

AUSTRALIA

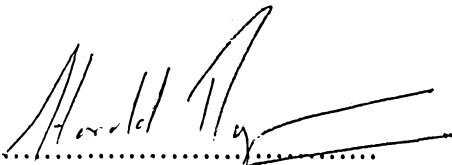
PATENTS ACT 1990

660802

NOTICE OF ENTITLEMENT

We, HAROLD ROPER of 115 Manning Road, Woollahra, New South Wales 2025, Australia and THE MINISTER FOR PUBLIC WORKS FOR AND ON BEHALF OF THE STATE OF NEW SOUTH WALES, of New South Wales Public Works Department, 2-24 Rawson Place, McKell Building, Sydney, New South Wales 2000, Australia, being the applicants in respect of Application No. 40369/93, state the following:-

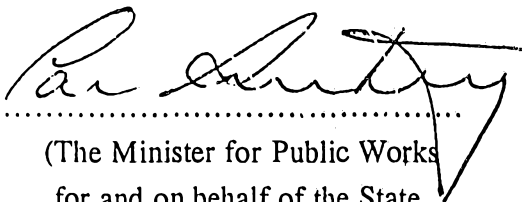
1. Harold Roper, a person nominated for the grant of the patent, is the actual inventor; and The Minister for Public Works for and on behalf of the State of New South Wales a person nominated for the grant of the patent has entitlement from the actual inventor by assignment.
2. The provisional application listed in the declaration made under Article 8 of the PCT was filed in Australia not more than 12 months before the filing date of this application.
3. The persons nominated for the grant of the patent are the applicants of the application listed in the declaration under Article 8 of the PCT.



(Harold Roper)

22/11/94

(Date)



(The Minister for Public Works
for and on behalf of the State
of New South Wales)

10 JAN 1995

(Date)

File: 16937.80

SHELSTON WATERS
55 CLARENCE STREET, SYDNEY, AUSTRALIA



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METHOD FOR INHIBITING CONCRETE CANCER
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- (71) Applicant(s)
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- (56) Prior Art Documents
AU 55815/90 E04B 1/64
EP 200428
CH 676978
- (57) Claim

1. A method for removal of chloride from concrete having a reinforcing member embedded therein, the method comprising the steps of:
 - (a) mounting an electrolytic layer in conductive contact with the concrete, said layer comprising a moisture absorbing matrix in which is embedded an electrode, said matrix containing a particulate conductor distributed therein; and
 - (b) applying a voltage between the reinforcing member and the electrolytic layer so as to cause migration of chloride ions from the concrete into the electrolytic layer.

20. An electrolytic layer for use in removal of chloride from concrete, said layer comprising an

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electrode which is embedded in a moisture absorbing matrix comprising cellulose or a polymer sponge, the matrix containing a distribution of conductive materials.

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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<p>(21) International Application Number: PCT/AU93/00173 (22) International Filing Date: 21 April 1993 (21.04.93) (30) Priority data: PL 1999 21 April 1992 (21.04.92) AU (71) Applicant (for all designated States except US): THE MINISTER FOR PUBLIC WORKS for and on behalf of THE STATE OF NEW SOUTH WALES [AU/AU]; NSW Public Works Department, 2-24 Rawson Place, McKell Building, Sydney, NSW 2000 (AU). (71)(72) Applicant and Inventor: ROPER, Harold [AU/AU]; 115 Manning Road, Woollahra, NSW 2025 (AU).</p>		<p>(74) Agent: ERNST, Ian, Thomas; Shelston Waters, 55 Clarence Street, Sydney, NSW 2000 (AU). (81) Designated States: AT, AU, BB, BG, BR, CA, CH, CZ, DE, DK, ES, FI, GB, HU, JP, KP, KR, KZ, LK, LU, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SK, UA, US, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i></p> <p style="text-align: center;">660802</p>
<p>(54) Title: METHOD FOR INHIBITING CONCRETE CANCER</p> <p>(57) Abstract</p> <p>Chloride is removed from concrete by mounting an electrolytic layer in conductive contact with the concrete. The layer comprises a moisture absorbing matrix, for example papier-mache, in which is embedded an electrode. The matrix contains distributed carbon particles. A voltage is applied between the electrolytic layer and concrete reinforcing to cause migration of the chloride ions to the layer.</p>		

Title: "METHOD FOR INHIBITING CONCRETE CANCER"

TECHNICAL FIELD

The present invention concerns a method for rapid removal of chlorides from reinforced concrete structures.

