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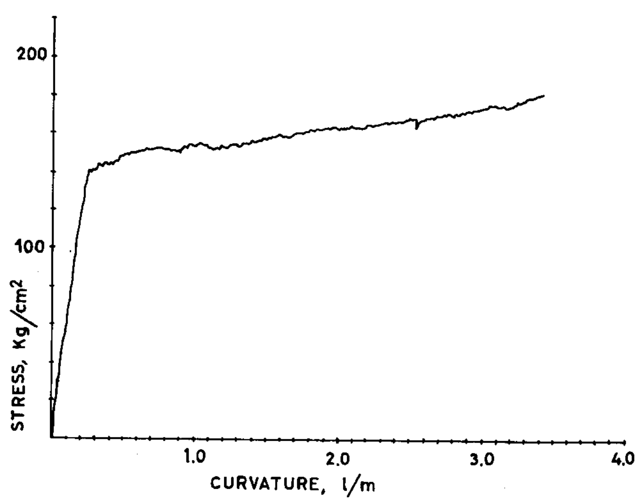
(54) Cement-like support material for the cathodic protection of reinforced concrete structures.

(57) This invention relates to a cathodic protection system for reinforced concrete structures comprising the application of an anodic structure consisting of rows of apertured valve material strips activated by catalytic coating and supported by spacers consisting of prefabricated elements of cement-like material, characterised by comprising dispersed, continuous or meshed fibres of a non-conducting material or polymer material; said strips being connected together by connection elements such as insulated metal cables, rods or bars. The structure formed in this manner is incorporated into the concrete during the construction of the reinforced concrete structures.

Fig.1



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Cathodic protection for metal structures is well known. The metal structure is made to operate substantially as the cathode in a circuit also comprising a current generator, an anode and an electrolyte. The exposed anode surface is made of a corrosion-resistant conductive material of high electrocatalytic activity such as platinum, applied to a valve material substrate such as titanium, or organic polymer containing a sufficiently inert conductive filler such as carbon black or graphite.

Among metal structures requiring corrosion protection, those formed by the reinforcement bars of reinforced concrete are important. The concrete is sufficiently porous to allow the passage of oxygen and aqueous electrolytes. Consequently, the saline solutions which accumulate within the concrete either because they were originally present or because they penetrate from the outside can corrode the reinforcement bars.

A typical case is that of a reinforced concrete structure exposed to sea water. Another important case is that of road viaducts in which the concrete necessarily contains salt used for melting ice. Another typical situation is that of structures formed from mortar to which calcium chloride is added as hydration acceleration agent. The products deriving from the corrosion of the reinforcement iron occupy a volume which is much greater than the metal itself, and hence the corrosion process not only weakens the bars but causes fracture and crumbling of the concrete, with more serious consequences. It is only in recent years that the seriousness of the reinforced concrete corrosion problem has been considered in terms not only of cost but also of safety. In this respect, many structures are currently unusable because of concrete deterioration due to reinforcement bar corrosion, and in the absence of practical solutions the number of such structures is destined to increase dramatically. Consequently, considerable effort and investment have been directed to the development of cathodic protection methods for the reinforcement structures of reinforced concrete. As a result, cathodic protection is now beginning to be used as a method for preventing corrosion in newly constructed concrete structures which may be subject to chloride contamination during their scheduled life (such as motorway viaducts in mountain regions, jetties and marine structures in general). Up to now the cathodic protection system has been applied only to finished structures. A considerable cost saving could be achieved if the cathodic protection system were to be applied during the actual construction of the structure. In this case the anode used would not only have to ensure uniform current distribution through the reinforcement to be protected, but would also have to possess excellent mechanical properties so that no breakage or yielding of the anodes takes place during pouring by the effect of the concrete weight. If this should happen, the anode could finish by being in contact with the metal of the iron reinforcement, so short-circuiting the system.

U.K. patent 2,175,609 describes an electrode of expanded structure comprising a mesh formed from a plurality of wires covered with an active covering and used for the cathodic protection of the reinforcement bars in reinforced concrete. U.S. patent 4,708,888 describes a cathodic protection system using an anode in the form of a very expanded structure with more than 90% of the area empty, the rest of the space being full. The anodic systems described in these patents cannot be used during the setting-up before pouring the concrete because the highly expanded structure does not provide the mechanical strength required in such a situation.

In addition the flexibility of the described anodic structures would cause them to make contact with the metal reinforcement due to the weight of the overlying concrete during pouring, with consequent short-circuiting of the cathodic protection system.

According to Italian patent application No. MI 91A 002527 the drawbacks of the known art can be overcome by an anodic system for cathodic protection consisting of rows of apertured strips of valve material activated by a catalytic coating, and supported by suitable spacers.

