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(54) **SYSTEM FOR CONNECTING TOGETHER SHEET STEEL AND CONCRETE**

(57) Composite concrete-steel sheet structures usually suffer from the fault of relative separation or slipping of the two materials, for example, the fault of longitudinal slipping in composite slabs. The present invention consists of a steel sheet in which repeated series of many small crown-shaped breakages are generated. The

steeply inclined projections of said breakages are oriented towards the side of the sheet which will remain in contact with the concrete such that when concrete is poured onto the sheet, they are embedded therein and resist the shear forces which are usual in composite structures.

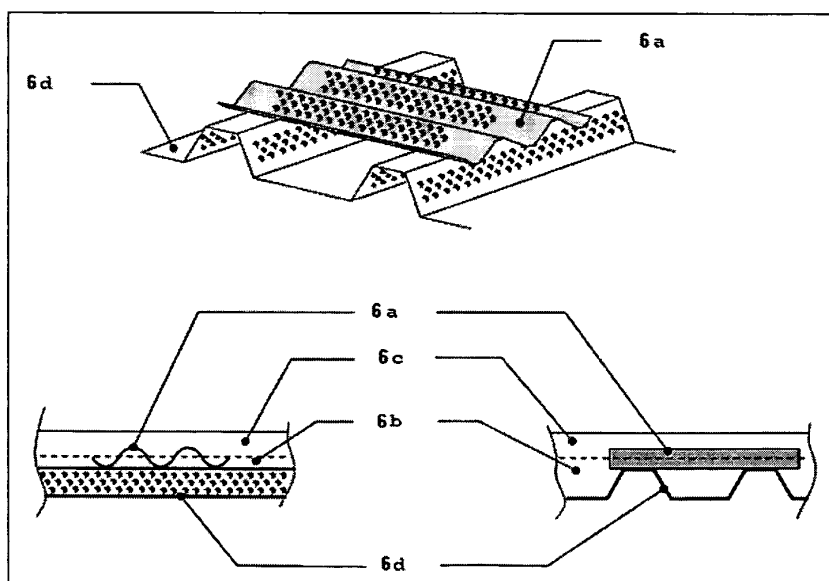


Fig. 6

Description

Field of the Art

[0001] The invention is comprised in the construction sector, particularly in the construction of concrete structures and composite steel-concrete structures.

Prior Art

[0002] The common fault of composite steel-concrete structural elements, such as composite slabs for example, generally occurs due to the relative slipping or separation of the steel sheet and the concrete. The design difficulty of sheets for composite slabs resides in assuring their effectively composite performance; i.e., in designing retaining systems achieving high resistance to the separation and relative slipping of steel and concrete.

[0003] Current sheet designs, such as that disclosed in patent W009321405, or FR2807081, among many others, for example, incorporate a pattern of deep drawings which are repeated along the entire length of the sheet. Their function is to hinder the longitudinal slipping similarly to the corrugation of the rods for reinforcing the concrete, although their resistance mechanisms are completely different. In composite slabs, the wedge effect of the deep drawings transforms the relative slipping of the steel sheet and concrete into stresses perpendicular to the sheet causing their transverse bending, the separation and relative slipping of the two materials and, in most cases, complete detachment.

[0004] The forming angle defining the ribs of the slab, the position of the deep drawings, their depth, length, etc., are some of the important design parameters because the slipping resistance depends on them. The design and optimization process of this geometry, and also efficacy testing, are currently performed in an entirely empirical manner. The computation methods adopted according to worldwide standards for the calculation of composite slabs are also based on experimental parameters obtained from testing small standard models. These tests attempt to reproduce, more or less truthfully, the fault of relative slipping of steel and concrete.

[0005] The doctoral dissertation entitled "Estudio Numérico y Experimental de la Interacción entre la Chapa de Acero y el Hormigón para la Mejora Resistente de las Losas mixtas frente al Deslizamiento longitudinal" (Numerical and Experimental Study of the Interaction between Steel Sheet and Concrete for the Improved Resistance of Composite Slabs to Longitudinal Slipping) by Miquel Ferrer Ballester and read on 8 March 2006 in the Universidad Politécnica de Cataluña (UPC), summarizes the prior art to date and is included in a line of research intended for improving the connection between the steel and concrete of current systems and devising innovative concepts which can mean complete connection without slipping.

