

LEAK TIGHT JOINT AND METHOD, AND LEVELLING POLYMER FOR
PROVIDING A SMOOTH SURFACE ON A CONCRETE BODY BEING JOINTED

Field of the Invention

The invention relates to leak tight joints between
5 two segments, at least one of which is made of concrete. In
particular, the invention relates to leak tight joints, in
segmental constructions, including joints in containment
vessels having enclosures intended to be pressurized or under a
vacuum.

10 Background of the Invention

Concrete joints are commonly found in segmental
constructions wherein primary load bearing members are composed
of individual segments post-tensioned together after being
fitted together. In particular, individual concrete segments
15 are jointed, in horizontal or vertical spans for example, to
form larger structures. As such, segmental construction allows
smaller concrete segments to be pre-cast and then transported
to a site for assembly with size limitations on the pre-cast
concrete segments being imposed only by the manufacturing
20 process used, transportation and handling.

Segmental constructions are also found in concrete
containment vessels intended to be pressurised or under a
vacuum. In such vessels an important aspect of design relates
to joints between individual pre-cast concrete segments as well
25 as joints between concrete segments and metal segments. For
example, proper design of a joint between a concrete vessel and
its metal cover is necessary to ensure leak tightness of the
joint against liquids and gases for both short and long term
use.

In segmentally constructed structures, open joints and closed joints have been used to produce waterproof joints. In open and closed joints, gaskets made of polymer are placed between abutting pre-cast concrete segments or abutting pre-cast concrete and metal segments. A polymer is a viscoelastic material and therefore when a compressive force is applied to a gasket made of polymer it has the ability to shape itself to a surface profile of a surface upon which it is in contact. When such a gasket is placed between two segments being jointed, a compressive force is applied to the gasket through pre-stressing, post-tensioning or through the weight of one the segments being jointed. The gasket therefore shapes itself to the surface profiles of the segments down to a small length scale making it effective in providing leak tightness. In this way, polymers are well suited for making gaskets and these gaskets are crucial for jointing pre-cast concrete segments and concrete-metal segments. Furthermore, the gaskets have the added benefit of being easily manufactured irrespective of the complexity of the joint design. The gaskets can also be easily manufactured using a number of chemical components, each having respective physical properties. The chemical components are combined to provide improved physical properties such as improved elasticity and higher operating temperatures and to provide improved chemical properties such as resistance to acid attack.

Although gaskets made of polymer provide some leak prevention, there are limitations. In particular, a fundamental requirement for effective leak prevention is that an rms (root-mean-square) roughness of the surfaces in contact with the gasket, or equivalently an O-ring, must be less than or equal to 63 μm ; otherwise, gases or even liquids may leak through a joint containing the gasket. Surface preparation of concrete at a joint is therefore vital for achieving leak

tightness. Furthermore, surfaces being jointed must be free from all traces of foreign substances such as release agents, curing compounds, oil, dirt and loose concrete. The presence of such foreign substances on a concrete surface of a joint may
5 cause gas or even liquid to leak.

It is well known that for concrete surfaces of cast concrete segments, obtaining a surface finish having a rms roughness of 63 μm or less over large surfaces is almost impossible. As such, even with the use of polymer gaskets,
10 conventional open and closed joints are inadequate in providing leak tightness for concrete containment vessels under pressure or vacuum. Furthermore, the leak tightness of a joint may also depend on the alignment of the segments being jointed. In particular, improper alignment of the segments may lead to an
15 unequal loading on a gasket resulting in a reduction in long term leak tightness.

Another common practice involving the jointing of concrete-concrete and concrete-metal segments makes use of a polymer glue to seal joints. However, in joints in which
20 segments are glued, the segments are not detachable. Furthermore, such joints are not well suited for vacuum or pressure tight joints. These drawbacks are of special importance in cases where a detachable joint is required.

