EFFECT OF MICROSILICA ON A PROPYLENE FIBRE REINFORCED FIBRE CEMENT PRODUCT

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KEYWORDS: PP fibre, Microsilica Slurry,

PP fibre is used for fibre cement products in Brazil due to availability issues with Polyvinyl alcohol (PVA) fibre in the local market. Microsilica Slurry was suggested as a means to enhance the performance of a PP reinforced product. This is a paper describing the preliminary test to evaluate the likely effect of Microsilica Slurry.
The Microsilica Slurry addition was designed to replace cement in the formulation; the replacement ratio of MS/cement was designed to 1:1, 1:1.5, 1:2, 1:2.5 and 1:3. The limestone in the mix design was modified accordingly to compensate for cement when the replacement ratio of MS/cement was not 1:1.
PVA fibre reinforced fibre cement was also studied as reference.

The following properties were measured in the test.

1) Bending strength (MOR)

2) Dry density

3) Water absorption

4) Moisture movement

5) Filtration time

6) Bending work

Primary conclusions from the test:

1. The general properties of the PP fibre reinforced fibre cement product were improved with the addition of Microsilica Slurry. These included higher strength and lower water absorption.

2. As limestone was used to compensate for replaced cement in this test, 2.5-3 parts of cement could be replaced by 1 part of Microsilica Slurry, which also gave better properties compared to the reference sample without Microsilica Slurry.

3. Sample with PP fibre had higher toughness (bending work) than the sample with PVA fibre.

4. Microsilica Slurry addition improved the fibre reinforcement effect.

For air-cured fibre cement products, PVA fibre is the main reinforcement fibre for asbestos replacement worldwide but PP fibre is used in Brazil due to poor availability and higher cost of PVA fibre. Saint-Gobain

Brasilit produces locally a high tenacity PP fibre for this purpose. For better understanding of the effect of Microsilica Slurry on this fibre cement product, a test using Brazilian cement and PP fibre was made.

Microsilica Slurry was used to replace the cement in the recipe at different ratios. Replacement ratio of Microsilica Slurry/Cement (MS/CMT) was designed to 1:1, 1:1.5, 1:2, 1:2.5, and 1:3. Limestone was used to compensate for cement where the ratio MS/CMT was not 1:1. Furthermore, PVA fibre reinforced samples were also tested for reference in the test.

EXPERIMENT

Test materials:
Cement: from Brazil
PP fibre: from Brazil
PVA fibre: Chinese
Cellulose Pulp: Usutu, unbleached (Chinese FC plant)
Limestone: Elkem FC lab (Omya A/S)
Microsilica Slurry: Elkem FC lab
Specification of these raw is shown in the Appendix.
Test recipes are listed in Table1.

Test procedure

Sample preparation and measurement was according to Elkem Fibre cement lab standard. (Elkem FC lab standard, MAT-11-12-05.803; MAT-Aug-02-06.802) NB The curing program was slightly modified to save time.

RESULT AND DISCUSSION

Bending strength

Wet Bending strength was measured. The other results are also shown in table 2 and fig1 to fig12.
For the sample group with 2% PP fibre, it is shown in fig1 that MOR was increased as Microsilica Slurry was added. MOR increase level was different according to the different ratio of MS/CMT.

For the group with 3% Microsilica Slurry, replacing 7.5% cement reached a higher MOR (replacement ratio 1:2.5), which increased to 14.8MPa from 11.3MPa, an increase of 21% over the reference sample.

For the group with 5% Microsilica Slurry, replacing 5% cement and 15% cement reached the highest MOR in this test, increasing to 15.6MPa and 15.5MPa respectively, an increase of 55% over the reference sample.
The above results indicate that MOR could be improved even more if replacement ratiosof 2.5-3 were used and limestone was used to compensate for the missing cement.

