

Steel fibre reinforced cement flat sheets

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The paper describes an investigation carried out to produce steel fibre reinforced cement flat sheets for use as wall claddings, partitions, etc. The results obtained show that sheets of size 1800 × 900 × 6mm, having properties comparable to asbestos cement sheets can be produced by using neat cement and cement-sand mix of 1:0.5 to 1.0 proportion by weight, and 5 per cent steel fibre of aspect ratio (length to diameter ratio) 74. A predesign tentative estimate of production cost is given and the production of the sheets at a cottage industry level is suggested.

Fibre reinforced cement composites and concretes have been a subject to extensive investigations in various countries for the past many years^{1,2,3}. As a result a variety of building materials have been produced using different types of mineral, organic or metallic fibres. Research and development work on the production of building materials using steel fibre was taken up at Central Building Research Institute in the year 1975. An account of the work done on steel fibre reinforced concrete roofing units such as cellular concrete units and doubly curved concrete tiles has already been published in the *Indian Concrete Journal*⁴. The work described here, pertains to the production of thin steel fibre reinforced cement flat sheets for use as wall claddings, partitions, etc.

Materials used

(i) *Portland cement*: It conformed to IS:269-1976 for ordinary portland cement⁵.

(ii) *Steel fibres*: The steel fibres were prepared by cutting mild steel binding wire of 0.5-mm diameter. The tensile strength and aspect ratio (length to diameter ratio) of the fibre was 6108Kg/cm² and 74 respectively.

Casting of sheets

Steel fibre reinforced cement flat sheets of size 1800mm × 900mm × 6mm were cast by hand on a hard, smooth and non-absorbant base. The amount of steel fibres used was 5 percent by the weight of cement. The steel fibres were sandwiched between two layers of cement paste. The water cement ratio was kept at 0.3. The sheets were lifted from the base after 24 to 48 hours of moist curing and placed under water in a curing tank for 10 days. After taking out of the water, the sheets were stacked in a shed to complete a minimum curing period of 28 days after casting. Fine sand having fineness modulus of 1.1 was also used to bring down the cement consumption.

Testing of sheets

These sheets were tested for load bearing capacity, water absorption, water impermeability and density by following the methods specified in IS:5913-1970⁶.

The incidence of corrosion of steel fibres in the sheets was tested by exposing test specimen to (i) natural weathering and (ii) alternate wetting and drying cycles. One cycle of alternate wetting and drying lasted for 24 hours and consisted of wetting test specimens by immersion under water for 6 hours, drying for 1 hour in air and 16 hours in an oven at 55 ± 2°C and cooling for 1 hour.

Properties of sheets

The properties of steel fibre reinforced cement sheets are shown in Table 1. There is at present no Indian standard specification for such sheets. The data given in Table 1 can, therefore, be best evaluated on the basis of IS specifications on asbestos cement sheets. As no pressure was applied during casting, the steel fibre reinforced cement sheets were classified as uncompressed sheet and evaluated as described below.

Transverse strength: From the data in Table 1, it can be seen that the sheets made from neat cement paste conform to the requirements specified in IS:2096-1966⁷ for uncompressed asbestos cement flat sheets. The addition of sand to the cement paste decreased the strength of the sheets. The effect was, however, marginal upto 50 percent addition of sand and the strength of sheets produced using a paste of cement-sand mix of 1:0.5 proportion, by weight, remained above the specified minimum value of 160 Kg/cm². In terms of IS:2098-1964⁸, the breaking load of the sheets produced using a paste of cement-sand mix of 1:1 proportion, by weight, is still well above the specified minimum value of 20 Kg for class A boards.

TABLE 1 Properties of steel fibre reinforced cement sheets

Properties		IS requirements for asbestos cement sheets
1. Transverse strength, kg/cm ² Neat cement	172.5	IS: 2096-1966 160 kg/cm ²
	170.5	minimum for uncompressed sheets
Cement-sand, 1:1 pro- portion, by weight	134.4	
2. Breaking load, kg. Neat cement,	46.01	IS: 2098-1964
	45.47	20kg, minimum, for class 'A' boards
Cement-sand, 1:1 proportion, by weight	35.84	
3. Water absorption, percent Neat cement,	16.4	IS: 2096-1966
	20.5	28 percent maximum
Cement-sand, 1:1 proportion, by weight	26.5	IS: 2096-1964 40 percent maximum
4. Water impermeability Neat cement	nil	IS: 2096-1966
	nil	no drop of water should appear on lower side during 24 hours of test.
	Cement-sand, 1:1 proportion, by weight	nil
5. Density, kg/cm ³ Neat cement	1.69	IS: 2096-1966 1.2 for uncom- pressed sheet

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Water absorption: The water absorption of the sheets ranged from 16.4 to 26.5 percent as the material changed from neat cement paste to a paste of cement-sand mix of 1 : 1 proportion, by weight, *Table 1*. This is well below the maximum limit of 28 and 40 percent specified in IS:2096-1966 and IS:2098-1964, respectively.

Water impermeability: The sheets did not show any water permeability and no drops of water on the lower side could be detected during 24 hours of test. In fact, even traces of moisture on the lower side were not visible.

Density: Steel fibre being itself heavier than asbestos, the density of the steel fibre reinforced cement sheets was found to be 1.69kg/cm³ as against a minimum value of 1.2kg/cm³ specified for uncom-pressed asbestos cement sheet.

Corrosion of steel fibres: No rust spots formed on the surface of test specimens exposed to natural weathering for over 2½ years and 200 cycles of alternate wetting and drying. The steel fibres which were sandwiched between two layers of the paste of neat cement or cement sand mix of 1 : 0.5 and 1 : 1 proportion, by weight, thus remain well protected against corrosion.

Conclusion

The work described above leads to the conclusion that steel fibre reinforced cement flat sheets of size 1800 mm×900mm×6mm and suitable for use as wall claddings, partitions, etc., can be produced using 5 percent steel fibre of diameter 0.5mm and aspect ratio 74 by weight of cement. A cement-sand mix of 1 : 0.5 or 1 : 1 proportion, by weight, can be used in place of neat cement paste. The production of these sheets can be taken up at a cottage industry level. An estimate of capital investment and cost of production is given in *Appendix 1*.

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APPENDIX 1

Pre-design cost estimates for the production of steel fibre reinforced cement flat sheets:

Basis: 7200 sheets per annum assuming 300 working days.

1. Capital investment		Rupees
fixed capital on land and building		56,300
fixed capital on plant and accessories		35,700
working capital: 20% of Annual sales:		
(i) neat cement sheets		63,360
(ii) cement-sand (1:1) sheets		52,720
2. Cost of production:		
neat cement sheets		278,765
cement-sand (1:1) sheets		242,640
3. Profitability		
neat cement sheets:		
Gross annual income (sales) 7200 sheets @ Rs 44/- a sheet		316,800
return on total capital investment		24.48 percent
cement-sand (1:1) sheets:		
gross annual income (sales) 7200 sheets @ Rs 38/- a sheet		273,600
return on total capital investment		21.10 percent