In pre-stressed concrete pressure vessels, when metal
25 segments, such as a metal cover for example, are required to be jointed to a concrete body, it is also common to embed a piece of metal into the concrete body for engaging with the metal segment. In such structures, it is difficult to maintain vacuum tight seal, against a pressure gradient, at an interface
30 between a smooth surface of the embedded metal segment and a rougher surface of the concrete body.

Object of the Invention

A principle object of the invention is to provide a leak tight joint, and method, between a concrete body and another body and to prevent premature failure of the joint.

- 5 Another object of the invention is to provide a smooth surface finish with an rms roughness of $63\text{ }\mu\text{m}$ or less at the surface of a concrete body. Yet another object of the invention is to provide a leak tight, but yet readily detachable, joint.

Summary of the Invention

- 10 A self-levelling polymer has a thermosetting resin which has a low viscosity before curing and provides a smooth surface finish and a high bond strength to a concrete segment once it is cured. The concrete body is jointed with another body. The other body may also be made of concrete in which
- 15 case it also has a smooth surface provided by the self-levelling polymer. The two bodies are jointed together with a sealing device, such as a gasket, an O-ring, a yarn or a seal for example, located between the smooth surfaces. The bodies are post-tensioned so that they are kept in place and to
- 20 provide a compressive force on the sealing device. With the sealing device being compressed between the smooth surfaces of the two bodies a very effective leak tight seal against gases and liquids is obtained. In particular, the self-levelling polymer provides a surface finish having a rms (root-mean-
- 25 square) roughness which is less than or equal to $63\text{ }\mu\text{m}$ which a maximum rms roughness for which a joint can provide an adequate leak tight seal and prevent premature failure of the joint. Such a joint is used in segmental constructions such as, for example, containment vessels which are pressurized or under a
- 30 vacuum. Furthermore, the joint is readily detachable. This is especially desirable in cases where the two bodies are required to be frequently detached. This is a common situation in a

leak tightness test facility designed for pressure and/or vacuum leak tightness evaluation of joints.

The leak tight joint provided by the invention, is also useful in the construction of large-scale leak tight enclosures such as enclosures for equipment in operation and for engine testing.

In accordance with a first broad aspect, the invention provides a self-levelling polymer for smoothing a first surface of a first concrete body which is to be jointed to a second body. The self-levelling polymer includes a thermosetting resin which flows before curing and which bonds to concrete when cured.

In accordance with a second broad aspect, the invention provides a first concrete body jointable to a second body. The first concrete body has a layer of a self-levelling polymer for smoothing a first surface of the first concrete body. The self-levelling polymer has a thermosetting resin which flows before curing and which bonds to the first surface when cured. In some embodiments of the invention, the layer of self-levelling polymer is provided over the first surface of the first concrete body by applying the thermosetting resin over the first surface; allowing the thermosetting resin to wet the first surface of the first concrete body; and allowing the thermosetting resin to cure.

In accordance with a third broad aspect, the invention provides a joint between a first concrete body and a second body. The joint has a sealing device located between the first concrete body and the second body and a layer of a thermosetting resin located between the sealing device and a first surface of the first concrete body. The thermosetting

resin is used for smoothing the first surface of the first concrete body.

In accordance with a fourth broad aspect, the invention provides a method of jointing a first concrete body and a second body. The method includes the steps of: smoothing
5 a first surface of the first concrete body with a layer of a thermosetting resin; aligning the first body and the second body in a manner that the first surface and a second surface of the second body substantially face each other; providing a
10 sealing device between the first surface and the second surface; and compressing the sealing device between the first concrete body and the second body.

In some embodiments of the invention, the sealing device is compressed by coupling together the first and second
15 bodies.

In all aspects of the invention, different types of thermosetting resins can be used including epoxy resins, unsaturated polyester resins, polyurethane resins, phenolic resins and other resins such as epoxy vinyl ester resins for
20 example. These resins have a low viscosity before curing and have high tensile strengths and large bond strengths when cured.