[0006] The present invention has been developed

within the line of research in the Escuela Técnica Superior de Ingeniería Industrial of Barcelona (UPC), which substantially improves the relative connection problem of steel sheet and concrete both in the case of composite slabs and in other applications.

Detailed Description of the Invention:

[0007] The present invention relates to the connection between steel sheet by means of generating in the steel sheet a series of many small crown-shaped breakages (Figure 1-1b) oriented towards the side of the sheet which will remain in contact with the concrete (towards both sides alternately if needed, such that when fresh concrete is poured, the projections of said breakages are embedded therein.

[0008] When the concrete sets, these small breakages embedded therein have the function of resisting shearing stresses or separating stresses generated between both materials when the composite steel-concrete element is subjected to a load.

List of figures

[0009]

Figure 1 shows an example of steeply inclined projections caused by punching the sheet and a photograph of a prototype (case of planar sheet and crown-shaped breakages with 4 tips).

Figure 2 shows the typologies of the punched through crown-shaped breakage of 3 and 4 tips.

Figure 3 shows other breakage typologies (cylinder, cone, prism, diaboló).

Figure 4 shows projections formed by breakages in alternating directions.

Figure 5 shows the application to formed sections for composite columns or beams.

Figure 6 shows the application to profiled sheets for composite slabs.

Figure 7 shows the auxiliary device for pouring the concrete of composite slabs in two phases.

Figure 8 shows the auxiliary device for the connection between the metal section and the concrete in composite beams.

Ways of using the Invention

[0010] The present invention is additionally illustrated by means of the following examples which are not intended to limit the scope thereof.

Example 1:

[0011] In the case of cold-formed tubular sections, the present invention can be used to assure the connection of the metal section (with the inner concrete typical of a composite column. If the punching is towards the inside

of the tube, before or after the section forming process, when the concrete is poured into the tube, the projections are embedded in the fresh concrete. Once the concrete sets, they assure the effective connection of the two materials and their composite working.

Example 2:

[0012] In the case of composite slabs (forged elements cooperating together, Figure 5), the projections in the sheet (Figure 6-6a) are distributed in the most suitable areas, preferably the side flanks of the ribs, and as regularly as possible, to assure an effective connection with the concrete (Figure 6-6b). It does not lead to the relative vertical separation of the two materials since the sheet does not have the typical deep drawings of forged elements cooperating together, which cause the wedge effect that separates them. Furthermore, the bending strength of the sheet would be considerably maintained if the upper and lower planar bands are not perforated.

[0013] In the event that the apertures associated with the breakages of the sheet are open enough, the outer surface must be coated with a sealing layer (paint, impregnation, plastic film, vermiculite, etc.) which prevents fresh concrete from dripping while pouring the concrete.

Example 3:

[0014] The application of the present invention is also envisaged for improving the adhesion between different concrete pouring phases. The device consists of a planar, corrugated, or any other section sheet, the projections having been made in alternating directions, i.e., towards both sides (faces) of the sheet (see Figure 4). Therefore, by placing the device on the free surface of the first concrete pouring phase, the breakage crowns oriented towards it act as anchors and those oriented towards the outside will act as anchors in the next concrete pouring phase in the case of planar devices. In the case of ribbed devices, a part of the device is embedded in the concrete of the first concrete pouring phase and the other part is exposed to the air while waiting to be embedded in the concrete of the next phase.

Example 4:

[0015] Examples 2 and 3 can be combined to design an auxiliary device which serves as a connection when pouring the concrete of composite slabs in two phases, useful in reducing the loads of the building phase (see Figure 7).

[0016] Therefore, designing a device formed by a non-planar portion or sheet strip (corrugated, ribbed, etc.) such that part of the device is immersed in the fresh concrete of the first phase (Figure 7-7b), being supported on the ribs of the ribbed sheet of the composite slab (Figure 7-7d), and the other part being exposed above the free surface of the first concrete pouring is of interest. The

complete sinkage of the sheet in the fresh concrete of the first phase -which would probably occur if the sheet was planar- is prevented and the existence of raised sectors which will be embedded in the concrete of the second concrete pouring phase (Figure 7-7c), an efficient connection being assured.

