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RESEARCH ARTICLE

EVALUATING THE STRENGTH BEHAVIOUR OF CONCRETE BY USING COIR FIBRE AND ALCCOFINE AS PARTIAL REPLACEMENT OF CEMENT

***Mahesh, S. M. and Ravi Chandra, S.**

East Point College of Engineering and Technology, Bangalore, Karnataka, India

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ABSTRACT

The main objective of this work is to analyse the situation and behavior of M30 grade concrete with proportion 1:1.6:2.6 with 0.45 w/c. Here cement is partially replaced by 5%, 10%, 15% of alccofine by weight of cement also addition of coir fibre in percentage of 0.5%, 1%, 1.5% by weight of cement is used to produce M30 grade concrete. Aspect ratio (l/d) of coir fibre used is 125. Compression strength test, flexural strength test and split tensile strength tests are conducted according to guidelines of BIS. The tests were compared with the normal concrete. Due to addition of coir fibre and alccofine compression strength, tensile strength, and flexural strengths are increased. The high results were obtained at a percentage of 10% of alccofine with 1% of coir fibre.

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INTRODUCTION

Natural fibres are the reinforcing materials which are obtained at low cost and low levels of energy using local manpower and technology. The utilization of natural fibres as a form of concrete enhancement is a major interest to less developed regions where the conventional construction materials are not readily available and are too expensive. One of the suggestions in the forefront has been the sourcing, development and use of alternative, non-conventional local construction materials including the possibility of using some agricultural wastes as construction materials. The demand of better concrete is increasing day by day. Improved quality of concrete will only perform better if concrete improves workability, durability, flow ability and resistance to chemical attack corrosion and reduce w/c ratio, heat of hydration and segregation mainly. For the fulfillment of above properties waste produced from the steel and other industries are used for effective and efficient strength and durability of concrete. There are many waste products which are generated from industries and factories, dumped openly which cause environmental problems and also spread disease. These waste products can be recycled in useful way to save the environment. These waste material or so called by-product are fly ash, silica fume, ground granulated blast furnace slag and Alcoofine which are being reused now a days in construction industries mainly by making few stabilized changes in these waste materials. In present days some waste material are used to produce efficient and effective concrete as blending material or mineral admixture. Most common and known blending materials or mineral admixture used in concrete production industries are marble powder, silica fume, fly ash, ground granulated blast furnace slag and new by product admixtures Alcoofine which is glass based and take from iron factories. This is due to the fact that recycling of industrial wastes as blending materials has technical, economical and environmental benefits. Containing mineral admixtures within pozzolanic concretes are used extensively throughout the world for their good performance and ecological and economic reason and the applications of such concretes are increasing day by day due their superior structural performance, environmental friendliness and energy conserving implications. Mineral admixture, super plasticizers and retarders etc are playing effective role for high performance of concrete industries, a mineral admixtures which performs in superior manner than all admixture used in India is Alccofine 1206 has been added into OPC which varies from 5% to 15% at internal of 5% by total weight of OPC and partial replacement of OPC by Alccofine 1206 which varies from 5% to 15% at the interval of 5% by weight of OPC for M30 grade of concrete.

Corresponding author:* **Mahesh, S. M.
East Point College of Engineering and Technology, Bangalore, Karnataka, India.

About coir fibres

Coir or **coconut fibre**, is a natural fibre extracted from the husk of coconut and used in products such as floor mats,

doormats, brushes and mattresses. Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut. Other uses of brown coir (made from ripe coconut) are in upholstery padding, sacking and horticulture. White coir, harvested from unripe coconuts, is used for making finer brushes, string, rope and fishing nets. Coir fibres are focused as one of the substitution for natural plant fibres having many of the advantages such as low cost, low density, ecologically friendly, sustainability, biodegradability.. Coir in comparison with other natural fibres ecofriendly with high growth rate and fixing the carbon dioxide of atmosphere, which makes it most important plant fibres.