Brief Description of the Drawings

Preferred embodiments of the invention will now be
25 described with reference to the attached drawings in which:

Figure 1A is a perspective view of a first concrete body upon which is applied a self-levelling polymer according to an embodiment of the invention;

Figure 1B is a cross-sectional view of the first
30 concrete body of Figure 1A;

Figure 2 is a flow chart of a method of applying the self-levelling polymer of Figures 1A and 1B onto a rough surface of the first concrete body;

Figure 3 is a cross-sectional view of a joint between
5 the first concrete body of Figures 1A and 1B and a second concrete body;

Figure 4 is a flow chart of a method of jointing the two concrete bodies of Figure 3;

Figure 5 is a cross-sectional view of another joint
10 between two concrete bodies, according to another embodiment of the invention;

Figure 6A is an exploded view of a concrete container having a metal lid for sealing the container, according to another embodiment of the invention; and

15 Figure 6B is a cross-sectional view of a portion of the concrete container of Figure 6A.

Detailed Description of the Preferred Embodiments

Referring to Figure 1A, shown is a perspective view of a first concrete body 10 upon which is applied a self-levelling polymer 30 according to an embodiment of the
20 invention. The first concrete body 10 is a cast concrete segment which is shaped as a rectangular parallelepiped; however the shape is important for structural design purposes only and not to the invention. In Figure 1B, a cross-sectional
25 view of the first concrete body 10 has a first surface shown as a rough surface 20. The rough surface 20 has peaks 15 and dips 25 and also has other features, such as cracks, throats, crevices and interconnected cavities, which are generally indicated by reference numeral 50.

A backing strip 40 on a periphery 80 of the first concrete body 10 has portions 40A and 40B extending above and below the rough surface 20, respectively. The backing strip 40 is made of high density polyethylene; however, the invention is not limited to high density polyethylene and other materials may be used.

The self-levelling polymer 30 is made of a low viscosity thermosetting resin which is able to flow before it is cured and which bonds to concrete when cured. In particular, in some embodiments of the invention, the self-levelling polymer 30 contains a single component of thermosetting resin while in other embodiments of the invention the self-levelling polymer 30 contains a mixture of two or more thermosetting resins. The thermosetting resins include for example, epoxy resins, unsaturated polyester resins, polyurethane resins and other resins all characterised, in part, by low a viscosity before being cured. The self-levelling polymer 30 provides a smooth surface 60 for the first concrete body 10 and the portion 40A of the backing strip 40 extends above the surface 60 to prevent the self-levelling polymer 30 from spilling over sides 70 of the first concrete body 10 before it is cured. The self-levelling polymer 30 provides a smooth surface finish over the rough surface 20 as shown by the smooth surface 60. As will be discussed in more details herein below, the smooth surface finish is used to provide a leak tight seal when the first concrete body 10 is jointed with another body.

Referring to Figure 2 shown is a flow chart of a method of applying the self-levelling polymer 30 of Figures 1A and 1B onto the rough surface 20 of the first concrete body 10. At step 2-1, the first concrete body 10 is thoroughly cleaned, by vacuuming or brushing for example, to remove loose or weakly bonded cement paste or foreign particles. At step 2-2, a

bonding agent is applied to a portion 65 of the sides 70. At step 2-3, the backing strip 40 is fixed to the sides 70 on the periphery 80 of the first concrete body 10 with the portion 40A of the backing strip 40 extending above the rough surface 20.