Claims

1. A system for connection between steel sheet (Figure 1-1a), with a thickness equal to or less than 12 mm, and concrete, wherein the sheet has a repeated series of steeply inclined projections (Figure 1-1b) generated by local breakage of the sheet and oriented towards the side of the sheet in contact with the concrete, such that they are embedded therein after pouring the concrete, **characterized in that** said local breakages of the sheet are separated (Figure 1-1c) by a distance not less than the thickness thereof and not greater than 200 times said thickness, projecting from the surface of the sheet at a height between 0.1 and 50 times said thickness (Figure 1-1d), and the general size of the breakages (Figure 1-1e) is comprised between 0.5 and 100 times the thickness of the sheet.
2. The system for connection according to claim 1, **characterized in that** the breakages have a crown shape in a configuration of 3 or more tips (Figure 2-2a, Figure 2-2b), depending on the process used to make the local breakages, for example, depending on the shape of the punch.
3. The system for connection of claim 1, **characterized in that** the projections are arch-shaped.
4. The system for connection of claim 1, **characterized in that** the projections are cone-shaped.
5. The system for connection of claim 1, **characterized in that** the projections are diabolo-shaped.
6. The system for connection of claim 1, **characterized in that** the projections are prismatic-shaped.
7. The system for connection of claim 1, **characterized in that** the projections are pyramidal-shaped.
8. The system for connection of the previous claims, **characterized in that** the shape of the projections is any combination described in claims 3 to 7, such that the breakages in the sheet occur at the edges indicated as 3e in the corresponding figures (Figure 3-3e).
9. The system for connection of any of the previous claims, **characterized in that** the projections are

alternately incorporated towards both sides of the sheet -the latter being planar, corrugated or of any other section- to be anchored to the concrete present on both sides thereof (Figure 4-4a and Figure 4-4b).

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10. A use of the new system for connection of any of the previous claims,, wherein the steel sheet is subjected to a forming process to become a structural element, for example, a closed tubular (Figure 5-5a), circular or rectangular section, for use as a composite column or composite beam, the effective connection between the metal section and concrete being assured (Figure 5-5b). 10
11. A use of the new system for connection of any of the previous claims" wherein the steel sheet is subjected to a forming process to become a profiled sheet for composite slabs, whatever the shape of the section (for example Figure 6-6a), also referred to as forged elements cooperating together, the effective connection between the profiled sheet and the concrete thereof being assured (Figure 6-6b). 15 20
12. A use of the new system for connection of any of the previous claims in a corrugated (Figure 7-7a), trapezoidal or any other non-planar section sheet device intended for anchoring two concrete pouring phases, such that the lower part of the section of the device is embedded in concrete of the first phase (Figure 7-7b) and the upper part is exposed while waiting for the concrete of the second phase, at which time it will be embedded therein (Figure 7-7c), for example, in the case of composite concrete slabs poured in two phases shown in Figure 7. 25 30 35
13. A use of the new system for connection of any of the previous claims for the connection between the metal section (Figure 8-8a) and the concrete mass (Figure 8-8b) of an embedded composite or cantilever beam (cantilever case shown in Figure 8) by means of a planar (Figure 8-8c), corrugated, trapezoidal or any other section sheet device adhered by means of welding or other systems on the face or faces of the metal section which will remain in contact with the concrete, such that the projections incorporated in the sheet are embedded therein after pouring the concrete. 40 45 50 55

