

CONNECTOR FOR USE IN CATHODIC PROTECTION AND METHOD OF USE.

Field of the Invention

5 This invention relates to the cathodic protection of steel in reinforced concrete employing a sacrificial anode, more particularly to an electrical connector for connecting the sacrificial anode to the reinforcing steel it is intended to protect and to a method for the installation of the anode.

10 Background of the Invention

Sacrificial anodes are well known. To be effective the sacrificial anode is made of a metal which has a more negative electrode potential than the steel to be protected so that it will corrode in preference to the steel. Sacrificial anodes are described in European Patent No 0707667 and United States Patent No 5292411.

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Problem to be solved by the Invention

To fulfil its purpose the sacrificial anode needs to be connected electrically to the steel to be protected. Metal conductors have been previously used for this purpose. Previously these metal conductors such as wires, have been attached to
20 the steel reinforcement by drilling a hole into which a self tapping screw is inserted. Alternative methods have involved the use of clips or clamps to secure the wire to the metal to be protected.

These methods have problems in that the drilling of holes and use of self tapping
25 screws is time consuming and there is always a risk that the clips and clamps may be dislodged.

The present invention provides a solution to these problems by the use of a ductile elongate connector that is connected to the steel reinforcing element by
30 winding the connector around the reinforcing element..



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Summary of the Invention

According to the present invention there is provided an assembly for use in the cathodic protection of steel reinforcement in reinforced concrete said assembly comprising:

- 5 (i) an anode of a metal having a more negative electrode potential than steel and, in electrical contact therewith,
- (ii) an elongate electrical connector made of a ductile metal capable of being wound around the steel reinforcing element to be protected.

10 Advantageous Effect of the Invention

The connector can be installed in less time than the previously used methods involving the use of self tapping screws and is more secure than the clips or clamps.

15 Brief Description of the Drawings

Fig 1 is a perspective view of one embodiment of the invention in which two wires are twisted together

Fig 2 is a perspective view on a smaller scale than Fig 1 in which the anode has been cast around the wires of the connector and

- 20 Fig 3 is a perspective view on the same scale as Fig 2 of another embodiment in which the anode is surrounded by a mortar which has been cast around it.

Detailed Description of the Invention.

- 25 The anode is preferably zinc but aluminium, cadmium or magnesium may be used. References to these metals include alloys containing them.

The electrical contact between the connector and the anode is preferably provided by having the anode in the form of a block which has been cast (by cast we mean allowing the liquid metal to solidify to form the block) around a portion of the length
30 of the elongate connector. Alternatively the electrical contact may be provided by the elongate connector being wound around the anode or by the connector being soldered or similarly attached to the anode.

The elongate connector is conveniently in the form of a wire, although other elongate forms may be used. The wire may conveniently be of steel, preferably a
35 mild steel.

Preferably the wire is as noble or more noble than the steel of the reinforcement.

The connector may comprise a plurality of wires twisted together over a portion of their length and the anode may be cast around the twisted portion. By the word twisted we mean to include folded or bent or crimped. The purpose of the twisted portion is to increase the surface area of the wire forming the interface with the cast anode and thereby improve the electrical contact. The wires may be twisted together at a position which is intermediate their ends (for example near the middle of their lengths) so that lengths of wire extend on both sides of the cast anode.

Patent Application No WO 94/29496 (European Patent Application No 0707667) describes a method of cathodic protection in which to maintain the cathodic protection over a sustained period of time the anode is surrounded by a material containing an electrolyte of high pH. To avoid passivation of the anode it recommends that in the case of a zinc anode the pH is at least about 14.

Suitable materials described in this patent are cementitious mortars which may be cast around the anode to form a unit. It is not essential that the mortar is cementitious although such mortars are more readily available. The mortar may be prepared from a cement that has an intrinsically high alkali content or additional alkali may be added to the mortar eg sodium hydroxide or lithium hydroxide, the latter being preferred.

The assembly of anode and connector of the present invention may have a porous material eg a cementitious mortar cast around the anode. By cast we mean forming a solid block from the liquid or semiliquid mortar. The casting is preferably carried out in a mold. The porous material is one that preferably contains a high pH electrolyte as described in European Patent Application No 0707667 ie one containing an electrolyte solution whose pH is sufficiently high to maintain corrosion of the anode and passive film formation on the anode to be avoided when the anode is galvanically connected to the steel reinforcement. In the case of a cementitious mortar the electrolyte solution is the pore solution.

