

Readymixed Production of Scanfibre Reinforced Concrete

INTRODUCTION

It would be possible to make a high performance steel fibre totally unsuited to practical application in concrete. In fact such fibres created considerable problems in the pioneering days of SFRC (steel fibre reinforced concrete). High aspect ratio (ie long & thin) fibres were developed to give high performance but when added to the concrete 'balling' often occurred.

Scanfibres have high aspect ratio and are collated (ie glued together like staples, figure 1). The latter makes them simpler to use than loose fibres but the method of addition is different. Failure to follow the correct mixing procedure can still lead to problems.



Fig 1 – Collared Scancem Fibres

MIX DESIGN

For SFRC ACI Committee 544 (1993) suggests the following:

- Increase paste content to obtain improved workability, possibly by employing pozzolans such as fly ash, slag or silica fume in addition to, or as a replacement for cement.
- Limit coarse aggregate to 55% of total aggregate
- Keep coarse aggregate size to 19mm maximum
- Keep w/c low. A value as low as 0.35 is quite possible. It should not go above 0.55.

More specific recommendations for Scanfibre reinforced concrete based on Scancem's experience are:-

Minimum cement content of 300kg/m³

Ensure a reasonable sand content

(0-4mm). Around 750-850kg/m³ is typical

Table 1:- Maximum Dosage of Scanfibre(kg/m³)

| Max Agg Size | Aspect Ratio | | | | | |
|--------------|--------------|-------------|-------------|-------------|-------------|-------------|
| | 60 | | 75 | | 100 | |
| | Workability | Pumpability | Workability | Pumpability | Workability | Pumpability |
| 4mm | 160 | 120 | 125 | 95 | 95 | 70 |
| 8mm | 125 | 95 | 100 | 75 | 75 | 55 |
| 16mm | 85 | 65 | 70 | 55 | 55 | 40 |
| 32mm | 50 | 40 | 50 | 30 | 30 | 25 |

Minimum characteristic compressive strength of 25MPa.

Workability

SFRC appears relatively stiff and unworkable compared to conventional concrete. However, when vibrated, the thixotropic mix flows quite well. Additional water should not be added as it may only improve slump, not real workability, and it will certainly have a negative affect on concrete performance. Any problems with workability should be overcome by the use of plasticisers.

The consistency of steel fibre reinforced concrete can be measured using the inverted slump cone method (ASTM C995). The time taken for a vibrator to fall under its own weight through an inverted slump cone full of uncompacted concrete is measured. Values between 10 and 30 secs are recommended. When the standard slump cone test (ASTM C143) is used, values of 25mm-100mm are recommended, ref ACI Committee 544 (1993).

Edgington (1974) suggests that the V.B. consistometer test is a better measure of workability of SFRC as it simulates in some respects the compaction of concrete by vibration. Results from his tests for uncollated fibres show the very large effect of aspect ratio and fibre volume on workability. The critical fibre content for each aspect ratio beyond which response to vibration rapidly decreases can be assessed from the curves he presents. Using this approach for Scanfibre, the maximum quantity of fibres for workability is defined in Table 1.

Experience suggests that if a normal concrete's slump of 100mm gives a suitable workability Scanfibre concrete with a 120mm slump before addition of 40kg/m³ of 60mm long fibres will give a similar workability, but a slump of 70-80mm.

Pumping

SFRC is generally well proportioned for pumping and has been reported to pump with less trouble than normal concrete even though it may appear stiff and unworkable. However, squeeze concrete pumps should be used with caution. This type of pump has been used to pump 100m horizontally with a slow bend using 100mm pipe. The mix had 40kg/m³ of Scanfibre.

Based on response to vibration criterion (Edgington 1974) for Scancem SFRC, recommendations for the maximum quantity of fibres for pumping are defined in Table 1.

ACI Committee 544 (1993) recommends:

- Use large diameter line, preferably 150mm(100mm is common in Australia).
- Avoid flexible hose.
- Use a screen on the pump hopper to help prevent balling (50-75 mesh) [Scancem Materials recommend vibration of such screens and to drop the concrete from 0.5m onto the screen in order to avoid bridging]
- Don't pump SFRC that is too wet. The paste will be squeezed out causing a fibre plug.

FIBRE ADDITION

Uncollated (Loose) Fibres

Uncollated fibres have a tendency to ball, particularly at high aspect ratios (>45) hence ACI Committee 544 (1993) recommends:

- Avoid over-mixing to minimise balling
- Add fibres to a fluid mix through a 100mm mesh screen to ensure no clumps are incorporated. Use conveyor belts or chutes as appropriate.

- Alternatively add the fibres to the aggregate as it travels along the conveyor belt. (NB fibres should be 'sprinkled')

Scanfibre Collated (Glued) Fibres

Scanfibres are glued into bundles, making the dosing and mixing process easy and reliable. Scanfibres should never ball, despite high dosages and their high (65-80) aspect ratios, provided the mixing procedure is correct.

The glue is softened by the mixing water. Hence, it is important that the fibres are added at the correct time in the mixing sequence.

The most important thing to remember is not to add Scancem steel fibre before aggregates.

There are three ways of mixing Scanfibre reinforced concrete:

1. Adding Scanfibre to the Weigh hopper

Scanfibre can be added like an extra aggregate, directly to the weighing hopper. This can be achieved by loading bags into a front end loader. The fibre should be added between the sand and coarse aggregate.

Figure 2 shows the bags of fibre being opened and emptied into the front end loader.

The combined materials are added to the truck and mixed as normal. No extra mixing time is required.

2. Adding Scanfibre at the Conveyor

If the conveyor belt that feeds the truck is accessible, Scanfibre can be added to the moving conveyor belt during or after adding the aggregates (Figure 3). No extra mixing time is required.

3. Adding Scanfibre to the Truck

Scanfibre can be added at the slump stand or on site after all other mix components have been batched (Figure 4):

Scanfibres should be added while the truck is rotating at full mixing speed (ie. ≥ 12 rpm).

The following are the maximum fibre addition rates:-

<65MPa concrete - 60 kg/min

>65Mpa concrete - 40 kg/min

There is no need to open the degradable bags.

When mixing at the plant allow 5 minutes after fibre addition before discharge.

When adding at site rotate the truck at mixing speed for an extra 5 minutes after all bags have been added.

Fibres with an aspect ratio of less than 50 or collated fibres can be added to the mix as the last step with no likelihood of fibre balling.

HANDLING

Steel fibres are packed in degradable bags (Figure 5) with up to 1200kg on each pallet. They can also be supplied in bulk bags for automated systems.

It's common to use mechanised equipment to help lift the fibres into the truck mixer. Conveyors are frequently used but in confined spaces a "step ladder" (Figure 6) that incorporates a motor pulling a small fibre bin that empties into the gob hopper has proven efficient for collated fibres.

Automated Systems - At least two manufacturers make automated dosing equipment (Fig 6). In both cases the fibres are loaded into a bin and vibration is used to shake the fibres out. Weight loss from the bin can be used to automate the batching system. These systems work well for collated fibres but the addition rate slows for loose fibres and may make its use impractical. The equipment is expensive and is only suited to batchers where a high through put is expected.

Fig 3 – Conveyor Belt



Fig 4 – Adding to a Truck Mixer



Fig 5 – Scanfibre Degradable Bags



Fig 6 – Automated Dosing Equipment



Fig 2 – Front End Loader



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