Said spacers, which protect the system and are positioned on the reinforcement, are stated to be of plastics or generally of cement-like material of high mechanical strength comparable to that of the concrete used to construct the structure itself.

The method for forming an active cathodic protection system for reinforced concrete structures comprises applying the anode to the last layer of reinforcement or within the reinforcement cage during the setting-up, before pouring the concrete. The rows of strips of valve material activated by a catalytic coating are connected together by connection elements of various geometrical shapes, such as solid or apertured strips, bars, rods, or insulated metal cables.

The apertures in the strips can be in the form of holes made in the strips, but the most economical method is to use strips of expanded metal.

The active cathodic protection method comprises the application of a constant current to the anodic structure formed from the spaced-apart apertured strips connected together by connection elements.

Optimum current distribution and hence optimum cathodic protection are achieved by virtue of the particular geometry, which is exactly adapted to the reinforcement density per unit of concrete surface area.

In this respect, the anodic structure, incorporated into a concrete structure, can have a variable reinforcement per unit of concrete surface area. For example, in the case of motorway viaducts the density of the iron bars in the slabs of the parts above the columns is greater than at the centre of the span in order to provide maximum structural strength to the viaduct.

The strips are applied, before pouring the concrete, and their number, size and spacing are determined on the basis of the iron bar density in every region of the structure to be protected. In this manner an optimum current distribution and effective cathodic protection of the bars are achieved without applying excessive protection in some areas or limited protection in others.

The problem of correctly distributing the protection current is extremely important. If the iron reinforcement is under-protected it can corrode, whereas over-protection can cause embrittlement by hydrogen, especially if the iron to be protected has a high yield point such as that used in precompressed concrete structures.

The correct choice of material to be used as spacer is therefore a particularly critical aspect in the described protection methods.

The cement-like material described generically as spacer in Italian patent application MI 91A 002527 has however not satisfactorily solved this problem of correct choice.

In this respect a generic cement-like material for use as support for an anodic material for cathodic protection during the setting-up stage of a reinforced concrete structure, even if of high mechanical strength, has a series of operating drawbacks which can make the entire protective process invalid.

A first drawback is the fragility of the material, which easily breaks particularly if it has to support anodic strips of critical dimensions (length 1-2 m, width 1-10 cm). If such breakage occurs on the building yard, the damage is merely economical, however if it occurs inadvertently during the setting-up of the system or during the pouring of the concrete, contact could take place between the metal strip and the reinforcement to produce a short circuit which would totally invalidate the chosen protection system, as stated heretofore. In addition the workability of the generic cement-like material is relative, and hence the requirement of being able to cut it into strips becomes a burdensome operation besides substantially increasing costs.

A further drawback is the rigidity of the concrete-anode system, which means that there is poor adaptability to the material with which the system is in contact. Lastly, the length of the strips once prepared cannot be varied because the material can not be glued.

It has been surprisingly found that all these problems can be solved by using an improved composite cement-like material characterised by comprising dispersed or continuous fibres of a non-conducting material or polymer material.

The characteristics of this composite cement-like material make it particularly suitable for use for cathodic protection because of its particular characteristics of lightness, flexibility (it can adhere even to a curved surface), adaptability (to the roughness of the material with which it comes into contact) and glueability (it being therefore possible to make properly adhering strips, which can be potentially infinite).

To give an idea of the behaviour of fibre-reinforced concrete sheets of the invention when subjected to flexural stress, it has been found that a support sheet of 5-10 cm width, 1 m length and 0.5-1 cm thickness can be bent until it forms a semicircle without breaking. Approach to the elastic limit is noted by the formation of a fissured layer. This fissured layer spreads out and becomes more dense as the curvature of the sheet increases.

After this stressing, the sheet easily regains its initial shape.

The aforesaid composite cement-like materials are prefabricated by methods well known in the art.

Any type of hydraulic cement can be used in the composite cement-like materials of the invention. The term "hydraulic cement" means any material which sets and hardens by the addition of water, and which consequently sets and hardens in the presence of water. The hydraulic cement can be a silicate-based (siliceous) cement such as Portland cement. If desired, it can be a high-alumina (aluminous) cement, such as a calcium aluminate cement, or a pozzolan cement. Mixtures of two or more hydraulic cements can be used. In a preferred aspect of the invention, type 425 Ptl or type 525 Ptl cement is used.

All the aggregates, fly-ash and additives for preparing mixes known in the art can be used in the composite cement-like material of the invention. Some illustrative examples of these mixes are described in the experimental part.

The cement-like material must have a conductivity comparable with that of the concrete covering the anodic structure.