The mortar will preferably have a content of alkali equivalent to at least 1% lithium hydroxide based on the dry weight of the ingredients used to make the mortar. An equivalent amount of sodium hydroxide is 2% by weight. Conveniently the amount of lithium hydroxide is greater than 2% or an equivalent amount of sodium hydroxide of 4%.

Lithium hydroxide is the preferred alkali because lithium ions provide protection against alkali silica (or alkali aggregate) reactions in concrete. However mixtures of alkalis may be used for example mixtures of lithium hydroxide and sodium hydroxide.

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The anode, the porous material eg mortar and the casting may also be as described in European Patent Application No 0707667.

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According to another aspect of the present invention there is provided a method of installing a sacrificial anode to protect the reinforcement of reinforced concrete which method comprises the following steps (a) and (b) in any order

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(a) making an electrical connection between an elongate connector and the anode and

(b) making electrical contact with the steel reinforcement by winding the elongate connector around the steel reinforcement.

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The step (a) may comprise casting the anode around a portion of the length of the elongate connector.

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A further step (c) may be carried out before or after step (b) which step (c) comprises casting around the anode a porous material containing an electrolyte solution having a pH sufficiently high for corrosion of the anode to occur and passive film formation to be avoided.

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Preferably the anode is zinc in which case the pH of the electrolyte solution is desirably at least about 14. When the anode is of another metal such as aluminium the pH may be lower, for example at least 13.3 or 13.5

The pH may be determined by measuring the hydroxyl ion concentration and applying the equation

$$\text{pH} = 14 + \log (\text{OH}^-) \text{ after Sorensen.}$$

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The invention is applicable to the construction of new reinforced concrete structures in which the anode assembly is connected to the reinforcement by means of the connector and a high pH porous material such as a mortar cast around the anode.

The invention is also applicable to the protection of existing concrete structures in which method a hole may be made in the concrete and (i) the anode inserted into the hole and (ii) the connector connected to the reinforcement and (iii) the high pH material cast around the anode. Steps (i), (ii) and (iii) may be carried out in any order

Referring to Fig 1 of the drawings two wires each being a 16 SWG (standard wire gauge) mild steel wire are twisted together over part of their length at 6. The length of the twisted portion 6 is typically from about 38 to 42 mm. Four lengths of wire in the form of arms 2, 4, 8 and 10 extend from the twisted portion 6. The length of the arms 2, 4, 8 and 10 is typically from about 148 to 152mm and at the end of each arm are loops 12, 13 14 and 15. The arms are each wound around the reinforcement. Usually one or two complete winds around the reinforcement is sufficient to make a satisfactory electrical contact. The diameter of the loops is typically from about 9 to 11mm. The purpose of the loops is to facilitate the use of a tool of the type used to close paper sacks for potatoes and the like. A suitable tool is a spring loaded ratchet twisting tool known as the Stanley tying tool and is available from Direct Wire Ties Limited. By means of the tool the arms which have been wound around the steel reinforcement (not shown) in reinforced concrete may then be twisted together. This has the effect of tightening the wire around the reinforcement.

In Fig 2 a cylindrical zinc block 20 of about 40 mm diameter and about 7mm thickness has been cast around the twisted wires. In the Figure the centre of the cylindrical block 20 has been omitted to show the wires. The top and bottom edges of the block 20 have been rounded to prevent crack inducement.

The assembly shown in Fig 2 was made by first twisting the wires together near the middle of their length and placing the twisted portion in a ceramic casting mould. Molten zinc was then poured into the mould. After solidifying the product which was removed from the mould. The wire arms 2, 4 8, and 10 extend on both sides of the anode and enable the anode to be connected to more than one reinforcing element if desired.

In Fig 3 a block of mortar 24 has been cast around the zinc shown in Fig 2 to give a thickness of 10 mm all round the zinc.

The assembly shown in Fig 3 was made by positioning the assembly shown in Fig 2 in a previously vacuum formed plastic mould so as to locate the zinc centrally in the mould. A high pH cementitious mortar containing a pore solution of pH greater than 14 was prepared by mixing a Portland cement powder (containing 2% by weight of added lithium hydroxide based on the weight of the cement powder) with water and poured into the mould. This was allowed to harden for four hours and then removed from the mould to yield the product shown in Fig 3.