BACKGROUND ART

Deterioration of concrete structures is often the consequence of depassivation of reinforcement in the presence of chloride ions within the concrete pore solution. In order to limit the auto-catalytic corrosion process of steel corrosion in the presence of chloride ions and prevent cracking and spalling of the surrounding concrete, or as a prelude to the repair of these defects if already manifest, reduction of the chlorides in the region of the reinforcement is necessary. In the case of prevention, attempts are made to stifle the corrosion by application of coatings or by means of a cathodic protection system attached to the

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concrete surface. As a rule, both damaged concrete and sections of physically sound, chloride contaminated concrete must be removed by using concrete saws, power hammers, chisels, and other tools, or by water blasting prior to repair. This work is labour intensive and may result in damage to the concrete left in situ.

An alternative method of chloride removal is by inducing outward diffusion of the chlorides under a direct current field as described by Slater, J.E. et al., "Materials Performance", 15(11) 1976, pp 21-26. The method is based on applying an electric field between the reinforcement which acts as the cathode and a planarized titanium anode supported within a calcium hydroxide solution either with or without an ion exchange resin. This technique has been of limited use because:

- (i) the high amount of energy that Slater states is necessary is prohibitive both for security and economic reasons.
- (ii) the method is feasible only for the upper surface of horizontal plates or slabs, because a liquid electrolyte is used.

Removal of concrete from horizontal surfaces by mechanical methods is a relatively simple operation and therefore not expensive. Slater's method for removal of chlorides in concrete on horizontal surfaces is expensive compared to simple, mechanical methods.

In U.S. Patent No. 4,832,803 Vennesland et al sought to provide an alternative method that requires smaller amounts of energy and one that can be used not only on horizontal surfaces but others, and is less expensive than the existing known methods. To achieve this, they allowed slow removal of chlorides to reduce the necessary requirement of current and voltage. They state, that it is advantageous to use an electrolyte different from calcium hydroxide solution, in order that other types of surfaces can be treated. They note, that the main demands on such an electrolyte are that it should have high conductivity and that it should adhere to vertical surfaces and to downward facing surfaces. The electrolyte also must be easy to remove and may not cause a reduction in the adhering ability of any possible subsequent repair of concrete.

In their method a thin net electrode is attached to the outer surface of reinforced concrete. A thin electrolytic layer of a viscous, self-adhering, set retarded material such as gunite is applied to the outer surface of the reinforced concrete so as to cover the net electrode. A relatively low level direct current between the reinforcing members and the net electrode is applied so as to cause the chloride ions within the said concrete to migrate to the electrolytic layer. Once the chloride in the electrolytic layer reaches a pre-determined value, the electric current is

disconnected.

Some of the disadvantages observed with this system are:

- (i) slow removal of chlorides is advocated, thus leading to long periods of use of the most expensive equipment necessary for chloride removal, namely the field generator.
- (ii) the mesh must be attached to the concrete prior to applying the self adhering set retarded material to the concrete surface.
- (iii) if left on the surface, the electrolytic layer is a source of chlorides which, once the current is switched off, can rapidly re-difuse to the steel corrosion sites.
- (iv) the spraying of gunite may not be feasible on many structures such as city buildings and, if not, completely removed may tend to disfigure the surface.

In Australian Patent Application 55815/90 Vennesland et al., sought to provide an alternative method for overcoming the forementioned disadvantages. in which an exterior surface of the concrete is sprayed with an adherent temporary coating of a fibrous cellulosic material, in which a mesh electrode is embedded. This method suffers the disadvantages that:

- (a) spraying of self adherent material onto the exterior surface of the concrete creates serious problems in removal of the self adherent material once

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chloride removal from the concrete has been accomplished;

(b) once the charge is switched off, the self adherent material cannot be easily removed, thereby allowing rediffusion of chloride ions to take place.