Structure

Coir fibres are found between the hard, internal shell and the outer coat of a coconut. The individual fibre cells are narrow and hollow, with thick walls made of cellulose. They are pale when immature, but later become hardened and yellowed as a layer of lignin is deposited on their walls. Each cell is about 1 mm (0.04 in) long and 10 to 20 µm (0.0004 to 0.0008 in) in diameter. Fibres are typically 10 to 30 centimetres (4 to 12 in) long. The two varieties of coir are brown and white. Brown coir harvested from fully ripened coconuts is thick, strong and has high abrasion resistance. It is typically used in mats, brushes and sacking. Mature brown coir fibres contain more lignin and less cellulose than fibres such as flax and cotton, so are stronger but less flexible. White coir fibres harvested from coconuts before they are ripe are white or light brown in color and are smoother and finer, but also weaker. They are generally spun to make yarn used in mats or rope.The coir fibre is relatively waterproof, and is one of the few natural fibres resistant to damage by saltwater. Fresh water is used to process brown coir, while seawater and fresh water are both used in the production of white coir. It must not be confused with coir pith, or formerly cocopeat, which is the powdery material resulting from the processing of the coir fibre. Coir fibre is locally named 'coprah' in some countries, adding to the confusion.

Figure 1. Coir fibre

Advantages of Coir fibres

Fibres, which are randomly distributed throughout the concrete, can overcome cracks and control shrinkage more effectively. These materials have outstanding combinations of strength and energy absorption capacity. In general, the fibre reinforcement is not a substitution for steel reinforcement where the fibres and steel reinforcement has their own role in concrete technology. Fibres are more closely spaced in concrete than steel reinforcement, which are better in controlling crack and shrinkage, where as fibres are more effective in crack control.

- Coir fibre is a naturally available material which can compare with glass fibre because of its characteristic properties.
- Coir fibres are locally available material at low cost.
- Coir fibres having low density, eco friendly, sustainability and biodegradability as compared to other natural plant fibres.
- Coir fibre reinforced concrete can be a total cost effective.
- Coir fibres proved to have the potential to increase the post-cracking energy absorption capacity of cement based materials, enhancing the ductile character of concrete structures behaviour.

Coir fibre Extraction

Table 3.6. Typical properties of coir fibre

Colour	Brown
FIBRE LENGTH, mm	10-200
FIBRE DIAMETER, mm	0.2-0.35
BULK DENSIT, kg/m3	140-150
ULTIMATE TENSILE STRENGTH, N/mm2	80-120
MODULUS OF ELASTICITY N/mm2	18-25
WATER ABSORPTION, %	30-40

The traditional method of coir fiber extraction from the coconut husk is retting, a laborious and time consuming process and often results in the pollution of the environment. However, this natural retting process yields fiber, which is strong and has a golden colour. This is due to the leaching out of deleterious matter by the constant tidal action. Defibering of husk is carried out traditionally by soaking in backwaters, which require 10-12 months. Novel development using biotechnological approach with selected strains of microbial cultures *viz.,* 'Coirret' developed by Central Coir Research Institute (Coir Board) has reduced the period of retting from 11 months to 3 months. The traditional coir industry in the state of Kerala is facing an acute crisis of fibre shortage. For some time, it has been depending on the green husk fibre, the major part of which is brought from the neighbouring states. The industry feels that there is an untapped stock of husks in the rural areas from where collection of husk is difficult and on-site defibering is not possible. Therefore the coir fibre can be extracted through MFEM (Mobile Fibre Extraction Machine) developed by the Coir Board that could be taken to the remote villages so that unutilized husks from such areas could be tapped and fibre could be made available to the coir industry. The time required for the extraction of fibre by MFEM is only for a few seconds and the problem of polluting backwaters can be eliminated by the new technology. However despite the advantage of yielding coir fibre in a short span of time, the

greatest disadvantage of the mechanically extracted fibre is its inconsistent colour and harsh texture. Obviously environmental pollution and occupational health hazard from traditional husk retting for coir extraction have been a serious concern not only to general public but also to labours involved in the retting work.

Figure 3.1. Traditional extraction of coir fibre

Figure 3.2 Mobile Fibre Extraction Machine (MFEM)

Quality Improvement of Coir Fibre

A successful cleaner, faster and eco friendly technology of bleaching and softening of coir using "Biochem" has been developed by Coir Board through its Central Coir Research Institute and is being popularized among coir entrepreneurs. Biochem is a consortium of phenol degrading bacteria grown in softer media (Tamarind extract & Auxisoftener) and the treatment of coir fibre with selected strains of bacterial cultures in Biochem solution yielded a fibre exhibiting a higher degree of light fastness and a softer feel which is advantageous. The advanced technology of "Biochem" treatment for quality improvement of machine extracted coir fibre is carried out in open areas on a tarpaulin sheet. It is a zero-effluent process and cost effective.