In practice, the conductivity of the cement-like support compound must be provided only by the cement and not by the fibres, or by the polymer material.

Fibres suitable for use in the cement-like material can therefore be of polyethylene, polypropylene, polyamide, polyester, polyvinyl alcohol, cellulose, polyacrylonitrile and the like, their copolymers or their mixtures. They can be fibrillated or can be in the form of continuous threads or meshes with various mesh apertures, either random or orientated. Preferred cement-like materials are those comprising fibrillated polypropylene meshes, in particular Retiflex^R meshes in 12 sheets (8 parallel and 4 transverse to the bobbin unwinding direction).

However cement-like materials with only 2-8 mesh layers, and 4 in most cases, are equally preferred. The term "fibrillated" as used in this description and in the claims means the "generation of longitudinal fissures". It is not prejudicial for the material when used in accordance with the invention if different types of fibres are present in the same cement-like composition. An important characteristic of the materials used for this particular application to cathodic protection is that when mechanically stressed they present a fine multiple fracture without any separation.

This expression means that when the material is stressed beyond its elastic bending limit it deforms permanently with the formation of several fissures but does not break into pieces or flake. Examples of mechanical properties of fibre-reinforced sheets which are characteristic of the material of the invention are an elastic proportionality limit of between 90 and 190 kg/cm^2 and a modulus of elasticity of between 200,000 and 300,000 kg/cm^2.

The elastic proportionality limit corresponds to the stress which produces the first fissure, and is the maximum force which the slab can support without microfissuring.

The high deformability and high modulus of rupture ensure installation without difficulty. Taking account of the particular use for which the cement-like materials of the invention are intended, the curve of flexural stress (in kg/cm^2) against curvature shown in Figure 1 is of considerable importance. A cement-like material not fibre-reinforced would break.

The fibre content of the cement-like material of the present invention varies from 0.1% to 15% by weight, and preferably from 0.5% to 5%.

Particularly suitable for use in the invention are so-called MDF (macrodefect-free) cements comprising organic polymers and possibly also fibres, processed to reduce the pore volume, for example by extrusion or calandering.

Examples of cements of this type are for example those described in the following European patents: 332 388, 21 682, 158 471, 114 518, 115 137, 55 035, 38 126, 30 408 and 21 681.

Examples of polymers contained in MDF cements are water-dispersable polymers such as:

- alkyl ethers and hydroxyalkyl cellulose (methylcellulose, hydroxyethylcellulose, methylhydroxyethylcellulose, ethylhydroxyethylcellulose, propylcellulose, hydroxypropylmethylcellulose, hydroxybutylmethylcellulose)
- acrylamide or polyacrylamide polymers (polyacrylamide, polymethacrylamide, acrylamide/methacrylamide copolymer) or hydrolyzable polymers or copolymers of vinylacetate, in particular polyvinylacetate
- polyvinylalcohol polymers and copolymers
- polyalkylene oxide derivatives (polyalkylene glycols of molecular weight exceeding 10,000)
- polyalkoxy derivatives of alcohols or phenols.

Other polymers which can be included in these cements are polymers with a predetermined content of carboxyl groups (acid equivalent = 200-700 mg KOH/g of polymer, molecular weight exceeding 100,000) such as:

- polymers of methylmethacrylate with acrylic, methacrylic, crotonic or similar unsatuated carboxylic acids
- copolymers of methylmethacrylate with ethylacrylate, ethylhexylacrylate, butylacrylate or similar acrylic acid esters
- copolymers of vinylacetate with esters of acrylic, methacrylic, crotonic or similar unsatuated carboxylic acids
- copolymers of vinylacetate with acids or salts
- copolymers of vinylpyrrolidone with acids and which include esters of these acids as monomers
- copolymers of anhydrides of unsaturated acids (such as maleic acid) with unsaturated monomers such as styrene, diisobutylene or methylvinylether
- partly hydrolyzed polymers and copolymers of acrylamide, methacrylamide and acrylonitrile
- graft copolymers of polyethylene oxide with copolymers of acrylic and methacrylic acid, methylacrylate, methylmethacrylate. Bifunctional monomers such as divinylbenzene can be included as cross-linking agents.

Generally these polymer-containing cement compositions (MDF cements) have a polymer content varying from 0.1 to 10% by weight, and preferably between 0.5 and 2%.

The bending strength of these particular cement-like materials is of the order of 20-200 MPa, the modulus of elasticity about 35-50 GPa and the electrical resistance about 8-10 KV/mm. The polymer-containing cement material (MDF) can also contain the aforesaid non-conducting fibres.