(c) spraying of self adherent material is a costly labour intensive procedure which does not guarantee a uniform thickness of the self adherent material; and

(d) (Amended) the time required to obtain removal of chlorides from the concrete is longer than desirable.

It has been proposed to realkalize concrete which has become neutralized by the absorption of carbon dioxide or sulphur trioxide leading to a neutralization of the alkaline environment of steel reinforcement with consequent corrosion. That has been achieved by utilizing an alkaline medium such as calcium sodium or potassium hydroxide during application of an electric field of between 6 and 20 volts but this method also suffers from disadvantages similar to those discussed above.

The present invention seeks to overcome these disadvantages by providing a method which removes chlorides under a significant range of applied currents and voltages, which can be easily used on any surface whether vertical, angled or horizontal, using electrodes



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that can be made off-site and, although simply held against the concrete surface, provide intimate electrical contact and chloride diffusion paths having low resistance during the whole process.

DISCLOSURE OF THE INVENTION

According to one aspect, the present invention consists in a method for removal of chloride from concrete having A reinforcing member embedded therein, the method comprising the steps of:

- (a) mounting an electrolytic layer in conductive contact with the concrete, said layer comprising a moisture absorbing matrix in which is embedded an electrode, said matrix containing a particulate conductor distributed therein; and
- (b) applying a voltage between the reinforcing member and the electrolytic layer so as to cause migration of chloride ions from the concrete into the electrolytic layer.

According to a second aspect, the present invention consists in an electrolytic layer for use in removal of chlorides in concrete, said layer comprising an electrode embedded in a moisture absorbing matrix, the matrix containing a distribution of conductive particles, and preferably a hydroxide.

According to a third aspect, the invention comprises a method for treating concrete comprising the steps of:-

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(i) removing chloride ions and
(ii) subsequently treating the concrete with an alkali silicate. Desirably, the treated concrete is additionally treated with silane, preferably alkyltrialkoxo silane.

BEST MODES FOR CARRYING OUT THE INVENTION

The invention will now be more particularly described by way of example only.

In a preferred embodiment of the invention an electrode assembly is first manufactured. The electrode assembly consists of a wire net embedded in papier-mache to which is added lime and powdered carbon. The electrode assembly is manufactured on, and further includes, a panel which assists in handling the assembly.

After the electrode assembly has been prepared it is mounted in contact with the concrete to be treated, the papier-mache surface abutting the concrete. A plurality of electrode assembly panels are typically mounted side by side.

The electrode assembly constitutes an electrolytic layer comprising the papier-mache as a moisture absorbing matrix in which the wire mesh electrode is embedded. The matrix contains powdered carbon as a particulate conductor.

The wire mesh of the electrolytic layer is then connected to the positive (anode) terminal of an EMF source and the reinforcement of the concrete is

connected to the cathode. Typically, a 240 volt AC input transformer and rectifier power supply producing a rectified DC output rated at 100 volts and 10 amps is used as the EMF source. Desirably, the papier-mache is moistened. When the current is switched on chloride ions migrate from the concrete into the electrolytic layer and sodium ions migrate towards the reinforcement.

Following the removal of chloride from the concrete, a sodium silicate solution is applied to re-establish alkalinity of the concrete and block any minor cracks thus reducing the potential for steel corrosion to recommence. The application of a silane solution has also been found to be beneficial.

Although in the preferred embodiment a wire mesh electrode is employed, the electrode may be formed of any material which is capable of passing an electrical charge. Preferably, the electrode is a distributed electrode and is constructed of electrically conductive strands which could, for example, be made of graphite, carbon fibre yarns, steel or steel with a carbonaceous coating, platinized titanium or any other metallic or electrically conductive substance.

The physical and electrical characteristics of the strands should be selected by the intended use of the invention. If the strands do not have sufficient current-carrying ability to provide the desired current density at all the points when connected with the power

supply at a single point, then connection can be made at a plurality of points.

In a highly preferred aspect of the invention, the electrode is formed of bird wire. The wire strands may be formed either as a plurality of elongate strands which are joined to each other to form a flexible open mesh or separated as individual strands. The mesh may consist substantially of electrically conductive strands, or it can contain in addition to the electrically conductive strands, non-conductive strands which help to provide an open mesh structure. When non-conductive strands are present they can all run in one direction, or some can run in one direction and others in a difference direction; similarly the conductive strands can all run in one direction, or some can run in one direction and others in another direction.