5 Alternatively, the backing strip 40 may be made of several smaller backing strips in which case each one of the smaller backing strips are fixed to a respective portion of the sides 70. The backing strip 40 is fixed to provide a leak tight enclosure which is generally indicated by 90. At step 2-4, the
10 first concrete body 10 is oriented so that the rough surface 20 is arranged horizontally and faces upwards. Alternatively, step 2-4 may be performed prior to any one of steps 2-1 to 2-3. At step 2-5, the self-levelling polymer 30 is poured into the enclosure 90 over the rough surface 20 of the first concrete
15 body 10. At step 2-6, the self-levelling polymer 30 is allowed to wet the rough surface 20 performing self-levelling under the force of gravity. As the self-levelling polymer 30 wets the rough surface 20 it fills the dips 25 and the other features 50, which include any cracks, throats, crevices and
20 interconnected cavities. At step 2-6, the portion 40A of the backing strip 40 allows a layer of the self-levelling polymer 30 to form above the rough surface 20 without spilling over the sides 70 of the first concrete body 10. At step 2-7, the self-levelling polymer 30 is covered and allowed to cure in an
25 atmosphere free from excessive foreign particles that could otherwise deposit on the self-levelling polymer 30. It is to be understood that at step 2-6 the self-levelling polymer 30 may also be covered. After the self-levelling polymer 30 has cured, at step 2-8 the backing strip 40 is optionally removed
30 from the sides 70.

After the self-levelling polymer 30 has cured, the smooth surface 60 has a smooth surface finish and the first concrete body 10 is ready to be jointed to another body.

Referring to Figure 3, shown is a cross-sectional view of a joint 190 between the first concrete body 10 of Figures 1A and 1B and a second concrete body 100. The concrete bodies 10, 100 are aligned with each other with opposing rough surfaces 20, 120, respectively, substantially facing each other. The rough surfaces 20, 120 are each covered with a layer of the self-levelling polymer 30 to provide smooth surfaces 60, 160. A sealing device 110, such as a gasket, O-ring, yarn or seal for example, is located between the smooth surfaces 60, 160. The sealing device 110 is made of a material such as EPR (Ethylene Propylene Rubber), SBR (Styrene Butadiene Rubber), AR (Acrylic Rubber), NIR (Acrylonitrile-Isoprene Rubber), Teflon or Viton, for example, which all exhibit good elasticity. The sealing device 110 is in direct contact with the smooth surfaces 60, 160 of the bodies 10, 100, respectively. The concrete bodies 10, 100 are tensioned with the use of tendon 130 which holds the concrete bodies 10, 100 together and provides a force necessary to compress the sealing device 110. Having the sealing device 110 compressed between the smooth surfaces 60, 160 provides a leak tight joint against liquids and gases between a left-hand side of the joint 190 and a right-hand side of the joint 190. Alternatively, a plurality of tendons 130 may be used. The tendon 130 is kept in position by anchor plates 140, 150 which are made of a strong material such as steel for example.

In some embodiments of the invention, the concrete bodies 10, 100 form a wall, such as a wall of an enclosure which is pressurized or under a vacuum for example, with the wall having a pressure differential between the left-hand and the right-hand sides of the joint 190. In such embodiments, an rms (root-mean-square) roughness of the smooth surfaces 60, 100 is less than 63 μm and such a condition provides the necessary surface area of contact between the sealing device 110 and the

smooth surfaces 60, 160 to prevent gases and liquids from leaking through the joint 190. Furthermore, in some embodiments of the invention, a membrane 180 is located on sides 70A, 170A of the bodies 10, 100, respectively, over the joint 190. The membrane 180 provides additional protection against potentially adverse environments and may be, for example, a high temperature vapour-proof membrane to provide protection against potentially corrosive environments.

Referring to Figure 4, shown is a flow chart of a method of jointing the two concrete bodies 10, 100 of Figure 3. At step 4-1, the rough surfaces 20, 120 of the concrete bodies 10, 100, respectively, are each covered with a layer of the self-levelling polymer 30 using the method of Figure 2 for smoothing the rough surfaces 20, 120. At step 4-2, the first concrete body 10 is aligned with the second concrete body 100 in a manner that the rough surfaces 20, 120, (or equivalently, the smooth surfaces 60, 160) substantially face each other. At step 4-3, the sealing device 110 is placed between the smooth surfaces 60, 160 and at step 4-4 the first concrete body 10 and the second concrete body 100 are coupled together using the tendon 130 and the anchor plates 140, 150.