Dry density

Results for dry density correlated with the results for MOR; higher MOR correlates with higher dry density. (fig 2)
Moisture movement
Moisture movement was decreased as the replacement ratio of MS/CMT increased (fig 3), especially for the group using 5% Microsilica Slurry, where higher replacement ratios of MS/CMT produced lower moisture movement. This was influenced by the effect of the limestone. Limestone proved to be beneficial in reducing the moisture movement [1, 2]. For example, compared to 3% Microsilica Slurry, at the same replacement ratio of MS/CMT, 5% Microsilica Slurry needed more limestone in the matrix, which gave additional benefits in reducing the moisture movement.

Water absorption

Water absorption was in line with the results of MOR and dry density i.e. higher dry density gave lower water absorption (fig 4).

Filtration time

Microsilica Slurry does influence the filtration process according to the lab tests and industry trials. In this test, it was shown that filtration time became longer as Microsilica Slurry was added (fig 5). With the increasing replacement ratio of MS/CMT, more limestone was added and filtration times became shorter compared to the pure Microsilica Slurry recipes.

Bending work

Bending work could be used as one indicator to evaluate the toughness of the product. Higher bending work means higher toughness. PVA/PP fibre will give significant improvement on the toughness of fibre cement. Effect of Microsilica Slurry on the toughness is controlled by the following factors:

1. Microsilica Slurry will improve the bonding strength between PVA/PP fibre and the cement matrix, which increases the reinforcement effect of the fibres, which in turn will increase the toughness of the sheet.

2. On the other hand, strength and density of the sheet would be increased as Microsilica Slurry was used, so it could be said that sheets would become more brittle, which means toughness could be decreased.

3. If effect “1” > effect”2” as Microsilica Slurry was added, toughness would be improved; if effect “1” < effect”2”, the result would be opposite.

As indicated in fig 6, the bending work was improved by adding Microsilica Slurry in this test, which means the bonding strength between PP fibre and cement matrix was improved.

Comparison of PP and PVA fibre

Even though PVA fibre is the industry ‘standard’ for air-cured fibre cement products, PP fibre was developed and is used in Brazil for the reasons previously mentioned.
For reference, PVA fibre reinforced fibre cement was also studied in this test. Corresponding to the PVA fibre dosage, we have used two dosages of PP fibre in the recipes based on the weight and volume of the respective fractions. Results were shown in table 2 and fig 7 to fig 13. It was indicated from the result that both PP fibre and PVA fibre were beneficial in improving some properties, such as increase MOR and bending work, as well as decreasing filtration time; but it was disadvantage in some areas, such as water absorption and moisture movement. Furthermore, as indicated in fig 7 the MOR of the sample with 2% PP fibre was higher than that of the sample with 1.4% PP fibre, and close to the strength of the sample with 2% PVA fibre.
For same weight dosages, PP fibre (0.9g/cm3) presents a higher number of filaments than PVA fibre (1.3g/cm3). Process adjustments should be necessary to avoid the tendency of PP fibre to float (lower density than water) and the excess of fibre that may impact the dispersion and lower the density of the final products. It was shown from the test that dispersion quality of 1.4% PP fibre was probably better than that of 2% PP fibre.

However, because the elongation ratio of PP (18-22%) was higher than that of PVA fibre (6-10%), bending work of the sample with PP fibre has much higher value than that of the sample with PVA fibre in the test. (fig 13)

CONCLUSION

The general properties of the PP fibre reinforced fibre cement product were improved with the addition of Microsilica Slurry.

As limestone was used to compensate for cement, 2.5-3 parts of cement could be replaced by 1 part Microsilica Slurry, which gave the PP fibre reinforced cement product better properties.

In this test, 3% Microsilica Slurry could replace 7.5% cement increasing MOR by around 21% compared to the reference sample. 5% Microsilica Slurry could replace 15% cement increasing MOR by around 55%.

Samples with PP fibre have higher flexural toughness (bending work) compared to the sample with PVA fibre in this test.