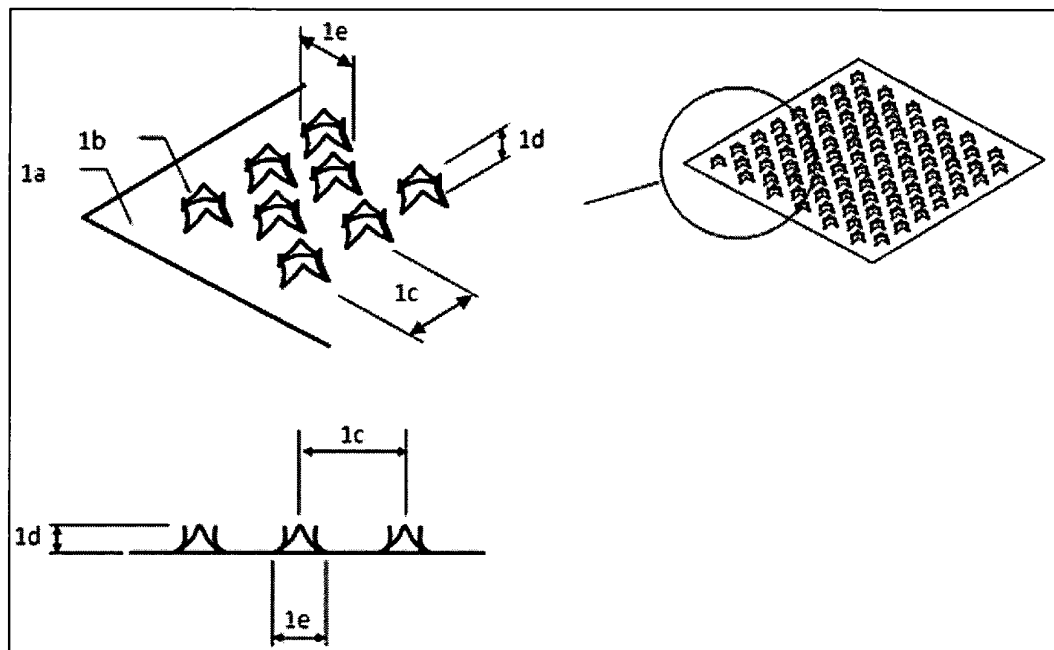


Fig. 1

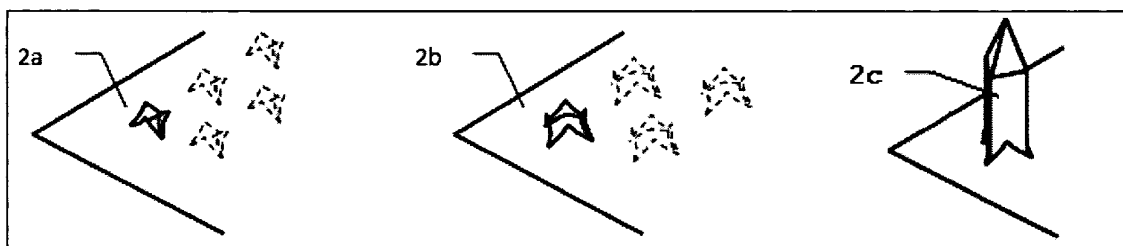


Fig. 2

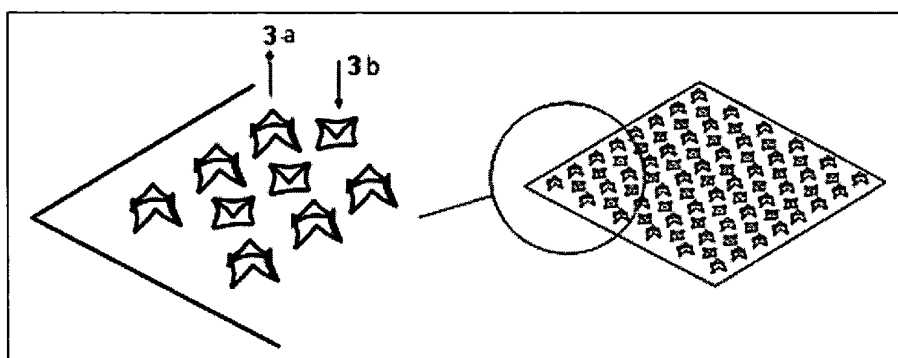


Fig. 3

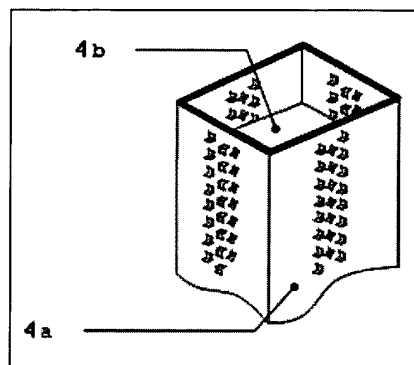


Fig. 4

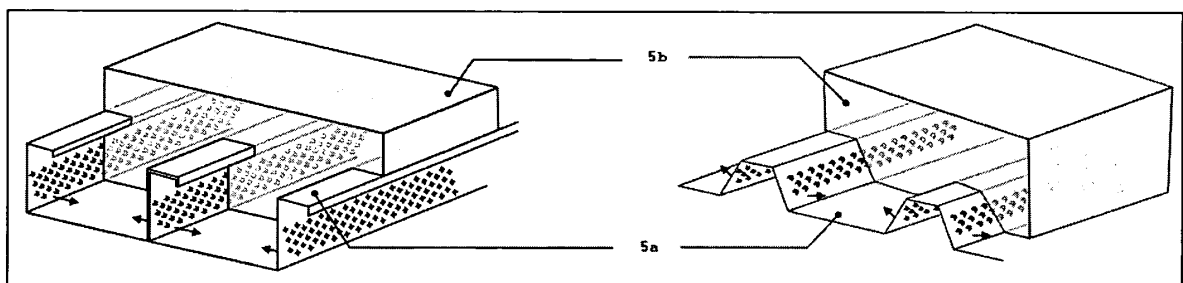


Fig. 5