The invention therefore provides a continuous anodic structure for concrete reinforcement cathodic protection which is covered with poured concrete and comprises a plurality of valve material strips and spacers of a cement-like material which support said strips on the reinforcement, characterised in that the spacers which support the strips on the reinforcement are of a composite cement-like material comprising dispersed, continuous or meshed fibres of a non-conducting material or polymer material.

The cement-like material support for the strips therefore has a mechanical strength such that it can be transported on site, positioned on the reinforcement and finally covered with the cast reinforced concrete without any risk of mechanical breakage.

The cement-like material separator of the invention ensures the absence of any short-circuiting between the anodic strips and the metal reinforcement and is perfectly compatible with the concrete used for casting the structure.

In addition, the use of this cement-like material as a support enables cathodic protection to be applied to metal reinforcement during the actual formation of a concrete structure, using as anode any of those anodic materials which up to the present time could not be used for this purpose because of fragility problems.

In a preferred configuration of the invention the flat strips are fixed onto the separators of cement-like material which are in the form of parallelepiped bars comprising a groove housing the anodic strip. Other separator forms can however be considered.

In a further embodiment of the invention said strips are fixed to the supports by plastic fixers of expansion plug type, the strip plus spacer then being positioned on the reinforcement, or the strips being fixed onto the spacer which has been previously installed on the reinforcement.

When the anodic strips have been positioned the whole is covered with the constructional concrete.

In a preferred configuration of the invention the anodic strips are fixed to the cement-like support by simple clipping.

In a further configuration of the invention the flat anodic strips are positioned between two spacer elements to form a sandwich structure.

The strips are generally of valve material, such as titanium, zirconium or niobium, titanium being preferred because of its mechanical strength, corrosion resistance, commercial availability and cost. Alternatively alloys of valve materials and intermetallic compounds can be used.

The valve material strips described in Italian patent application MI 91A 002527 are particularly preferred.

The cement-like support material of the invention can adapt to any desired strip size without problem.

The invention is described in detail hereinafter with reference to the figures, of which:

Figure 1 shows a typical stress/curvature curve for a mesh-containing test piece subjected to flexural stress;

Figure 2 is a detailed view of the strip plus spacer;

Figure 3 shows a photograph of the cement-like material after undergoing flexure with the appearance of the initial fissures;

Figure 4 is a schematic view of the device for determining the modulus of rupture and the elastic limit.

With reference to Figure 1, this shows the stress/curvature diagram for test piece No. 1 prepared and tested as described in the experimental part.

In Figure 2 the anodic strips 1 are fixed by fixing elements 3 onto the spacers of the cement-like material of the invention, these being of parallelepiped cross-section 2.

Figure 4 is a sectional view of the test device with the test piece 4 positioned on movable rods 5. The cell 6 transmits the load to the displacement transducer 7.

EXPERIMENTAL PART

Materials

a) Cement

The samples were prepared using 525 Portland cement. The characteristics of this cement are given in Table 1.

b) Aggregates

The mortars were formed using fine siliceous sand. The particle size distribution of the sand is shown in Table 2.

TABLE 1: 525 Portland cement

TEST	MEASUREMENT UNIT	VALUE
Loss on ignition	%	4.02
MgO	%	1.91
SO_3	%	3.23
Insoluble residue	%	0.51
Flexural strength		
7 days	kg/cm^2	84
28 days	kg/cm^2	90
Compressive strength		
7 days	kg/cm^2	536
28 days	kg/cm^2	618
Initial setting time	h.min	1.34
Final setting time	h.min	2.20

TABLE 2

Particle size distribution of siliceous sand	
SIEVE MESH mm	TOTAL PASSING %
0.850	100.00
0.600	99.15
0.425	82.65
0.300	68.85
0.212	55.60
0.150	45.90
0.106	38.85
0.075	33.30
0.045	28.05

c) Fly-ash

The fly-ash used in forming some of the mixes originated from ENEL thermoelectric power stations, its chemical composition and particle size distribution being shown in Table 3.

TABLE 3: Fly-ash: composition and particle size distribution

Loss on ignition	7.34
SiO_2	48.98
Al_2O_3	25.74
Fe_2O_3	7.88
CaO	2.51
Carbon	4.70
Dry residue	
(Alpine)	
40 µm	27.2
63 µm	18.6
90 µm	10.9
200 µm	9.5

d) Admixtures

The superfluidifier Superflux[R] was added to most mortars in a quantity of 0.3 wt% on the total of cement plus sand.