REFERENCES

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Table 1 test recipes

Sample ID	Cement (Brazil)	Cellulose (Usutsu,unble-ached pulp)	PP(Brazil)	HM PVA (China Wanwei,W2)	Microsilica Slurry (as dry)	limestone	Replacement ratio (MS/Cement)
SGB-Ref	96.5 %	3.5 %	0.0 %	0.0 %	0.0 %	0.0 %	-
SGB-PVA	94.5 %	3.5 %	0.0 %	2.0 %	0.0 %	0.0 %	-
SGB-PP1(W)	94.5 %	3.5 %	2.0 %	0.0 %	0.0 %	0.0 %	-
SGB-PP2(V)	95.1 %	3.5 %	1.4 %	0.0 %	0.0 %	0.0 %	-
SGB1	89.5 %	3.5 %	2.0 %	0.0 %	5.0 %	0.0 %	1:1
SGB2	87.0 %	3.5 %	2.0 %	0.0 %	5.0 %	2.5 %	1:1.5
SGB3	84.5 %	3.5 %	2.0 %	0.0 %	5.0 %	5.0 %	1:2
SGB4	82.0 %	3.5 %	2.0 %	0.0 %	5.0 %	7.5 %	1:2.5
SGB5	79.5 %	3.5 %	2.0 %	0.0 %	5.0 %	10.0 %	1:3
SGB6	91.5 %	3.5 %	2.0 %	0.0 %	3.0 %	0.0 %	1:1
SGB7	90.0 %	3.5 %	2.0 %	0.0 %	3.0 %	1.5 %	1:1.5
SGB8	88.5 %	3.5 %	2.0 %	0.0 %	3.0 %	3.0 %	1:2
SGB9	87.0 %	3.5 %	2.0 %	0.0 %	3.0 %	4.5 %	1:2.5
SGB10	85.5 %	3.5 %	2.0 %	0.0 %	3.0 %	6.0 %	1:3

Table 2 test result

Sample ID	Dry density g/cm^3	Moisture movement	Water absorption	MOR MPa	Std -MOR	Fm-Tb N.mm	Filtration time(s)
SGB-Ref	1.62	0.46%	22%	7.9	0.4	126	85
SGB-PVA	1.37	0.55%	28%	12.4	1.1	1076	64
SGB-PP1(W)	1.19	0.50%	35%	11.3	0.9	2071	55
SGB-PP2(V)	1.32	0.51%	30%	12.7	1.0	2525	63
SGB1	1.35	0.49%	25%	15.6	1.0	3954	123
SGB2	1.38	0.46%	23%	14.0	0.4	2603	163
SGB3	1.30	0.44%	27%	13.1	1.0	2162	120
SGB4	1.34	0.41%	25%	15.2	0.8	3431	150
SGB5	1.38	0.39%	24%	15.5	1.0	2667	156
SGB6	1.30	0.48%	27%	12.9	1.2	2565	143
SGB7	1.35	0.47%	26%	13.9	0.7	2531	106
SGB8	1.30	0.48%	27%	13.3	2.0	2666	123
SGB9	1.36	0.44%	26%	14.8	0.2	3265	107
SGB10	1.33	0.46%	26%	12.8	0.2	2611	105

