BEKAERT
better together

Technical Statement

Bekaert GmbH
Otto-Hahn-Straße 20
D-61381 Friedrichsdorf
Deutschland
T +49 6175 7970-130
F +49 6175 7970-108
philipp.guirguis@bekaert.com
www.bekaert.com

By:	Dipl.- Ing. Philipp Guirguis Technical Manager
Date	19.03.2009
Pages:	2 + attachments
Reason:	Thermal and electric conductivity of steel fibre reinforced concrete

1. Preliminary remark:

The question of thermal and electric conductivity of steel fibre reinforced concrete is sometimes rising without bringing in mind that for usual fibre amounts between 20 and 40 kg/m³ the Vol.% is lower than 0,5%. This paper deals with facts concerning thermal and electric conductivity of steel fibre reinforced concrete and tests which have led to the final statement due this matter.

2. Thermal and electric conductivity:

Steel fibre concrete behaves as unreinforced concrete regarding its thermal and electrical conductivity. This statement is extracted from the DBV-recommendation "Steel Fibre Concrete", Edition October 2001, paragraph 3.4.5.
Indeed there is nearly no influence of the steel fibres which are distributed in the concrete matrix as soon as the fibre dosage is in the range of usual amounts below approximately 40 kg/m³.

3. Test approaches:

Purpose of the realised test program is to investigate the conductivity of Steel fibres in concrete. The test program and the conclusions out of this are part of this technical statement and enclosed as an attachment.

4. Conclusion:

- No difference in electric conductivity is found by introducing Dramix-fibres (normal dosages) in concrete materials.
- The humidity of concrete is much more relevant than Dramix fibres introduced.
- The values for the unreinforced and for the fibre reinforced blocks are nearly the same.

Kind regards
Bekaert GmbH

i. V.

Dipl.- Ing. Philipp Guirguis

D I S   I N P U T   D O C U M E N T

Report No. : Res 010200	Language : NE	Weeding date : 2032
Date : 14/06/82	Stock I : 003	Stock II : 227
Project No. : 004071/001/82	Security code : 07	Fire code : 06

AUTHOR(S) (AU) :

SAMYN, J.

CORPORATE SOURCE (CS) :

D.N.A. - Dramix

TITLE (TI) :

Conductivity of dramix materials

ABSTRACT (AB) :

No difference in electric conductivity is found by introducing Dramix-fibres (normal loadings) in concrete materials. The humidity of concrete is much more relevant than Dramix loading.

pp. (2)

KEY WORDS (KW) :

Memorandum

Electric conductivity - Dramix

VARIA (VA) :

LD85331E

First evaluation of electric conductivity of some Dramix products

3 febr. '81.

1. Samples
   a) (BZ5) (1-11-3)A ; 30/80 ; 60 kg/m^3
   b) (BZ2) (1-11-3)A ; 30/50 ; idem
   c) (B083B) no fibres
   d) (BZ5) (1-10-4)B : 30/80 ; 80 kg/m^3

   Dimensions : L = 150 (mm)
   W = 150 (mm)
   H = 100 (mm)

   Planes W x H : contact surfaces with electrodes : sawn (uptimal electrical contact required).