Figure 3.3. Biochem Solution

Materials used and their properties

The materials used in the present experimental programme are as follows:

- Ordinary Portland Cement (53 grade)
- Sand (zone 2 as per IS 383:1970)
- Coarse aggregate (as per IS 383:1970)
- Bamboo fibre (l/d has to fix) naturally extracted.

(a) Cement (53-grade OPC): The cement consists of preliminary percentage of silicates and some percentage of lime aluminates. On this experiment 53-grade ordinary Portland cement manufacturer Adithya birla was used for the all mixes. The cement used was contemporary with none lumps.

(b) Coarse aggregates: Locally available crushed granite aggregate which are passing from the IS sieve size of 20 mm and which are retaining in the IS sieve size of 12.5 mm are to be generally used for the construction. The coarse aggregates used were confirming to IS 383:1970. The highest size and grading of the aggregates depends on the special applications.

(c) Fine aggregates: Locally available high quality sand gathered from river bed, that should be pass from IS sieve 4.75mm and the same will be for all of the mixes of concrete. The fine aggregate which is having fineness modulus 2.81 is used were confirming to zone II according to IS code.

(d) Water: Generally, cement requires about 3/10 of its weight of water for hydration. Water is an important ingredient of concrete as it actively participates in chemical reaction with cement. It also improves the workability. Since it helps to form the strength giving cement gel, the quantity and quality of water required is to be looked carefully. Some specification also accepts water of pH value between 6 and 8 for making concrete but water has to be free from organic matter.

(e) Alccofine: It is one type of special material which is produced based on the content of slag which almost contain the maximum content of glass which is formed because from the high reactivity and by the granulation process. These materials are formed by the composition of fewer silicates of calcium. The distribution of size of particles will be done based on the ingredients present in it. Due to the accurate procedure of this distribution of particle size this alccofine gives the greater results and reduces the content of water. So alccofine mainly called as a water reducing agent. This may also use up to 70% of replacement in the concrete which replaces the cement. So that Alccofine 1203 is almost used as a water reducer and it will gives the greater workability results.

Advantages of Alccofine 1203

In fresh state

- The workability of the mix retention is improved.
- Flowability of the mix is increased.
- Reduction in segregation can be observed in the mix.
- Reduction of heat of hydration of the mix.

In hardened state

- Improvement in durability of the mix.
- Resistance to AAR is increased.
- Strength at all edges is increased.
- Resistance to chemical attack/corrosion is improved as ingression becomes difficult.
- Lowers permeability of the mix.

Applications of Alccofine 1203

- Bridges.
- Roads and Airports.
- High rise buildings.

Table 1. Chemical composition of Alccofine

CaO	SiO_2	SO_3	Al_2O_3	Fe_2O_3	MgO	Cl
61-64	21-23	2-2.4	5-5.6	3.8-4.4	0.8-1.4	0.03-0.05

Properties of Alccofine 1203

Table 1.1 Physical properties

Analysis	Alccofine1203
Bulk density(kg/m3)	600-700
Particle shape	Irregular
Average particle size(microns)	4-6
d10	1-2
D50	4-5
D90	8-9
Specific Gravity	2.9
Fineness (cm2/gm)	12000

Necessity of Alccofine are

- Durability is improved.
- Strength gain is improved.
- Improves the workability and cohesiveness.
- Better retention of workability.
- Reduces segregation.
- Lowers the heat of hydration.
- Improves the flow ability.
- Many detoriating effects such as corrosion, carbonation and sulphate attack may be minimized or stopped.

Figure 2.1. Alccofine

Test Methods

Hardened properties tests for concrete

a) Compressive strength test: As per IS 516-1959, Cubes0of size 150 x 150 x 150mm were cast to evaluate the compressive strength of concrete. A test result is the average of at least three standard cured specimen. The maximum strength is at 28 days after curing. The compressive stress calculated in Kg/cm2 from the maximum load sustained by the cube before failure.