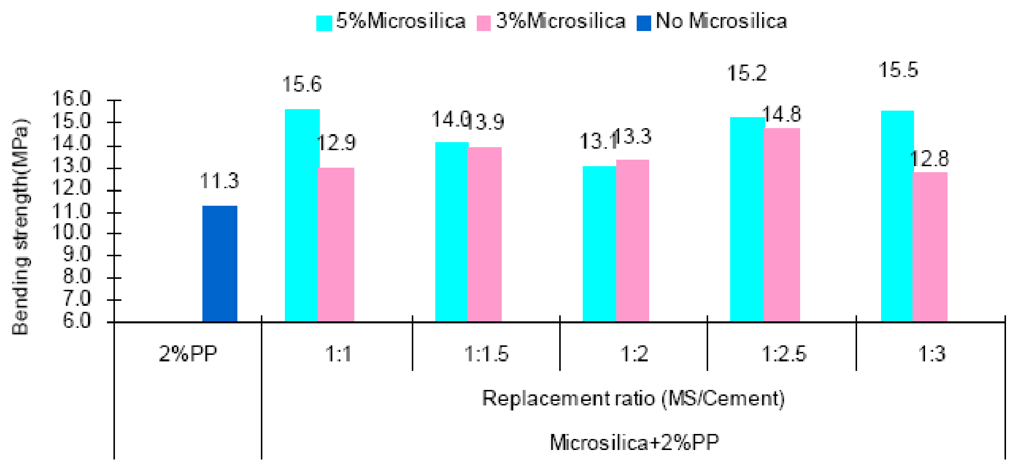


Figure1 Bending strength

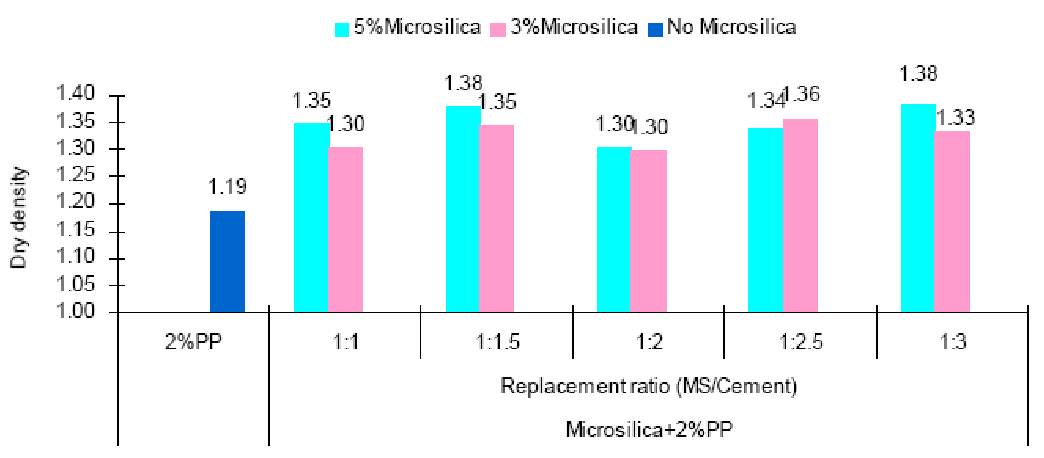


