properties of steel fibre reinforced refractory concrete. Despite this fact, little information [1-5] is available on the effect of fibre geometry on refractory performance and its resistance to thermal shock.

Suppliers and users of fibre reinforced refractories have found within the relatively short life span of these materials that the 'standard' fibre sizes are cost effective and little effort has been put into optimizing the composite's performance. The industry is also naturally secretive about information that is has obtained in the fiels.

The flexural toughness is determined by considering various portions of the load-deflection relationship produced in the test. A recent review of various methods of assessing flexural toughness has been given by Johnston [6] as well as a review of the general features and methods of interpretations of results from four-point loading tests have been given recently by Gopalaratnam and Gettu [7]. The later review describes the use of various toughness measurements (energy-based dimensionless indices, energy absorption capacity, strength-based dimensionless indices, equivalent flexural strength and deflection-based dimensionless indices) in European, American and Japanese standards.

The toughness index as defined by ACI 544 [8], is a ratio of the amount of enery required to deflect a fibre concrete beam by a prescribed amount of the energy required to bring the fibre beam to the point of the first crack. Similar notions were used in the development of the ASTM C1018 [9] standard, which , based on the work of Johnston [6], evaluates the flexural toughness of fibre reinforced concrete in terms of areas under the load-deflection curve obtained by testing a simply supported beam under three-point loading. This test method provides for the determination of a number of ratios that serve as toughness indices which identify the pattern of material behaviour up to the selected deflection criteria. The indices are determined by dividing the area under the load-deflection curve up to a specific deflection criterion by the area up to the deflection at which first-crack is deemed to have occured.

The main aim of the present study is to investigate the influence of the geometry of AISI 310 grade stainless steel melt extract fibres on the toughness indices of a proprietary 1400 °C medium duty calcium aluminate bonded castable. The work examine whether it is necessary to obtain toughness measurements at temperature in order to properly evaluate the performance of fibre reinforced refractories or whether it is possible to obtain meaningful results from a simpler room temperature test.

## 2. Materials

### *2.1. Refractory concrete*

A general duty refractory castable, 'Pinnacast 1400', was used throughout the test program. This is a proprietary hydraulically bonded material containing 37% alumina with a maximum service temperature of 1400°C. The water content of each the fifteen mixes was approximately 14% by weight of dry material. The chemical analysis for the material was given in Table 1.

### *2.2. Steel fibres*

All fibres used throughout this study were stainless melt extract fibres. The average fibre density $\rho_f$ of the AISI grade 310 (25% Cr, 20% Ni) was 7.89. The fibre content was fixed at 5% by weight of dry castable. Fibre geometries of the eleven types of ME310 fibre used to evaluate the effect of fibre aspect ratio and fibre diameter on toughness index are given in Table 2, while Table 3 gives the three types used to investigate the influence of fibre length on the toughness index measured in hot and cold conditions.