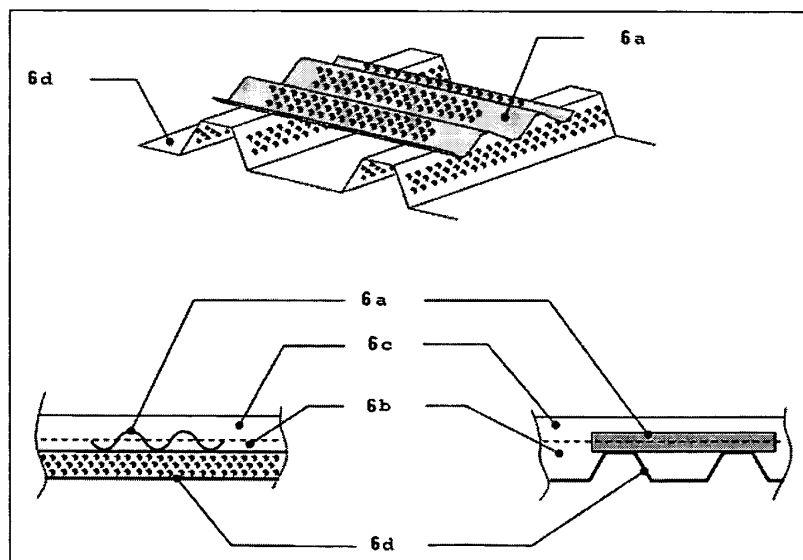


Fig. 6

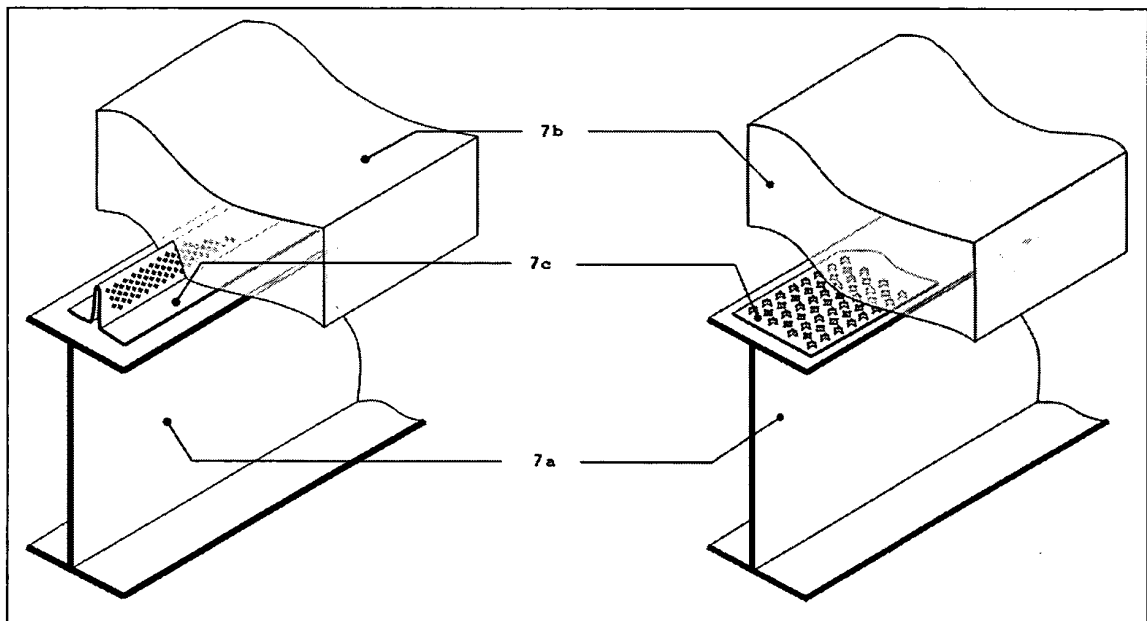


Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/ES 2009/000334

A. CLASSIFICATION OF SUBJECT MATTER

see extra sheet

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)