Figure2 Dry density

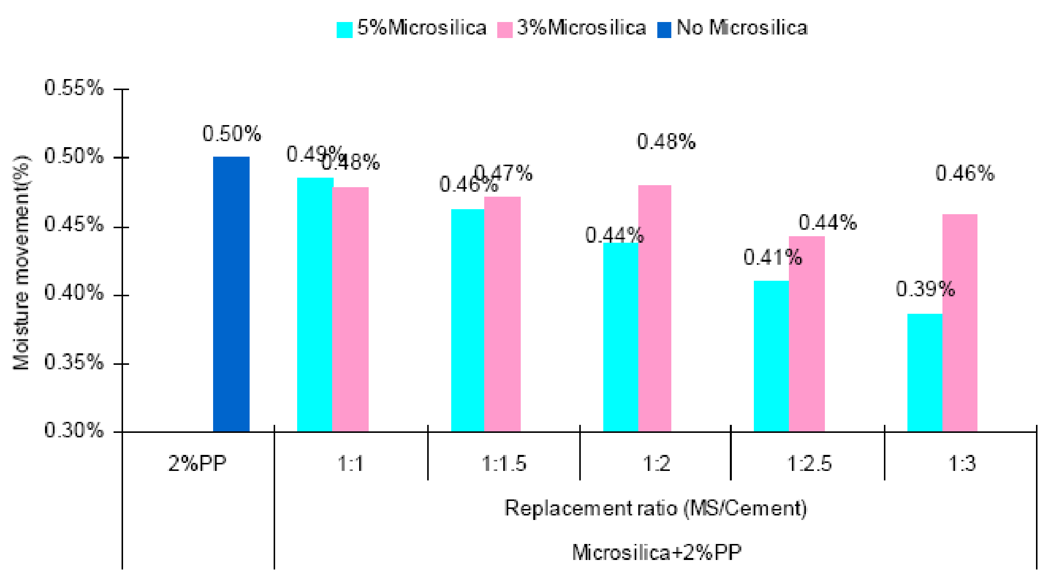


Figure 3 Moisture Movement

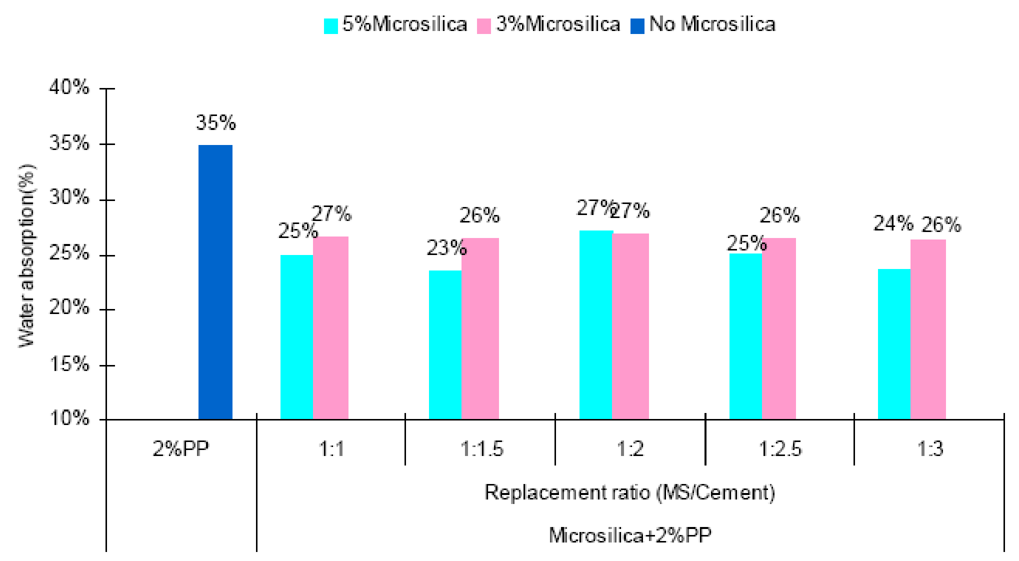