The strands can be joined together directly or indirectly in a convenient way, for example, by knotting or melt-bonding or with the aid of adhesive or clips. There can be electrical as well as physical connections at junction between electrically conductive strands. The preferred size of the mesh depends somewhat upon the installation, bearing in mind, both the electrochemical and physical requirements, including in some cases, the relative coefficients of thermal expansion of the strands and the materials contacting them.

The aperture size can be of any dimension but is

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preferably from 1 to 20 cm. It is desirable that the apertures of the mesh should be sufficiently large to ensure that the moisture absorbing matrix can bond to the mesh, thus avoiding the possibility that the anode will create a plane of weakness in the layer. The apertures in the mesh can be of any shape. Preferably, the size and shape of the apertures are uniform throughout the electrode.

Calculations should be made of the amount of metal required so that the mesh does not disintegrate before the chloride is removed.

The particulate conductor may, in principle, be formed of any material which conducts electrical charge. Preferably, the conductor is particulate carbon but could be, for example, magnitite, coke breeze, metal powder such as steel powder or any other electrically conductive material. The particulate conductor increases conduction through the matrix and aids the even distribution of current in turn permitting higher voltages and currents to be employed.

The moisture absorbing matrix may, in principle, be formed of any material which is capable of retaining moisture and, in such condition, having an adequate level of conductivity. Preferably, the matrix is composed of cellulosic fibres such as a papier-mache-like cellulosic material formed of a mixture of cellulosic pulp in water or other solution.

Other types of matrices may, however, be employed in the present invention, an example of which would include polymer sponge matrices. In a highly preferred embodiment of this invention, the method advantageously utilizes a conventional form of paper-making pulp, preferably but not necessarily formed of recycled or waste paper.

The inclusion of lime in the electrolytic layer is desirable but not essential. Lime provides ionic transfer of the electrical energy and further reduces electrical resistance.

Desirably the anode electrolytic layer anodes are mounted against the concrete surface by jacking the form board into position. However, it will be understood that the layer need only be in conductive contact and one or more additional conductive substances may be placed between the electrolytic layer and the concrete.

The method of removing chlorides from concrete preferably involves a process whereby a metal mesh electrode is encapsulated in wet paper pulp to which a quantity of powdered graphite has been added. Supported on a non-conductive material the electrode-pulp mix is clamped against a wet concrete surface and current is allowed to pass between it as the anode and the reinforcement as the cathode within the concrete. Ion diffusion takes place from the concrete and chlorides are concentrated within the pulp in proximity of the

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mesh which undergoes oxidation. When sufficient chlorides have been removed, to ensure passivity of the steel, the electrode-pulp layer is removed.

Current passes through the pulp both via water and carbon, wherein the carbon particles ensure an even charge distribution. Subsequent treatment with a sodium silicate solution ensures re-alkalization of the concrete, and is a pore blocker at the same time. Final treatment with a silane ensures that further chloride ingress is reduced to a minimum. For example, a 40% by weight solution of alkyl trialkoxy silane in an anhydrous solvent may be used at 3 - 4 sq.m./l coverage.

A particular embodiment of a method according to the invention will now be described:

PREPARATION OF THE CONCRETE MEMBERS

In order to allow the flow of current in the concrete members, a connection must be made to the reinforcement of each individual precast member and each concrete segment from which chloride ions are to be removed. Also, the concrete from which the chlorides are to be removed should be as damp as possible before commencement of current flow.

The continuity of the reinforcement in the structure should permit a single connection to be made to any one precast member surface, but each concrete structure/segment which is to be treated should be separately connected.

The method of connection should commence with the location of the reinforcing bar within the concrete area to be treated. This may be achieved by passing an electromagnetic cover meter probe over the surface and marking the pattern of major bars and stirrups in the section. The connection should, if possible, be made between stirrups onto a main bar itself. At such an expected location about a 100 mm diameter hole should be drilled into the concrete using a diamond bit so as to intersect the bar without damaging it or inducing significant cracking of the concrete. All drilling should be facilitated by clamping an electric drill to a guide-bar. A dust sheet which may also need to be water-proof should be used to protect the drill itself.