Compressive strength (fc) = P/A

Where, P = load at failure in kg and

A = surface area of bearing cube in cm^2

b) Flexural strength test: Concrete is weak in tension and strong in compression. Reinforced concrete members, little dependence is placed on the tensile strength of concrete since steel reinforcing bars are provided to resist all tensile forces. As per IS 516-1959,a beam of size 150 x 150 x 700mm is found dependable to measure flexural strength properties of Self Compacting Concrete (SCC). Flexural strength expressed as modulus of rapture ff in kg/cm^2 is calculated as:

Modulus of rapture, ff = Pl / (bd^2)

Where, P is the maximum load at failure in kg, L specimen length in cm, B specimen width in cm and d is the depth of the beam specimen.

RESULTS AND DISCUSSION

Compressive Strength

Table 4.1.1 Results of compressive strength Aspect ratio (l/d) 125 0.5% fibre

No	% of alccofine	Compressive strength	
		7 days	28 days
1	0%	24.88	37.11
2	5%	27.77	38.00
3	10%	30.88	40.66
4	15%	29.32	39.11

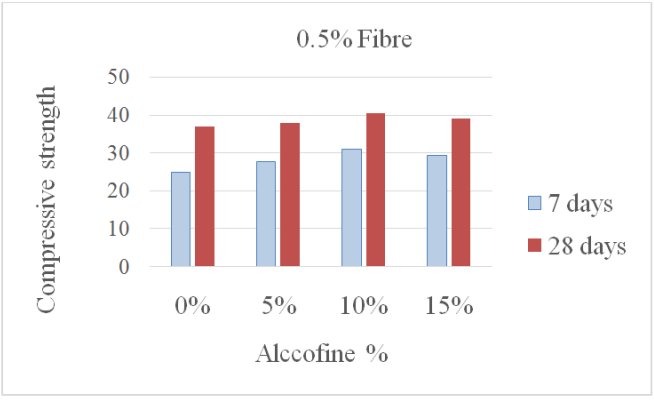

Figure 4.1.1 Compression strength of 0.5% Fibre

Table 4.1.2. Results of compressive strength Aspect ratio (l/d) 125 1% fibre

No	% of alccofine	Compressive strength	
		7 days	28 days
1	0%	23.33	35.78
2	5%	24.66	37.77
3	10%	27.33	40.22
4	15%	26.00	39.11

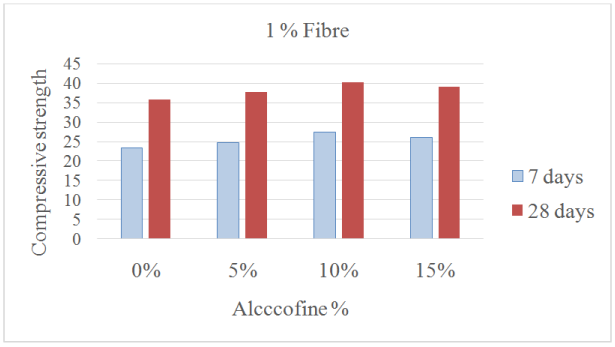

Figure 4.1.2 Compressive strength of 1% Fibre

Table 4.1.3 Results of compressive strength Aspect ratio (l/d) 125 1.5% fibre

No	% of alccofine	Compressive strength	
		7 days	28 days
1	0%	19.78	32.66
2	5%	20.66	33.55
3	10%	22.44	36.22
4	15%	21.55	34.89

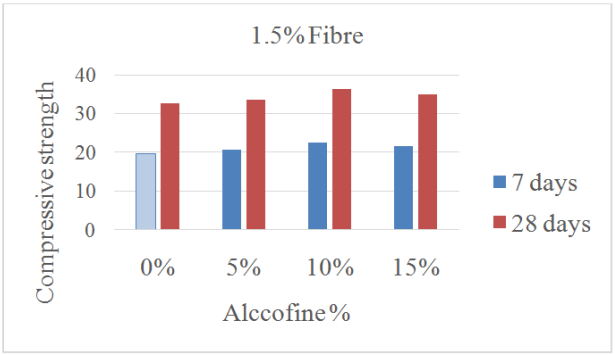

Figure 4.1.3 Compression strength of 1.5% Fibre

Split Tensile Strength

Table 4.2.1 Results of compressive strength Aspect ratio (l/d) 125 0.5% fibre

No	% of alccofine	Split tensile strength	
		7 days	28 days
1	0%	3.04	4.6
2	5%	3.46	4.88
3	10%	3.81	5.72
4	15%	4.10	5.37