Figure4 Water absorption

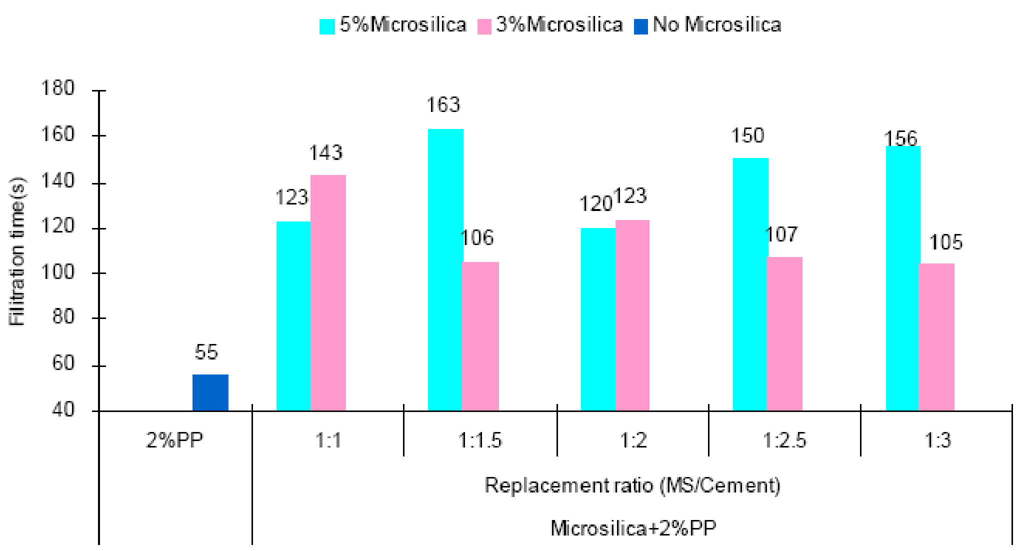
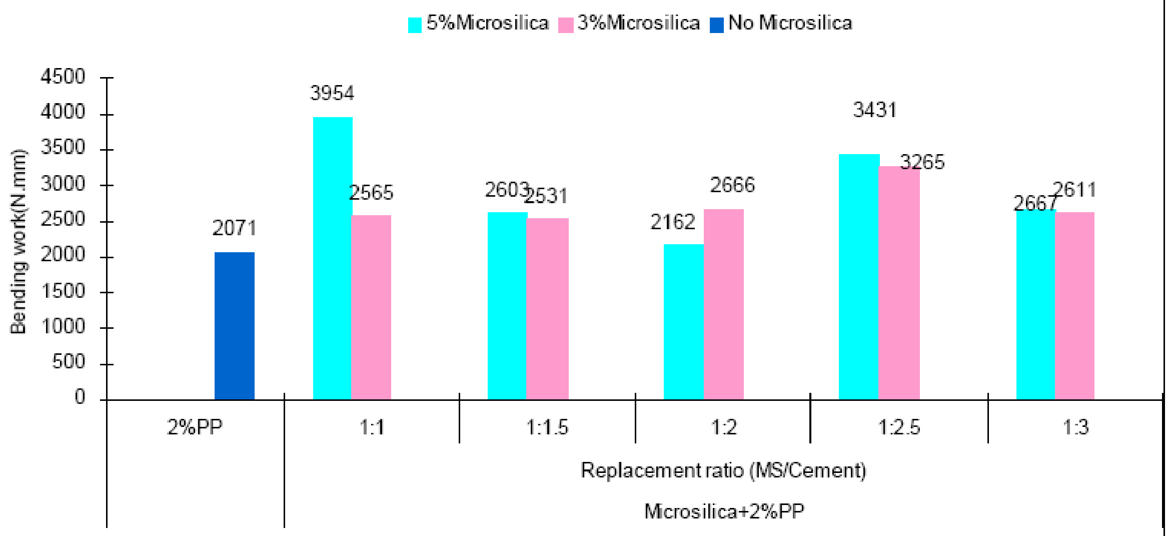