E04B5/+, E04C2/+, E04C5/+

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

INVENES, EPODOC, PAJ, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4251970 A (HOME MATTI P) 24.02.1981, the whole document.	1-13
X Y	DE 2325281 A1 (BOHM BETEILIGUNGSGESELLSCHAFT) 06.12.1973, the whole document.	1-8, 10-13 9
Y	SU 654780 A1 (UK NII METALLOV ; CH Z PROFILIROVANNOGO STALNOGO ; CH POLT I) 30.03.1979, figures and abstract WPI retrieved from the the base of datos EPOQUE.	9
X	ES 428827 A1 (W SOWA DIPL ING W REINSCH DR I) 16.12.1976, the whole document.	1-8, 10-13
X	US 4106249 A (MORTON VIRGIL R) 15.08.1978, the whole document.	1,3-8, 10-13
X	US 3496691 A (SEABURG PAUL A; OUDHEUSDEN ALBERT J) 24.02.1970, the whole document.	1,3-8, 10-13
X	EP 0372980 A1 (LYSAGHT AUSTRALIA LTD) 13.06.1990, figures and abstract WPI retrieved from the the base of datos EPOQUE.	1,3-8, 10-13

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

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C (continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of documents, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2201704 A (MONIER LTD) 07.09.1988, the whole document.	1,3-8,10-13
X	DE 2159959 A1 (SOWA WALTER DR ING) 14.06.1973, figures and abstract WPI retrieved from the the base of datos EPOQUE	1,3-8,10-13
X	WO 03085220 A1 (TONCELLI MARCELLO) 16.10.2003, figures and abstract EPODOC retrieved from the the base de datos EPOQUE	1,3-8,10-13

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EP 2 305 911 A1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/ ES 2009/000334

Patent document cited in the search report	Publication date	Patent family member(s)	Publication date
US 4251970 A	24.02.1981	NONE	-----
DE 2325281 A	06.12.1973	AT 328145 B AT 442372 A	10.03.1976 15.05.1975
SU 654780 A	30.03.1979	NONE	-----
ES 428827 A	16.12.1976	BE 818458 A SE 7409878 A NL 7410421 A DE 2339638 AB FR 2239570 AB DK 407374 A DK 136872 B DK 136872 C DE 2431913 A CH 582801 A AT 339554 B AT 639874 A GB 1469478 A IT 1017889 B SE 407602 BC	02.12.1974 05.02.1975 06.02.1975 20.02.1975 28.02.1975 24.03.1975 05.12.1977 16.05.1978 22.01.1976 15.12.1976 25.10.1977 15.02.1977 06.04.1977 10.08.1977 02.04.1979
US 4106249 A	15.08.1978	NONE	-----
US 3496691 A	24.02.1970	CA 928518 A	19.06.1973 19.06.1973 19.06.1973
EP 0372980 A	13.06.1990	EP 19890312803 AU 4553589 A AU 627245 B	08.12.1989 14.06.1990 20.08.1992
GB 2201704 AB	07.09.1988	US 4882889 A AU 611129 B	D1- E-LEP 1D- -LEP E1- -LEP E1- -LEP 1S- -LEP 1S- -E1D 28.11.1989 06.06.1991
DE 2159959 A B C	14.06.1973	NONE	-----
WO 03085220 A	16.10.2003	ITTV 20020034 CA 2482765 A EP 1490563 AB EP 20030720362 MX P US 2005055985 A US 7121053 B	06.10.2003 16.10.2003 29.12.2004 26.03.2003 11.01.2005 17.03.2005 17.10.2006

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/ ES 2009/000334

Patent document cited in the search report	Publication date	Patent family member(s)	Publication date
		US 2006254173 A	16.11.2006
		AT 382751 T	15.01.2008
		PT 1490563 E	04.03.2008
		ES 2298512 T	16.05.2008
			16.05.2008

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INTERNATIONAL SEARCH REPORT

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CLASSIFICATION OF SUBJECT MATTER

E04B 5/40 (2006.01)

E04C 2/08 (2006.01)

E04C 2/32 (2006.01)

E04C 5/12 (2006.01)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 09321405 A [0003]
- FR 2807081 [0003]

Non-patent literature cited in the description

- **Miquel Ferrer Ballester.** *Estudio Numérico y Experimental de la Interacción entre la Chapa de Acero y el Hormigón para la Mejora Resistente de las Losas mixtas frente al Deslizamiento longitudinal*, 08 March 2006 [0005]