The following were added to some mixes:
Dow Latex[R] N 465; acrylic lattice in a quantity of 0.1% on the sum of the constituents
Resin Lattice CM 1046, in a quantity of 0.3% on the sum of the constituents
Methylcellulose Methocell XZ 86248[R] in a quantity of 0.5 wt% on the sum of the constituents.

e) Polypropylene mesh

In the sheets comprising continuous fibrillated polypropylene mesh between 2 and 8 layers of mesh, 4 in most cases, were inserted, each mesh, of the Retiflex[R] type, comprising 12 sheets, 8 parallel and 4 transverse to the bobbin unwinding direction.

f) Fibres

The following "dispersed" fibres were added to the cement matrix of some of the mixes:

- Cellulose Arbocell[R] type NF 8/2.

Its characteristics are: density 1.3-1.5 g/cm^3, average fibre thickness 30 µm, average fibre length 1000 µm, cellulose percentage 80-90%.

- Cellulose Arbocell type ZZ 8/1.

Its characteristics are similar to the preceding, but its average fibre thickness is 45 µm, average fibre length 1100 µm and cellulose percentage 75-80%.

- Polyacrylonitrile SIPA C/15-6[R].

Its characteristics are: density ≈ 1.18 g/cm^3, average fibre thickness 6 µm, ultimate elongation 9-10%, modulus of elasticity 234,000 kg/cm^2.

- Kevlar[R] 49.

Aramidic fibre of high modulus of elasticity, with a fibre length of ≈ 6000 µm. Its characteristics are density ≈ 1,45 g/cm^3, ultimate elongation 26%.

- Polyvinyl alcohol Kuralon[R].

Density ≈ 1.30 g/cm^3, modulus of elasticity 370,000 kg/cm^2.

- Polypropylene Moplefan[R].

Fibre obtained by cutting Retiflex mesh.

g) Mix compositions.

The mix compositions are given in Table 4.

TABLE 4

Mix compositions								
Component %	Mix No.							
	1	2	3	4	5	6	7	8
525 Ptl	60	60	60	60	60	70	60	60
Silica	40	40	40	20	40	30	40	40
Superflux		0.3	0.3	0.3				0.3
Methocell		0.05		0.05				
Cellulose NF		0.75						
Polypropylene			0.75	1				
Fly-ash				20				
Additive 1046				0.3				
P.vinylalcohol						0.25		
P.acrylonitrile					0.75			
Kevlar								0.25
3 layer mesh							x	
4 layer mesh	x	x	x	x	x	x		x

EXAMPLE 1 - Preparation of samples

The samples, in the form of sheets of size 30 x 45 cm were prepared using a suitable mould formed from a perforated steel plate supported by welded vertical elements and channel sections.

The interior of the mould was connected to a vacuum pump via a robber connector. A piece of fabric stretched by a metal frame was placed on the perforated plate. The metal frame also acted as a template for the thickness of the sheets.

The mix ingredients were weighed out and mixed using a Hobart mixer of 5 litres capacity. The various components were poured into the mixer operating at low speed. After one minute the mixer was halted, the contents remixed with a spatula and the mixer operated again at higher speed.

The mortar consistency after mixing was measured by a slump test.

Using a measuring cylinder having a volume equal to the volume of the sheet divided by the number of layers, the fresh mortar was withdrawn from the mixer container and poured onto the mould. The mortar was spread by a trowel using a template, and after every layer a piece of fibrillated polypropylene mesh previously cut to size was inserted if required.

After applying the mortar and mesh layers the upper surface of the sheet was smoothed by rolling, during which the mould interior was put under a vacuum of 200 mmHg for 2 minutes 30 seconds by means of the vacuum pump.

Certain sheets were instead compressed by a hydraulic press at a pressure of 20 kg/cm^2, this having little effect on the final porosity of the sheets but providing them with uniform thickness.

When the samples had been made up they were each placed on a steel sheet and inserted into a sealed plastic bag where they remained for 24 hours at 20 °C.

After this initial curing, the samples were taken from their bag, suitably marked and placed in water at 20 °C, where they remained until the required degree of curing was achieved.

After curing, the sheets were cut into test pieces of suitable dimensions for the various tests.

EXAMPLE 2 - Modulus of rupture

The determination of the elastic limit stress and the modulus of rupture, this being the maximum stress between the elastic limit and a 27.5 cm radius of curvature deformation of the fibre mesh-reinforced samples, were carried out as follows:
the samples, prepared as in Example 1, were obtained by cutting the cured sheets with a diamond-set saw blade to a size of 7 x 30 cm. Before the test, the thickness and width were measured to an accuracy of 0.1 mm.

The determinations were made with a test machine operating at constant deformation increase rate, the speed of movement of the movable cross-member being set at 50 µm/sec. The load was measured with a load cell of 200 kg capacity connected to a suitable amplifier to provide a sensitivity of 10 g.