Figure5 Filtration time



Firgure6 Bending work

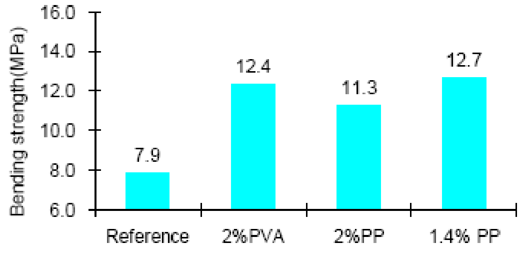


Figure7 Bending strength

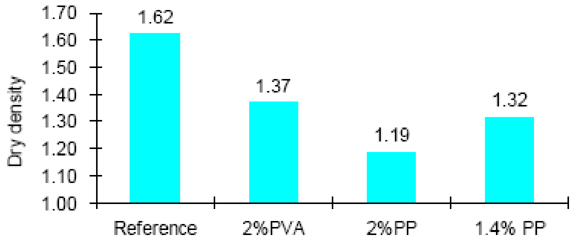


Figure8 Dry density

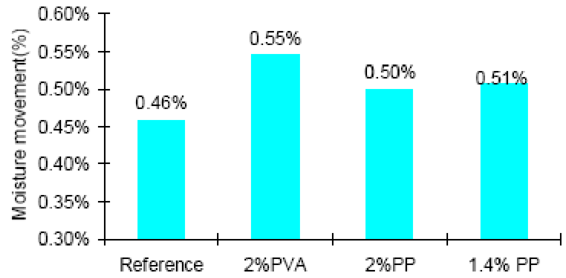


Figure9 Moisture movement

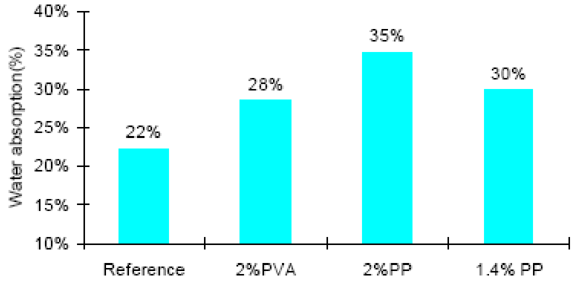


Figure10 Water absorption

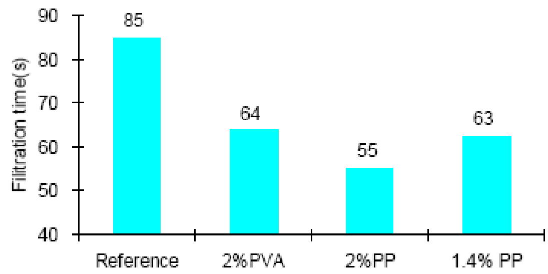
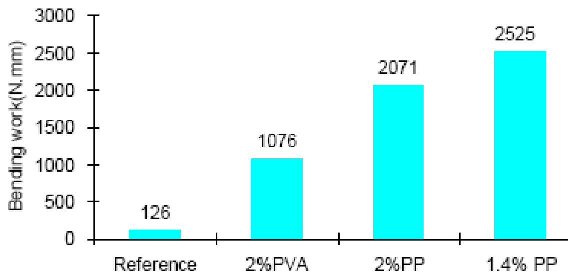


Figure11 Filitration time



Firgure12 Bending work

Appendices

PP fibre specification

Saint-Gobain do Brasil
Division Brasilit

PRODUCT DATA SHEET

POLYPROPYLENE CHOPPED FILAMENTS

Product description	*Polypropylene chopped filaments (PP)* are obtained by spinning process of a polypropylene resin following by a controlled drawing process to achieve physical and mechanical properties desirables. *Polypropylene chopped filaments (PP)* are covered by a thin layer of spin finishing which gives an adequate dispersion of filaments in water and an excellent adhesion to cement.

	Specification	**Typical values**
Length of chopped filaments available		6, 8, 10, 12 and 18 mm
Average diameter of chopped filaments (dtex)	0,8 to 1,2	1 dtex (~12 µm)
Density (g/cm3)		~0,905
Tenacity (cN/dtex)	Min. 8,5	9 to 10
Elongation at rupture (%)	Max. 25	18 to 22
Moisture (%)	Max. 2,5	2,2

Packing:	29kg bags.
Validity:	Not determined.

Limestone

Omya A/S

Kalendegatan 7B, SE-211 35 MALMÖ Sweden

GRENÅ

Grenåfiller 0-100

MINERAL	Kalksten, $CaCO_3$

Kemisk analys av råvaran

Kalciumkarbonat	($CaCO_3$)	96,0 %
Magnesiumkarbonat	($MgCO_3$)	1,5 %
Kiseldioxid	(SiO_2)	1,5 %
Aluminiumoxid	(Al_2O_3)	0,3 %
Järnoxid	(Fe_2O)	0,12 %
Fukthalt	(H_2O)	<0,3 %

Siktanalys

Partikelstorlek	Vikt-%, passerat
125 µm	99,8
75 µm	97
63 µm	94
45 µm	90

Tekniska data

Densitet	2,7 g/cm^3
Skrymdensitet	1.050 kg/m^3
Vithet	Off-White
Oljeabsorbtion	16
Ph	9,5
Hårdhet (Mohs)	3

Leveransform: Bulk och storsäckar.

Användningsområden: Inom segment miljö
Inom segment carpet backing

Redovisade data är medelvärden och lämnas utan förbindelse.