CLAIMS

1. An assembly for use in the cathodic protection of steel reinforcement in reinforced concrete said assembly comprising:

- 5 (i) an anode of a metal having a more negative electrode potential than steel; and
(ii) an elongated electrical connector physically and electrically connected to said anode and made of a ductile metal; and

wherein said anode is in the form of a block formed around a portion of the length of said elongated connector.

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2. An assembly as claimed in claim 1 wherein said elongated connector is in the form of at least one wire.

3. An assembly as claimed in claim 1 wherein said elongated connector comprises a
15 plurality of wires twisted together over a portion of their length, and wherein said anode has been formed around said twisted portion.

4. An assembly as claimed in claim 3 wherein said wires are twisted together at a position intermediate their ends so that said wires extend outwardly from more than one
20 side of said anode.

5. An assembly as claimed in any of the preceding claims wherein said anode is enclosed in a porous material which has been cast around said anode, said porous material containing an electrolyte solution whose pH is sufficiently high for corrosion of

said anode to occur and passive film formation on said anode to be avoided when the anode is galvanically connected to a concrete steel reinforcement.

6. An assembly as claimed in claim 5 wherein said anode is made of zinc and said
5 porous material is a cementitious mortar containing an electrolyte solution of pH at least about 14.

7. An assembly as claimed in any one of the preceding claims in combination with a
concrete steel reinforcing element; and wherein said assembly is connected to said
10 reinforcing element by winding said elongated connector around said reinforcing
element.

8. An assembly as claimed in claim 7 wherein said elongated connector comprises at
least one wire of a material as noble or more noble than the steel of said steel
15 reinforcing element.

9. An assembly as recited in claim 7 or claim 8 wherein said elongated connector
comprises a plurality of wires twisted together over a portion of their length, and
wherein said anode has been formed around said twisted portion.

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10. An assembly as claimed in claim 9 wherein said wires are twisted together at a
position intermediate their ends so that said wires extend outwardly from more than one
side of said anode.

11. An assembly for use in the cathodic protection of concrete-reinforcing steel reinforcing elements, said assembly comprising:

at least first and second wires twisted together at a position intermediate their ends to form a twisted portion;

5 a block of anode material cast around said twisted portion, so that at least four wire arms extend outwardly from said block; and
wherein said wires are of ductile metal.

12. An assembly as recited in claim 11 wherein said anode is made of zinc, and wherein
10 said wires are mild steel, and wherein said anode is enclosed in a porous cementitious mortar containing an electrolyte solution of a pH at least about 14.

13. A method of making an assembly for use in the cathodic protection of steel reinforcement in reinforced concrete using an anode of a metal having a more negative
15 electrode potential than steel, and an elongated electrical connector made of a ductile metal, said method comprising:

(a) melting the metal for the anode, so that it is in liquid form;
(b) placing a part of the length of the connector in a mold; and
(c) casting the anode from the liquid metal in the mold to form a block of metal around
20 a portion of the length of the elongated electrical connector.

14. A method as claimed in claim 13 further comprising (d) producing a liquid or semi-liquid mixture of a porous material containing an electrolyte solution having a pH sufficiently high for corrosion of the anode to occur and passive film formation on the

anode to be avoided when connected to a steel reinforcement; and (e) forming a solid block of the mixture around the anode from (c).

15 15. A method of installing a sacrificial anode to protect the steel reinforcement of reinforced concrete which method comprises in any order:

(a) making an electrical connection between the sacrificial anode and an elongated connector made of a ductile metal;

(b) making electrical contact between the elongated connector and the steel reinforcement by winding the elongated connector around the steel reinforcement; and
10 after (b)

(c) tightening the electrical connector around the reinforcement by twisting the ends of the elongated connector together using a twisting tool.

16. A method as claimed in claim 15 wherein (a) is practiced by casting the anode from
15 a liquid metal in a mold containing part of the connector to form a block of metal around a portion of the length of the elongated connector.

17. A method as claimed in claim 16 further comprising, carried out before or after (b),
(d) casting around the anode a porous material containing an electrolyte solution having
20 a pH sufficiently high for corrosion of the anode to occur and passive film formation to be avoided.

18. A method as claimed in claim 17 wherein (a)-(d) are practiced using a zinc anode and using an electrolyte solution having a pH of at least about 14.