The apparatus by which stress was applied to the test piece consisted of two rods which moved such that the intermediate region of the test piece was subjected to a constant moment.

The supports and the loading points acting on the test piece are cylindrical with a radius of 5 mm. Suitable articulated support joints enable the test piece to be flexurally stressed without introducing torsional effects. A flexometer for measuring curvature is applied to the test piece before it is inserted into the test machine. The flexometer consists of a frame with two supports 70 mm apart, and an inductive transducer with a measurement range of +5 mm and a sensitivity of 0.02 mm (see Figure 3).

The test is conducted at a constant deformation increase rate until a radius of curvature of 27.5 cm is reached. The load and curvature values are recorded every 0.3 seconds during the test by a miniprocessor. On termination of the test, the miniprocessor produces the following results: stress at elastic limit, maximum stress, modulus of elasticity and stress/curvature graph.

The results obtained after 7 and 28 days are shown in Tables 5 and 6 respectively. They represent the average of two determinations and were obtained on both wet and dry test pieces.

Table 5

Limit of elastic proportionality and maximum stress measured up to 27.5 cm radius of curvature deformation on mesh-containing sheets after 7 days				
Mix No.	7 DAYS			
	DRY		WET	
	Elastic limit	Max stress	Elastic limit	Max stress
1	-	-	-	-
2	133.2	170.0	87.5	127.2
3	150.0	179.0	177.0	160.0
4	98.0	154.0	59.0	114.0
5	156.0	185.0	112.0	139.0
6	140.0	179.7	92.7	147.9
7	120.0	136.0	110.0	117.0
8	135.0	197.6	109.0	103.2

TABLE 6

Limit of elastic proportionality and maximum stress measured up to 27.5 cm radius of curvature deformation on mesh-containing sheets after 28 days				
Mix No.	28 DAYS			
	DRY		WET	
	Elastic limit	Max stress	Elastic limit	Max stress
1	154.0	182.0	92.5	137.9
2	-	-	-	-
3	,152.0	194.0	140.0	140.0
4	-	-	80.0	131.0
5	172.0	179.0	122.0	154.0
6	164.0	224.3	98.9	104.5
7	134.0	171.0	169.0	129.0
8	155.0	200.0	133.0	179.0

Claims

1. An anodic structure for the cathodic protection of concrete reinforcement, the structure being covered with poured concrete and comprising a plurality of apertured strips of valve material or valve material alloy coated with an electrocatalytic layer, electrical connection elements and spacers of a cement-like material which support said strips on the reinforcement, characterised in that the cement-like support material is of composite type comprising dispersed, continuous or meshed fibres of a non-conducting material or a polymer material.

2. The structure of claim 1, characterised in that the fibres of the composite cement-like material are chosen from fibres of polyethylene, polypropylene, teflon, polyamide, polyester, polyvinylalcohol, cellulose and polyacrylonitrile, their copolymers or their mixtures.

3. The structure of claim 1, characterised in that the cement-like material comprises fibrillated polypropylene meshes.

4. The structure of claim 1, characterised in that the composite cement-like material is a macrodefect-free (MDF) cement comprising organic polymers.

5. The structure of claim 4, characterised in that the polymer content of the cement-like material is between 0.1 and 10% by weight.

6. The structure of claims 4 and 5, characterised in that the polymers used are chosen from:
   - alkyl ethers and hydroxyalkyl cellulose, preferably methylcellulose, hydroxyethylcellulose, methylhydroxyethylcellulose, ethylhydroxyethylcellulose, hydroxypropylcellulose, hydroxypropylmethylcellulose or, hydroxybutylmethylcellulose:
   - acrylamide or polyacrylamide polymers, preferably polyacrylamide, polymethacrylamide or acrylamide/methacrylamide copolymer;
   - hydrolyzable polymers or copolymers of vinylacetate, in particular polyvinylacetate;
   - polyvinylalcohol polymers and copolymers;
   - polyalkylene oxide derivatives, preferably polyalkylene glycols of molecular weight exceeding 10,000;
   - polyalkoxy derivatives of alcohols or phenols;
   - polymers of methylmethacrylate with acrylic, methacrylic, crotonic or similar unsatuated carboxylic acids;
   - copolymers of methylmethacrylate with ethylacrylate, ethylhexylacrylate, butylacrylate or similar acrylic acid esters;

- copolymers of vinylacetate with esters of acrylic, methacrylic, crotonic or similar unsaturated carboxylic acids;
- copolymers of vinylacetate with acids or salts;
- copolymers of vinylpyrrolidone with acids and which include esters of these acids as monomers;
- partly hydrolyzed polymers and copolymers of acrylamide, methacrylamide and acrylonitrile;
- graft copolymers of polyethylene oxide with copolymers of acrylic and methacrylic acid, methylacrylate or methylmethacrylate.