2. Test setup : see figure 1

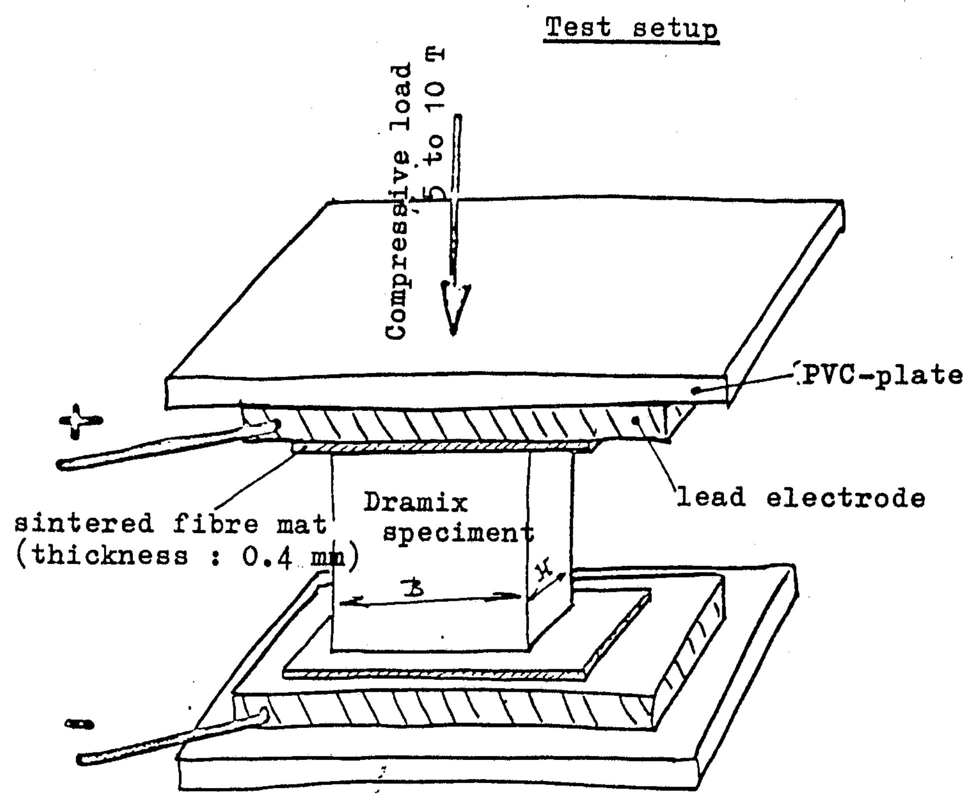


Fig. 1.

Note : - Lead electrodes are applied and are pressed under pressure against the sample (avoid contact resistances).

- Contact is further improved by providing an intermediate fibre mat.
- Check of contact resistance : see figure 2 : the resistance is measured between the upper side of a lead electrode, the underside of an accidental Dramix fibre touching the sintered mat : R_c : 0.2 (Ω)

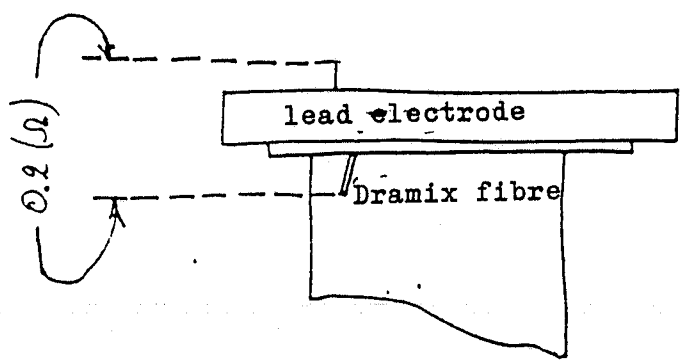


Fig. 2. Scheme : check of contact resistance

3. Measuring results

To ascertain conductivity it was essential to apply a high voltage.

a) (BZ5), A, 30/80 ; 60 (kg/m^3)

Voltage (V)	Resistance (Ω)	Specific resistance (Ωcm)
1 000	4×10^7	3×10^8
1 500	4×10^7	3×10^8
2 000	$4,1 \times 10^7$	3×10^8

b) (BZ2), A, 30/50 ; 60 (kg/m^3)

Voltage (V)	Resistance (Ω)	Specific resistance (Ω cm)
1 000	2×10^7	1.5×10^8
1 500	2×10^7	1.5×10^8
1 800	3×10^7	2×10^8

c) (BC83B) (neutral)

Voltage (V)	Resistance (Ω)	Specific resistance (Ωcm)
1 000	4×10^7	3×10^8
2 000	4×10^7	3×10^8
3 000	4×10^7	3×10^8

d) (BZ5), B, 30/80 ; 80 (kg/m^3)

Voltage (V)	Resistance (Ω)	Specific resistance (Ωcm)
1 000	4×10^7	3×10^8
2 000	5×10^7	3.5×10^8
3 000	5×10^7	3.5×10^8

4. Conclusion

Preliminary note : regarding the number of fibres present per unit of volume.

Sample BZ5, A is taken as Dramix reference sample.