Referring to Figure 5, shown is a cross-sectional view of another joint 230 between two concrete bodies, according to another embodiment of the invention. In particular, a first concrete body 200 is jointed to a second concrete body 210. The concrete bodies 200, 210 are similar to the concrete bodies 10, 100 of Figure 3 except that each one of the bodies 200, 210 has a channel 220. The concrete bodies 200, 210 are pre-cast concrete segments each having a layer of the self-levelling polymer 30 and, in some embodiments of the invention, the channels 220 are made when the concrete bodies 200, 210 are cast. The concrete bodies 200, 210 are jointed together to form the joint 230 using the method of Figure 4

with the additional step that the channels 220 are filled with a grouting material 35 after coupling the bodies together with the tendon 130. The grouting material 35 is, for example, a blended cement of similar composition to the composition of the material of the concrete bodies 200, 210 and preferably has no coarse aggregates. The grouting material 35 provides additional leak tightness.

Referring to Figure 6A, shown is an exploded view of a concrete container 310 having a metal lid 240 for sealing the concrete container 310, according to another embodiment of the invention. A sealing device 280 is located between the concrete container 310 and the metal lid 240. In the embodiment of Figure 6A, there is only one sealing device 280; however, in some embodiments of the invention there is one or more additional sealing devices arranged between the concrete container 310 and the metal lid 240. In particular, in some embodiments of the invention, the sealing devices are gaskets arranged on top of one another and in other embodiments of the invention, the sealing devices are O-rings arranged concentrically within one another. A plurality of bolts 290 (only five bolts 290 are shown for clarity) are anchored in a side-wall 320 of the concrete container 310. In Figure 6B, a cross-sectional view of a portion of the concrete container 310 clearly shows the bolts 290 being anchored in the side-wall 320.

The concrete container 310 has a rough surface 330 covered with a layer of the self-levelling polymer 30 to produce a smooth surface 340 for contact with the sealing device 280. The concrete container 310, the sealing device 280 and the lid 240 are coupled together using the bolts 290 and nuts 300 to provide a leak tight joint 235 between the side-wall 320 and the lid 240. The invention is not limited to coupling using the bolts 290 and the nuts 300 and other means

such as post-tensioning, clamping and the use of tie rods for example, are also used in other embodiments of the invention.

In the embodiments of Figures 3, 5, 6A and 6B, two bodies are jointed together; however, the invention is not limited to jointing of two bodies and in other embodiments of the invention, three or more bodies are jointed together at a joint.

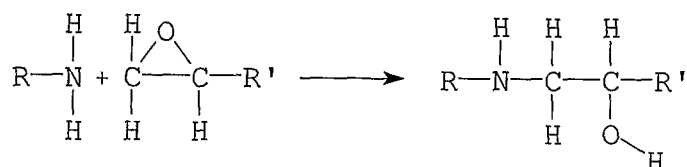
In all aspects of the invention, the self-levelling polymer 30 used for leak prevention has one or more components of thermosetting resin. At least one of the components of thermosetting resin has a low viscosity before curing to provide an overall viscosity of the self-levelling polymer 30 before curing. The thermosetting polymer resins are characterised, in part, by their capacity to flow and their self-levelling behaviour before curing. After curing, the thermosetting polymer resins provide a surface finish having an rms roughness of 63 μm or less, and have compressive strengths equal to or greater than the compressive strength of the concrete. Furthermore, the thermosetting polymer resins have high bond strengths to provide a cured polymer which is stronger than the concrete. For example, referring back to Figure 1B the bond strength between the thermosetting polymer resins, used in the self-levelling polymer 30, and the rough surface 20 of the first concrete body 10 is greater than the tensile strength of the concrete of which is made the first concrete body 10.