Using a reaming tool the hole should be locally enlarged over and around the bar so as to allow sufficient workspace to permit the welding of a connection bar to it. The connection should be a round steel bar of at least 7 mm diameter, and may be threaded at the exposed end to allow connection of lead wires to be made between nuts. This connection bar should be hard pressed into a shallow hole drilled into the reinforcing bar. Using a flame or preferably an electric spot welder, an enduring weld of minimum electrical resistance was formed between the connection and reinforcement bars.

Once the connection bar had been welded in place,

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the opening in the concrete should be sealed with a non-conductive organic material, preferably an epoxy, although an epoxy modified cement may be used if placement is difficult. The hole around the connection bar should be first capped by cementing with a quick setting adhesive, a piece of perspex or similar plastic material to the concrete surface. The connection bar should protrude through a hole in the perspex and any air gap sealed with the quick set cement. Through the perspex sheet a further two holes should be drilled, one to permit the introduction by pump of epoxy, and the other to allow a thin hollow bleed tube to be placed deep into the cavity so as to allow air to escape during filling. Once the bleed-tube has allowed escape of epoxy, it should either be withdrawn or itself filled. The epoxy used for the void filling can be of the same type as used for crack sealing.

After connections has been made, to the connecting bar, the protruding portion of the bar and wires should be sealed against water ingress by painting on an epoxy. The reason for this is that any current flow directly to the anode from this cathodic point may reduce considerably the efficiency of the removal process.

Prior to mounting of the anodes, the concrete to be treated should be thoroughly wetted down with fresh water and not allowed to dry until the current is

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switched on. The reason for this is that the chlorides travel through the water provided on their way out the concrete. Unavoidable heating effects during current flow reduce the available water and dries the concrete, thus slowing the process of chloride removal. It is, therefore, imperative that the concrete to be treated is as wet as possible when current flow starts.

MANUFACTURE OF ELECTROLYTIC LAYER

The electrolytic layer or anode serves several purposes. They allow the current to flow through the concrete in an even manner. Current passes through them by way of ion passage as well as by normal conduction through the carbon granules. The carbon in the form of graphite serves to increase the conduction of the papier-mache and to spread current evenly over the concrete surface. Lime is desirably added to provide for ionic transfer of the electrical energy and to protect the reinforcing steel against corrosion. The papier-mache serves as an extender for the graphite, a storage cell for the lime, if present, a sink for the extracted chloride ions and an environment in which the anodic reactions, which lead to the oxidation of the bird-wire to occur.

A sheet of formboard should be selected and a hole drilled, where necessary, to accommodate the cathode connection bar and any other metallic inserts not removable from the structure. Bird-wire must be folded

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so as to form four layers and cut so that it overlaps the board. Holes should be made in it to correspond to those in the formboard.

A mix of papier-mache, (i.e. shredded newsprint or similar paper, water and wallpaper paste), was made up to a consistency so that it could be spread on the board and pass between the opening in the wire yet retain a considerably quantity of water. 10 gms of powdered graphite and builders lime per 1 kg of dry paper used should then be added.

A layer of the mache mix about 10 mm thick should be spread on the board and the four layers of bird wire anode should be placed thereon in such a manner as to force the mache through the holes in the netting and totally encapsulate the individual strands. Care should be taken to align any holes made in the mesh with those in the formboard. Extra mache may be built up until a sandwich filling of the wire on the board was encapsulated within the mache, except for those wire sections which have been left to overlap the board. These should not be covered. The mache should be kept wet during these procedures and should be wet but not completely plastic when eventually placed in contact with the wet concrete surface. If it is seen to be advantageous for handling and erection the wire can be stapled to the board at this stage.

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MOUNTING OF ANODES

The anodes must be mounted against a wet concrete surface so that current flow and chloride capture within the mache can occur. No direct contact should be allowed between any embedded metals partly within the concrete and the anodes or direct shorting of the current may occur.