We assume No is the number of fibres present

In general one obtains :

$$\frac{N}{No} = k \times \left(\frac{Do}{D} \right)^2 \times \left(\frac{C}{Co} \right)$$

where : N = number of fibres present

Do = fibre diameter in reference sample (0.8 mm)

D = fibre diameter for sample considered

Co = fibre content in reference sample

C = content for sample considered.

Assuming that (for an identical fibre length) the number of contacts between the fibres (= likelihood of continuous conductivity) is proportional to the number of fibres present (N), then it may be assumed that :

- the best conductivity (lowest resistance) must be found in sample (BZ2), A, 30/50 ; 60 (kg/m^3).

  viz.

$$N = No \times \left(\frac{80}{50} \right)^2 = No \times 2.6$$

- that the sample with the highest concentration (BZ5), B, will not be the best in terms of conductivity.

$$N = No \times \left(\frac{80}{60} \right) = No \times 1.3$$

a) It has never been found that the microscopic conductivity in the Dramix materials investigated is significantly better than in neutral concrete.

b) Only sample (BZ2), A 30/50, which theoretically should offer the best conductivity, is indeed slightly better than the neutral sample. (The question, however, is whether this result is of any significance at all).

c) The resistance values, however, are so high that one can not yet talk about conductive concrete.

d) In practice the curve of the macroscopic conductivity of inhomogeneous materials (insulating basic materials with conductive filler) versus the volume of added filler is usually as follows : figure 3.

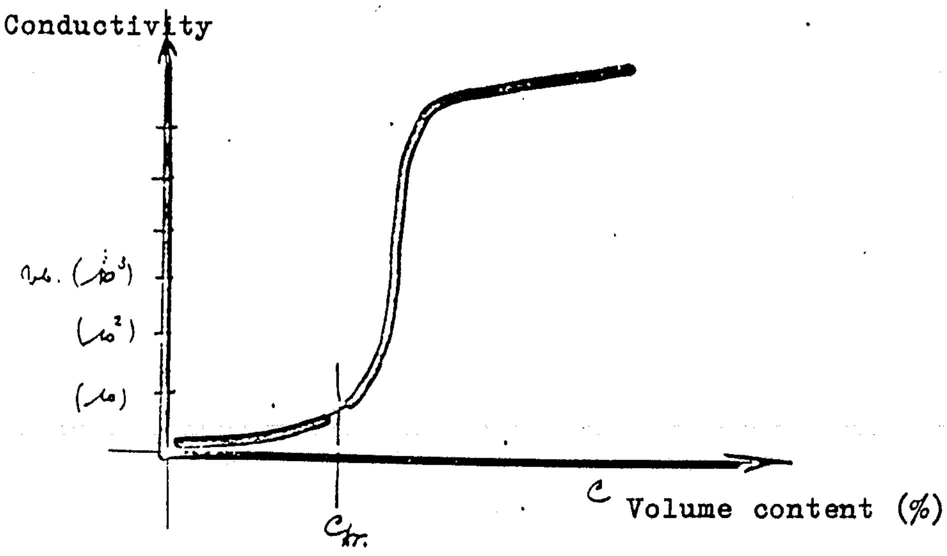


Fig. 3. Curve of conductivity versus volume content

The critical content C_{kr} is important, whereby suddenly a very strong increase in conductivity occurs.
This coincides with the content at which the closed network is formed by the filler.
It is quite unlikely that for the Dramix samples considered this critical volume concentration has already been reached.
This means that the resistance values found are still very high.

e) There is little chance that for all conventional Dramix products (conventional fibre geometry and contents), this critical volume content can be reached (compatibility of processing characteristics).

f) The used measuring method is probably not optimal for determining an absolute resistance value.
In the first place, the matter at stake was to determine the order of magnitude. As soon as certain Dramix-like products offer a conductivity which is many orders of magnitude greater, more attention can be paid to the measuring method.