Table 4.2.2 Results of Split tensile strength Aspect ratio (l/d) 125 1% fibre

No	% of alccofine	Split tensile strength	
		7 days	28 days
1	0%	3.39	4.88
2	5%	3.67	5..16
3	10%	4.55	5.87
4	15%	3.95	5.44

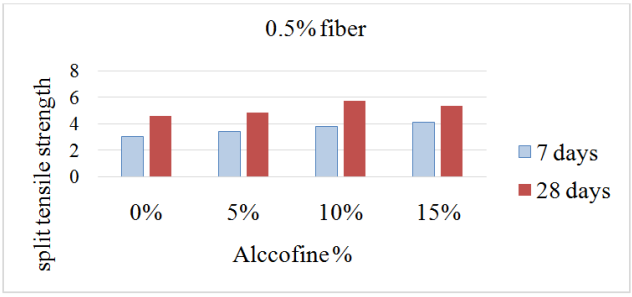

Figure 4.2.1 Split tensile strength of 0.5% Fibre

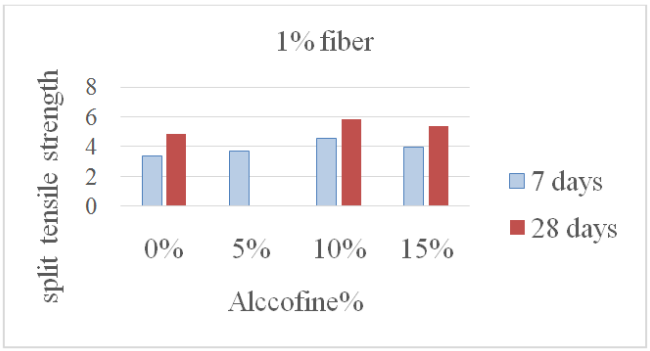

Figure 4.2.2 Split tensile strength of 1% Fibre

Table 4.2.3 Results of compressive strength Aspect ratio (l/d) 125 1.5% fibre

No	% of alccofine	Split tensile strength	
		7 days	28 days
1	0%	3.04	4.74
2	5%	3.53	4.95
3	10%	4.17	5.44
4	15%	3.89	5.16

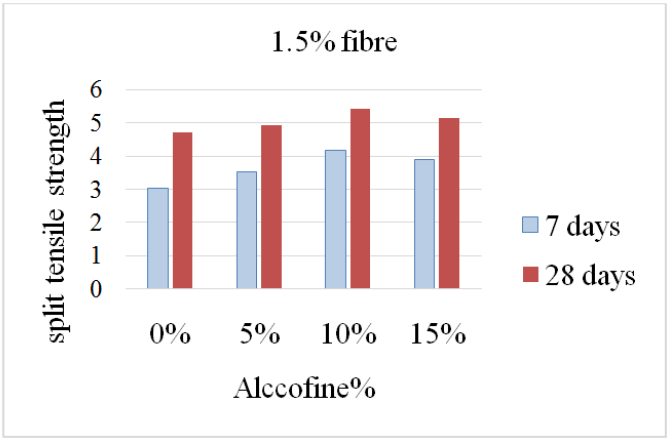

Figure 4.2.3 Split tensile strength of 1.5% Fibre

Flexural strength

Table 4.3.1 Results of flexural strength Aspect ratio (l/d) 125 0.5% fibre

No	% of alccofine	Split tensile strength	
		7 days	28 days
1	0%	7.65	11.92
2	5%	8.10	12.82
3	10%	9.67	14.17
4	15%	9.00	13.27