Mounting of anodes should be in such a way that no metallic fixings come in contact with the live wires or papier-mache. The anodes at all operating stages should be in intimate contact with the concrete. Cognisance was taken of relaxation of any supports or board deflection which would allow movement away from the treated surface.

The anodes can be mounted using a series of small car jacks or similar. Mountings may be made using the jacks or by ropes using tightening toggles. The concrete should be thoroughly wetted in advance, and gently sprayed with potable water immediately prior to pressing the anode into contact with the surface. The pressing should not be so violent as to severely dry the anode sandwich. There should be minimum delay between placing the anode in contact with the concrete and the switching on of current. For that reason, any connections which can be made should precede this step.

CONNECTIONS

The connections couple the anode and the

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reinforcement cathode to the transformer/rectifier. Several points are of importance. Polarity must be checked before switching on as if reverse polarity is applied the reinforcement will corrode and no chlorides will be removed. The lead and conduction rod to the reinforcement cathode must be completely insulated with epoxy at any joints or shorting will occur. Several connections will need to be made to the overlapping sections of wire mesh left for this purpose as this wire is consumed during current flow and problems will result if the current path is interrupted.

Current polarity of leads connecting to the reinforcement is critical. If the positive lead is by chance connected to the reinforcement and the current allowed to flow, rapid corrosion of any connections being made. Connections were made using 16 sqmm or greater insulated flexible colour coded cable. The positive connections were made with red insulated cable and the negative with black.

The connections to the reinforcement were made via a series of nuts and washers. These connections should be carefully insulated by encasement in epoxy resin or some other organic mastic.

Connections to the bird-wire anode may be made at several places to the overlapping section left for this purpose. Portions of the net should be twisted to form connection points and these should be attached by a

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crimp to the wire. Provided these wires or connections do not touch any other metal they need not be further insulated.

CURRENT APPLICATION

The flow of current allows the movement of chlorides from the zone of concrete between the outermost reinforcement and the surface of the member into the papier-mache.

The current should be switched on as soon as possible after installation of the anode. Note, should be taken of the time, voltage, amperage and the variac dial reading. At this time, the polarity of the system should again be checked by use of a volt meter. The amperage should be held at 10 A, or the corresponding voltage should be at or below 100V. As drying and heating occurs the resistance and voltage will be found to increase. The voltage can be held at 100V by varying the amperage. The system should be shut down after approximately three days.

SWITCH OFF AND ANODE REMOVAL

Once resistance has risen too much, or a period of three days has passed, the system should be switched off and the anode removed. It is of importance that the anode materials is removed as soon as possible after switching off of the system, as there is always the possibility of the chlorides re-entering the now more porous concrete.

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The system should be switched off after a period of three days after commencement of treatment. Also, the system should be switched off if the potential cannot be held at or below 100V by varying the amperage. The anode material must be removed after switching off to avoid re-diffusion of the chlorides back into the porous concrete. The concrete should be kept dry and removal of any adherent papier-mache should be carried out by scraping rather than water-jetting. The cleaner the concrete surface and the drier it is held the better it will be for realkalization and pore-reduction treatment.

REALKALIZATION AND PORE-REDUCTION TREATMENT

As removal of chloride results in an increase in permeability of the concrete treated, and OH^- ions may move outward with the Cl^- ions it is important that pore blocking is carried out and that realkalization of the concrete is achieved. These two processes may be achieved at the same time by the treatment of the concrete surfaces with sodium-silicate in the presence of calcium ions which undergoes base exchange, forming insoluble calcium silicate hydrate, a product virtually identical to that formed by hydration of cement, and sodium hydroxide, a very strong base. The insoluble silicate acts to block the pores, whereas the soluble hydroxide ion protects the steel from further corrosion.

Application, of a sodium-silicate product to the dry surface of the treated areas should be undertaken

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immediately after removal of the last portion of the papier-mache material. The directions given by the product manufacturers should be followed precisely except that treatment should be carried out up to the stage that further absorption of the material during treatment is obviously reduced. This may mean that several coats should be applied.

PREPARATION OF SILANE TREATMENT

The objective of this treatment is to dry the surfaces so that silane penetration can be facilitated. Penetration depths can be doubled by drying.