Notes : additional tests

A few additional tests were performed :

1) To obtain certainty as to the used measuring method : value of resistance contact between sample and measuring electrodes.
   Therefore measurements were conducted on
   - a Marconite sample
   - a Dramix sample, whereby, within the existing types - that type was selected which theoretically would give the largest number of contacts between the fibres (types 40/40 ; 1 %)

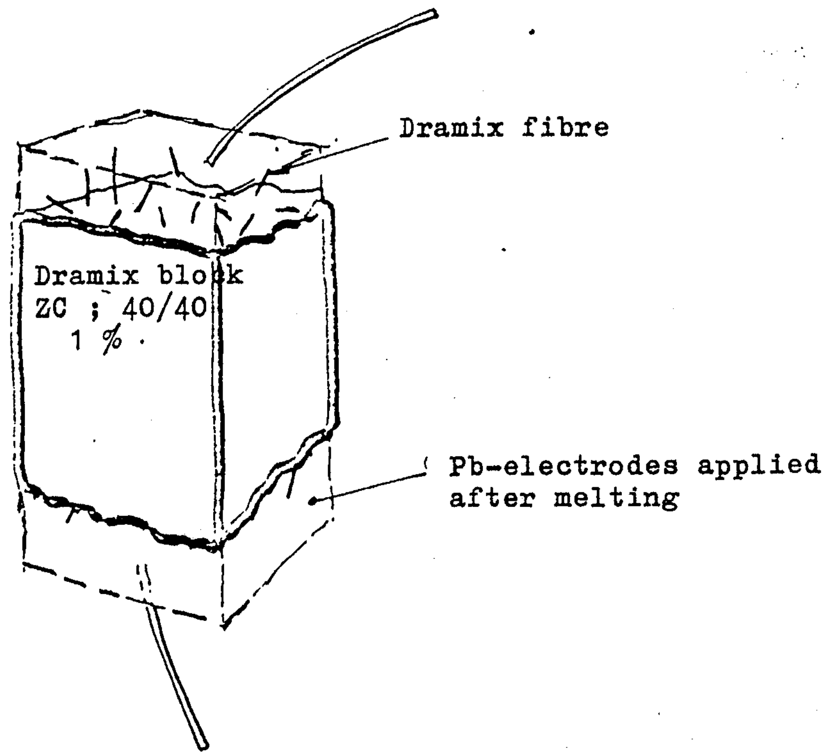
2) To obtain an idea of the value of the shielding capacity in case of very high frequencies (radar : 10 GHz).

---

1) Conductivity tests

a) Dramix : (40/40) ; 1 % : see figure 4.

Fig. 4. Scheme : application of Pb electrode



Sample preparation :

Concrete is removed from the Dramix fibres at 2 sides of the block (over 1 to 2 cm). Liquid lead is poured at these sides of the block to provoke good electric contact (see figure).

Result : = 3.5×10^8 (Ω cm)

b) Marconite-sample (type unknown)

With this sample no special precautions have been taken to make contacts between the electrodes and the block : even no additional pressure on the electrodes.

Result : = 75 (Ω cm)

Conclusion :

- It is certainly not possible to attribute very high electric resistance values of the Dramix block to the measuring method : see Marconite sample.
- The used Dramix type is not suitable as a conductive concrete. The resistance is many orders of magnitude too great. The critical concentration at which a close threedimensional network is formed has not been reached. No significant increase in conductivity is reached versus a neutral block.
- The order of magnitude of the measured resistance on a Marconite sample is in line with the values indicated in the Marconi documentation.

2. Shielding tests at radar frequency (10 GHz)

The following shielding efficiency values have been recorded for 3 concrete types.

Type	Shielding coefficient (dB), at 10 GHz
Marconite ; thickness 2 cm	16 ; 16 ; 16
Neutral concrete ; (BO 83 B) thickness : 10 cm	3 ; 3.1 ; 3.2
Dramix block (40/40 ; 1 %) thickness : 5 cm	2.9 ; 3.5

Comments :

a) The shielding value for the Marconite sample is in line with the order of magnitude to be expected and significantly higher than for the two other samples.

b) The (low) shielding (± 3 dB) by the neutral concrete and Dramix block is to be attributed to the difference in dielectric properties between air and concrete.
Because of the very low conductivity, this value will practically not be influenced by the concrete thickness.
The sole way to obtain higher values is to increase the macroscopic conductivity.