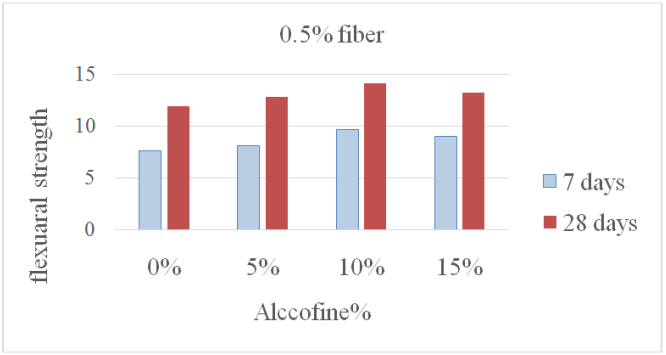

Figure 4.3.1 flexural strength of 0.5% Fibre

Table 4.3.2 Results of flexural strength Aspect ratio (l/d) 125 1% fibre

No	% of alccofine	Split tensile strength	
		7 days	28 days
1	0%	9.67	13.27
2	5%	10.57	14.17
3	10%	12.37	15.97
4	15%	11.43	15.07

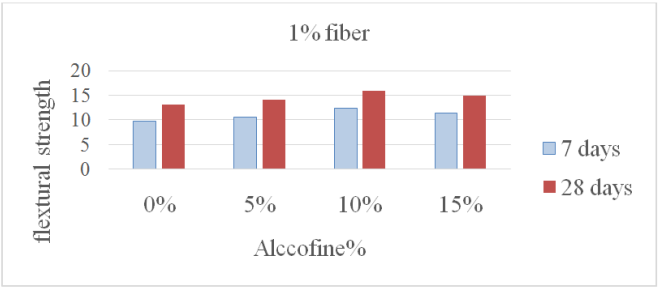

Figure 4.3.2 flexural strength of 1% Fibre

Table 4.3.3 Results of flexural strength Aspect ratio (l/d) 125 1.5% fibre

No	% of alccofine	Split tensile strength	
		7 days	28 days
1	0%	6.97	12.82
2	5%	7.87	13.72
3	10%	9.72	14.62
4	15%	8.77	14.17

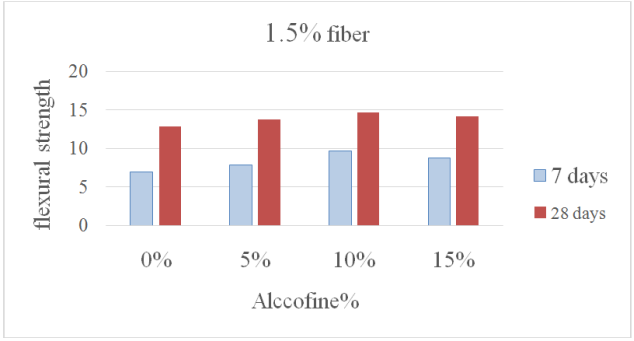

Figure 4.3.3 flexural strength of 1.5% Fibre

- It is observed that there is a gradual increase in the compressive and Flexural strength when cement is substituted by ALCCOFINE up to 10%, but further increasing in the percentage of ALCCOFINE results decreases in strength.
- It can to be concluded that if 10% cement is substituted by ALCCOFINE in concrete, it will not only decrease the cost of concrete but at the same time will save large magnitude of cement.

Conclusions

- It is a natural fibre which makes cost effective.
- Coir fibre is one which is of low cost and to produce high strength and high performance concrete.
- Its being used to enhance the tensile and torsion properties.
- Coir fibre has several advantages over other plant natural fibers such as high growth rate, strength.
- Alccofine is easy to use and can be added directly with cement, ultrafine particle of Alccofine provide better and smooth surface finish.
- The conclusion from the experiment can be drawn that Alccofine being use as mineral admixture in a concrete mix increase the initial strength of the concrete than the ordinary concrete.
- By increasing percentage of alccofine the compressive, split tensile and flexural strength are maximum at 10% alccofine.
- Presence of Alccofine increases the workability of concrete.
- For high strength concrete the cost of the concrete mix prepared with Alccofine is lesser than the concrete without Alccofine.
- It also lower the water/binder ratio.
- The FRC with alccofine gives early strength in concrete.
- The maximum Split tensile strength is obtained with 1% of fibres with aspect ratio of (l/d) 125 when compared to 0%,0.5%, and 1.5%.
- The maximum flexural strength is obtained with 1% of fibres with aspect ratio of (l/d) 125 when compared to 0%, 0.5% and 1.5%.
- From the experimental investigations the maximum results given with 1% of fibre content with 10% alccofine.

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