The residual materials of the sodium silicate treatment should be removed by brushing, light sanding or shotblasting. Importantly, the treatment selected should not involve rewetting of the surface or expose large areas of coarse aggregate. By using a paint remover or any other means of passing dry air over the concrete surface, the surface of the concrete can be dried to at least a few millimeters deep so as to facilitate silane uptake. The surface should be then allowed to cool before applying the silane.

SILANE TREATMENT

The use of a solution of 40% by weight alkyltrialkoxysilane in an anhydrous alcohol solvent has been found to be very beneficial in reducing chloride ingress both in the USA and the UK. An application rate of about 3 sq m/l for horizontal surfaces and 4 sq m/l

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for vertical surfaces is recommended in US literature.

The silane should be applied using a low pressure airless type spray at a nozzle pressure of between 100 and 275 kPa. Contamination of the silane with water prior to application must not be permitted. Moisture contamination will cause polymerization and the silane will no longer have the capacity to react with concrete to cause it to be water and chloride repellent. After application the silane should be given sufficient time to penetrate into the concrete, then the surfaces should be sprayed with water to allow reaction with the concrete by hydrolysis.

RESULTS

To determine chloride content of concrete before and after treatment, samples were obtained by drilling holes in concrete beams and collecting the dust produced. By analysing the dust from different depths separately, it was possible to determine chloride concentration profiles within the concrete.

In all cases, current was allowed to flow for a period of about 3 days. As a rule, voltage commenced at a low value, but rose to about 100 volts, the level at which it was held by varying the amperage. The analytical results of chloride content are detailed below.

TABLE 1TEST RESULTS

			PRE-TREAT #1
			4-OCT-90
SAMPLE	DEPTH		CHLORIDE %
1C-1	0 - 25		0.31
1C-2	25 - 50		0.13
1C-3	50 - 75		0.12
	AVERAGE		0.25
			POST-TREAT #1
			23-OCT-90
SAMPLE	DEPTH		CHLORIDE %
2C-1	0 - 25		0.05
2C-2	25 - 50		0.11
			(Note sample locations 2C and 3C correspond to location 1C)
2C-3	50 - 75		0.04
	AVERAGE		0.07
			POST-TREAT #2
			27-NOV-90
SAMPLE	DEPTH		CHLORIDE %
3C-1	0 - 25		0.01
3C-2	25 - 50		0.01
3C-3	50 - 75		0.01
	AVERAGE		0.01

TABLE 1: shows the pre-treatment and post-treatment chloride content of concrete. A comparison is also made of chloride content following treatment with an electrolytic layer void of carbon (Treatment #1) as compared to treatment with an electrolytic layer

containing carbon (Treatment #2). These results indicate that the chloride content after Treatment #2 was on average lower than the results obtained from Treatment #1. Hence, the results indicate an improvement in chloride removal when graphite is present in the papier-mache layer.

Although the invention has been described with reference to particular embodiments, it will be understood that the electrolytic layer may be embodied in other forms and may be used for similar applications without departing from the scope hereof and that the method may be varied to an extent which will be apparent from the teaching herein contained.

6. A method according any one of the preceding claims wherein the electrode comprises a plurality of electrically conductive strands which are arranged in a mesh like structure.
7. A method according to claim 6 wherein the strands are in electrical contact with each other.
8. A method according to any one of the preceding claims wherein the particulate conductor is selected from the group consisting of particulate carbon, magnite, coke breeze or metal powder.
9. A method according to Claim 8 wherein the particulate conductor is carbon.
10. A method according to any one of the preceding claims wherein the moisture absorbing matrix is selected from the group consisting of cellulosic fibres or polymer sponge matrices.
11. A method according to any one of the preceding claims wherein the moisture absorbing matrix comprises cellulosic fibres.
12. A method according to any one of the preceding claims wherein the matrix is papier-mache.
13. A method according to any one of the preceding claims wherein the applied voltage is from 1 to 120 volts.
14. A method according to Claim 13 wherein the applied voltage is from 50 to 110 volts.
15. A method according to any one of the preceding claims further including the further step of removing the

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- 28 (Amended) -

claims 20 to 23 further comprising a hydroxide.