7. The structure of claim 1, characterised in that the composite cement-like material comprises the polymers of claim 6 and the fibres of claim 2.

8. The structure of claim 1, characterised in that the cement-like material presents a fine multiple bending fracture without any separation.

9. The structure of claim 1, characterised in that the composite cement-like material has a fibre content of between 0.1% and 15% by weight, and preferably between 0.5% and 5% by weight.

10. A method for constructing an anodic structure for the cathodic protection of concrete reinforcement, the structure comprising a plurality of apertured strips of valve material or valve material alloy coated with an electrocatalytic layer, electrical connection elements and spacers of a cement-like material, said spacers being laid on the reinforcement, said strips being connected together by the connection elements and the continuous anodic structure thus formed being covered with poured concrete, characterised in that the cement-like support material is of composite type comprising dispersed, continuous or meshed fibres of a non-conducting material or polymer material.

11. A reinforced concrete structure which in addition to concrete comprises iron reinforcement, an anodic structure and a composite cement-like material as described in the preceding claims, these being in place before the concrete is poured.

12. The use of a composite cement-like material comprising dispersed, continuous or meshed fibres of a non-conducting material or polymer material in a cathodic protection method.

Fig.1

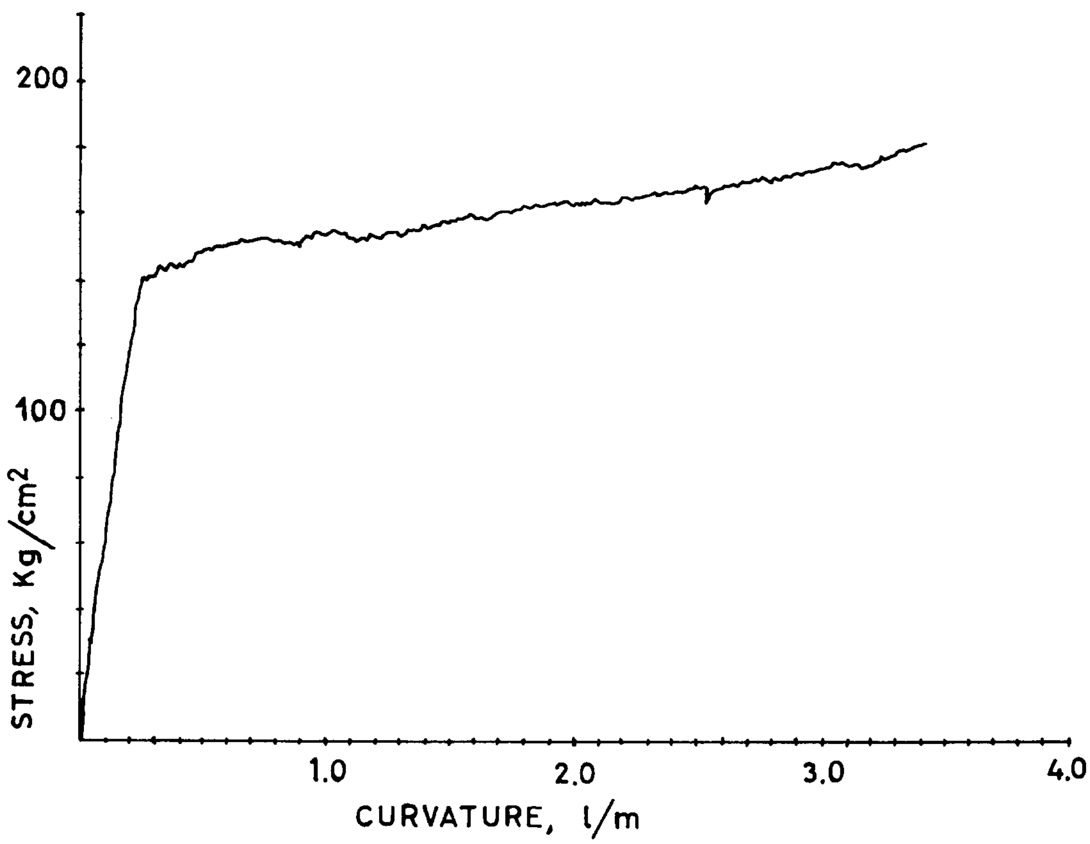


Fig.2

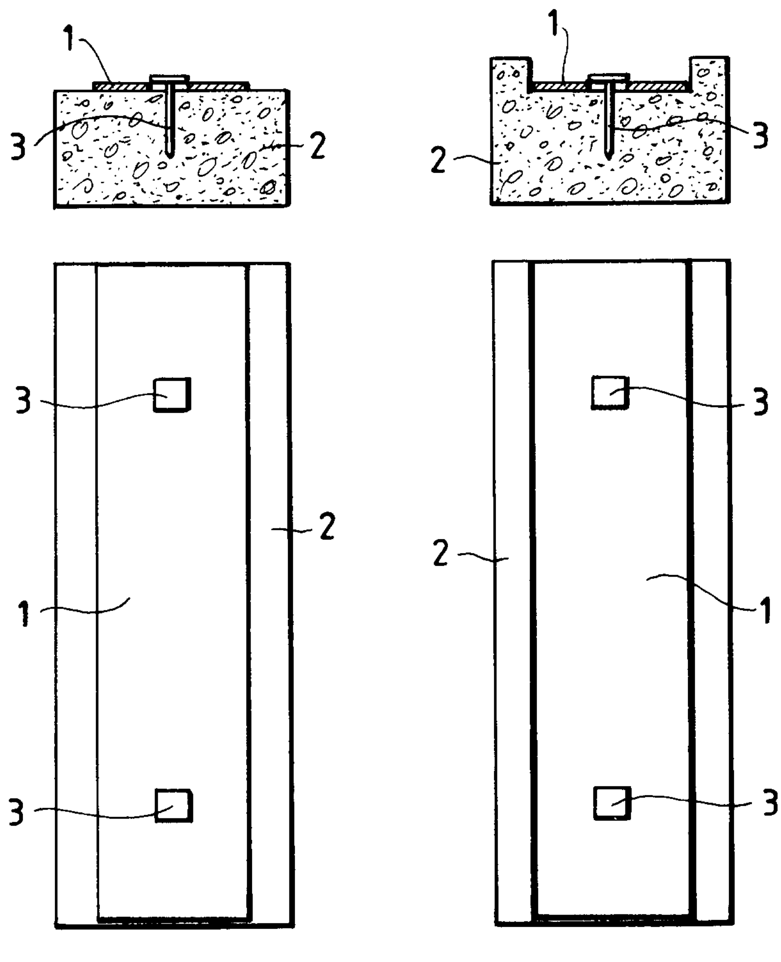


Fig.3

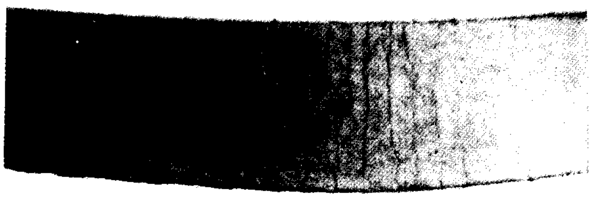
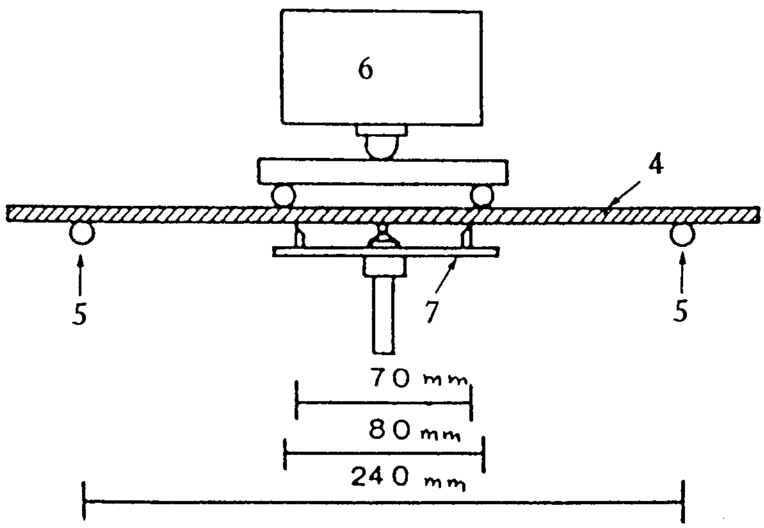


Fig.4



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EUROPEAN SEARCH REPORT

Application Number

EP 93 20 0692

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 262 835 (RAYCHEM CORPORATION) * claims; figures * ---	1-12	C23F13/18
A	EP-A-0 407 348 (ELTECH SYSTEMS CORPORATION) * the whole document * ---	1-12	
A	WO-A-9 119 829 (SAVCOR-CONSULTING OY) * the whole document * ---	1	
D,A	GB-A-2 175 609 (MARSTON PALMER LIMITED) * claims; figures * -----	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

C23F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	19 MAY 1993	KAUMANN E.K-H.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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