Leverantör:
Omya AB

2001-12-08

Cellulose Pulp

To: 林震

本色浆技术参数分析表

品名 Brand	单位	索罗门 Solombala	乌斯奇 Ust-Ilimsk	春木(A) Usutu	春木(B) Usutu	金鼎 Celco	红星深色 Hyogo(A)	红星浅色 Hyogo(B)	沙漠王子 Samoa
原产地 Origin		Russia	Russia	Swazi	Swazi	Chile	Japan	Japan	USA
卡伯值 Kappa		22-38	28	25	35	38	22	39	28
色谱Color —H		27.3	30.4	27.2	21.2	27.1	24.4	21.9	28.6
—L		64.1	67.1	64	58.5	64	62.3	56.7	66.6
—a		2.7	2.9	3.7	5.1	3.1	3.6	3.6	3.1
—b		15.1	15.2	15	15.6	15.2	16.1	12.6	16.5
尘埃 Dirt	mm2/100g	600	1400	350	2000	350	1000	1100	350
转速 PFI Revs		14500	12750	11500	12500	24000	7300	8000	13000
游离度 Freenees	ml	517	498	484	494	492	500	507	483
裂断长 Br.Length	km	9.81	9.65	8	7.84	8.38	9.69	9.62	7.61
耐破度 Burst		7.18	7.25	6.67	6.58	6.49	6.84	6.44	6.12
撕裂度 Tear		124	134	128	136	137	107	112	177
折叠次数 Folding	times	1459	1339	1296	1029	1719	1040	1168	1177
纤维长 Fibre Length	mm(Max)	5.51	4.2	4.71	4.87	4.97	5.16	4.76	4.82
	mm(Min)	0.91	0.59	1.08	0.94	0.54	0.67	0.73	0.66
	mm(Ave)	2.28	2.04	2.33	2.46	2.43	2.2	2.23	2.21

Microsilica Slurry

Elkem Microsilica®

EMSAC® 500 S

Fibre Cement

FC2-02 Products

General

EMSAC® 500 S is an aqueous suspension of Elkem Microsilica®.
The suspension has a solids content of 50 % by weight. It is easy to handle and pump.
Average bulk density is approximately 1,4 MT/m³.

Packaging

EMSAC® 500 S is supplied in a range of packaging:

- Bulk in road tanker
- 1 m³ containers
- 200 litre drums

Special packaging can be supplied on request.

Storage & Handling

EMSAC® 500 S is a stable product. However, if the product is left undisturbed for months, some segregation may occur. In such case the product should be re-agitated before use.

Quality Control

Elkem Materials is certified according to ISO 9001. The chemical composition and physical properties are regularly tested, and EMSAC® 500 S exceeds the requirements of the prEN 13263 from the European Committee for Standardization, as shown in the table below.

EMSAC® 500 S				
	prEN 13263		Elkem	
Chemical and physical requirements	Spec.	Frequency	Spec.	Frequency
SiO_2 (% by weight of dry mass)	> 85	weekly	> 90	weekly
SO_3 (% by weight of dry mass)	< 2,0	weekly	< 2,0	weekly
Cl (% by weight of dry mass)	< 0,3	weekly	< 0,3	weekly
Free CaO (% by weight of dry mass)	< 1,0	weekly	< 1,0	weekly
Free Si (% by weight of dry mass)	< 0,4	monthly	< 0,4	monthly
Available alkalis (Na_2O-equivalent, % by weight of dry mass)			< 1,5	weekly
C (% by weight of dry mass)			< 2,0	weekly
Loss on Ignition, LOI (%)	< 4,0	weekly	< 2,5	weekly
Specific surface (m^2/gram)	15 - 35	monthly	15 - 35	monthly
Pozz. Activity Index (%) - 28 days normal curing	> 100	monthly	> 105	monthly
Retained on 45 micron sieve (%)			< 1,0	weekly
Bulk (slurry) density (kg/m³)			Report	weekly
pH value			4 - 7	weekly
Dry mass variation (+/- % from declared)	< 2	weekly	< 2	weekly

The above Elkem specification refers to analysis performed using the Elkem Standard Test Methods for Microsilica, calibrated against the methods given in prEN 13263. Elkem Standard Test Methods for Microsilica are available upon request.

DISCLAIMER:
The information given on this datasheet is based on many years of research and field experience and is accurate to the best knowledge of Elkem Materials. However, due to the numerous factors that can affect the performance of a fibre cement, with or without microsilica, Elkem Materials offers this information without guarantee and accepts no liability for any direct or indirect damages from its use.

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