25. (Deleted)


26. (Deleted)

27. (Deleted)

28. (Deleted)



IPEA/SUBSTITUTE SHEET

A. CLASSIFICATION OF SUBJECT MATTER Int. Cl. ⁵ C04B 41/72, E04B 1/64, C25F 7/00 According to International Patent Classification (IPC) or to both national classification and IPC				
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC C25F 7/00, E04B 1/64, C04B 41/72, 41/53, 41/00 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched AU: IPC as above Electronic data base consulted during the international search (name of data base, and where practicable, search terms used) DERWENT: C25F 7/00 and (partic: or fib: or strand); E04B 1/64 and concret: C04B 41/72, 41/53, 41/00 and (electrod: or cathod: or anod:) CHEM. ABS: (partic: or fib: or strand) and concret: and (electrod: or cathod: or anod:)				
C. DOCUMENTS CONSIDERED TO BE RELEVANT				
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.		
X Y	AU,A,55815/90 (VENNESLAND et al) 13 December 1990 (13.12.90) claims, page 9 lines 3-19 page 6 lines 15-22	1-16, 17 24, 27, 28 17, 18, 25-27		
X	EP,A,200428 (NOTEBY, NORSK TEKNISK) 5 November 1986 (05.11.86) claims 1 and 4	1-9, 15, 20		
X	CH,A,676978 (HELBLING) 28 March 1991 (28.03.91) page 2 lines 23-24, page 3 lines 25-31	20, 23		
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.				
* Special categories of cited documents : <table style="width:100%; border:none;"> <tr> <td style="width:50%; border:none;"> "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed </td> <td style="width:50%; border:none;"> "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family </td> </tr> </table>			"A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family
"A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family			
Date of the actual completion of the international search 1 July 1993 (01.07.93)		Date of mailing of the international search report 8 JULY 1993 (8.07.93)		
Name and mailing address of the ISA/AU AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No. 06 2853929		Authorized officer  M. BREMERS Telephone No. (06) 2832052		

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim No.
Y	GB,A,2071173 (ALEXANDER) 16 September 1981 (16.09.81) claims	17,18,25-27
Y	G.G. HAWLEY, "The Condensed Chemical Dictionary" Ninth Edition, published 1977 by Van Nostrand Reinhold Company (New York) page 800-801 ("sodium silicate")	17,18,25-27

Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)	
This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:	
1.	<input type="checkbox"/> Claims Nos.: because they relate to subject matter not required to be searched by this Authority, namely:
2.	<input type="checkbox"/> Claim Nos.: because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3.	<input type="checkbox"/> Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).
Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)	
This International Searching Authority found multiple inventions in this international application, as follows:	
The international application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept. In coming to this conclusion the International Searching Authority has found that there are two inventions:	
1. Claims 1-24 define a method or electrolytic layer for the removal of chlorides from concrete. These claims include the features of an electrolytic layer comprising an electrode embedded in a moisture absorbing matrix containing conductive particles.	
2. Claims 25-26 define a method of treating concrete by removing the chloride ions by electro osmosis and then treating the concrete with an alkali silicate.	
The specification admits that removing chlorides from concrete by electro osmosis is known. Therefore, there is no single inventive concept common to all of the claims.	
1.	<input type="checkbox"/> As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims
2.	<input checked="" type="checkbox"/> As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3.	<input type="checkbox"/> As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4.	<input type="checkbox"/> No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
Remark on Protest	
<input type="checkbox"/>	The additional search fees were accompanied by the applicant's protest.
<input type="checkbox"/>	No protest accompanied the payment of additional search fees.

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
AU	55815/90	BR	9000476	CS	9002336	EP	398117
		ES	2022031	HU	57344	JP	2302384
		PL	285207	PT	94043	YU	946/90
		US	4832803	US	5198082	NO	901965
		EP	200428	DK	6074/85	EG	18053
		NO	851521				
EP	200428	DK	6074/85	EG	18053	NO	851521
		US	4832803	US	5198082	BR	9000476
		CS	9002336	EP	398117	ES	2022031
		HU	57344	JP	2302384	NO	901965
		PL	285207	PT	94043	YU	946/90
		AU	55815/90				
END OF ANNEX							