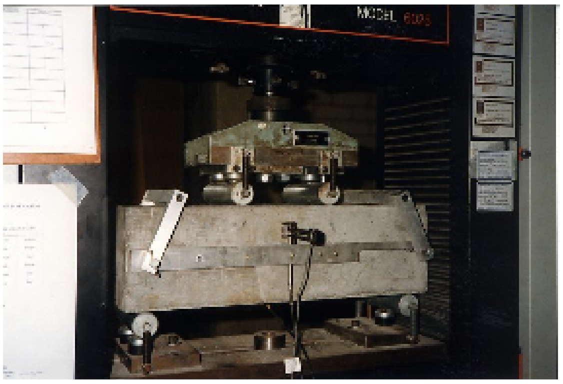
BOSFA A1 Chart Explanation

The two charts shown are produced from laboratory tests intended to establish the material properties of fibre reinforced concrete. Pictures of two typical test setups are shown below:-

Beam Test



Round Determinate Panel (RDP)

Despite the different geometry of the test specimens they are both statically determinate. Hence, when the flexural tensile strength, or modulus of rupture, of the concrete matrix is reached, either a single crack, in the case of the beam, or three simultaneously forming cracks in the case of the RDP, develop. Once these cracks have developed the ability of the element to carry load is determined solely on the basis of the cumulative effect of the fibres bridging the cracks and hence the reinforcing properties of the particular fibre used. Typically this performance is reported in the form of a load versus deflection graph (shown over) from which an engineer can then design fibre reinforce concrete (FRC) structures using the recommendations provided in either National Concrete Standards or, where these are not yet developed, publications from learned societies, typically being National Concrete Societies.

It is important to realise that all the current design recommendations for FRC are based on STEEL fibres only and even though the same design values can be theoretically determined for synthetic fibres, to date no specific design rules for structural load carrying capacity have been published anywhere for either Micro or Macro synthetic fibres. It is also important to realise that even when no determination of the load carrying capacity for FRC is required e.g. when the fibres are just added for crack control, in say a slab on grade, the different load /deflection response characteristics of Steel and Macro or Micro synthetic fibres can result in markedly different crack patterns and widths.

There are a few very good technical reasons why the design rules developed for steel fibres over more than 30 years of technical R&D cannot be simply used for design with either macro or micro synthetic fibres. The first, and most pertinent, relates to the serviceability of a finished FRC structure in terms of crack widths, deflections and rotations. Steel fibres, with an elastic modulus of 200,000MPa pick up load a lot faster and reach their peak load carrying performance at significantly smaller crack widths, deflections and rotations than can be achieved with either micro of macro synthetic fibres that are currently in the market. This has been effectively highlighted for both the Beam and RDP tests by the simple expedient of showing the relationship between deflection and crack width for the two tests. The macro synthetic fibres used in the tests were quite typical of what is currently available commercially by being made from polypropylene and having an elastic modulus in the region of 3-5,000MPa.

Other properties of macro synthetic fibres that will need to be addressed before suitable design rules can be formulated are:-

1. Performance in Fire – macro synthetic polypropylene fibres melt at around 160^0C compared to steel fibres which melt at approximately 1130^0C.
2. Creep – macro synthetic fibres, although similar to steel in terms of geometry, differ from steel fibres that behave elastically under load in that their behaviour is inherently elasto-plastic, meaning that under a sustained load they continue to strain. Consequently crack widths, deflections and rotations may significantly increase over time, dependent on the level of stress carried by the fibres. Fibre rupture and hence structural failure can also be a possibility, even after many months of increasing creep strains.