In some embodiments of the invention, the types of thermosetting resins used for the self-levelling polymer 30 include, for example, epoxy resins, unsaturated polyester resins, polyurethane resins and other resins such as epoxy vinyl ester resins for example. Generally, any suitable resin having a low viscosity before curing and having a large tensile

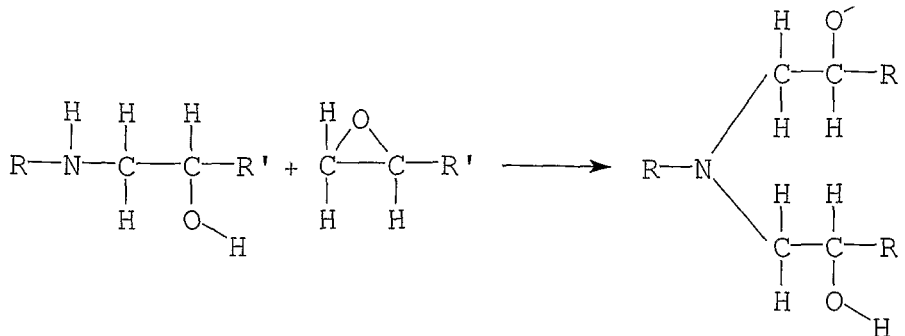
strength and a large bond strength to concrete after curing may be used.

In embodiments of the invention, an epoxy resin used for leakage prevention contains at least one base epoxy and at least one of a hardener with or without an accelerator.

Example base epoxies include low viscosity, bisphenol A-based 100% liquid epoxy resins, TGAP (TriGlycidyl epoxide based on AminoPhenol), TGDDM (TetraGlycidyl epoxide based on DDM (4,4' Diamino Diphenyl Methane)), and Novolac resins. The hardeners include primary and secondary polyamines and their respective amine adducts, such as polyoxypropyleneamines for example, that can cure at room temperature. The amine adducts are, for example, low molecular weight copolyamines reacted by amines and other monomers. For example, amines react with oxypropylene to form polyoxypropyleneamines. Example polyamines include diethylene triamine, triethylene tetramine, tetraethylene pentamine, and different polyoxypropyleneamines. When curing, primary and secondary amine groups of a polyamine react with epoxide groups of a base epoxy through a reactive hydrogen of the primary and secondary amines. Each primary amine group is theoretically capable of reacting with two epoxide groups, and each secondary amine group is capable of reacting with one epoxide group. A first reaction equation of a primary amine group with a base epoxy is given by



resulting in a secondary amine being formed on the base epoxy. The secondary amine reacts with another base epoxy according to a second reaction equation which is given by



- 5 For the second reaction equation, the formation and presence of hydroxyls assist in opening the epoxide ring.

In embodiments of the invention in which an accelerator is used, the accelerator contains one or more of alcoholic hydroxyls and phenolic hydroxyls. The hydroxyls of
 10 the accelerator are used to accelerate curing of the primary and secondary amines and therefore provide a shorter gel time of the amine adducts and higher molecular weight resins. In embodiments of the invention, the curing time and the curing speed is controllable by adjusting the amount of hardener and
 15 accelerator.

In embodiments of the invention, an unsaturated polyester resin which is used for leakage prevention is a low viscosity unsaturated polyester which is reacted with vinyl monomers through a polymerisation catalyst system when being
 20 cured. In some embodiments of the invention, the polymerisation catalyst system initiates a polymerisation reaction of the vinyl monomers with the unsaturated polyester. In such embodiments, one or more catalysts may be used simultaneously. In other embodiments of the invention, the
 25 polymerisation catalyst system catalyses the polymerisation reaction. In such embodiments, one or more catalysts may be used simultaneously. In embodiments of the invention, the polymerisation catalyst system is a mixture of an organic peroxide and one or more aromatic amines. The aromatic amines
 30 are used in small amounts with the organic peroxides to

accelerate the action of the peroxide by lowering an initiating temperature of the peroxide. In particular, in one embodiment of the invention, a mixture of the aromatic amines has a percentage by weight of unsaturated polyester in the range from
5 approximately 0.1% up to approximately 5% and contains any one or more of aniline, N,N-dimethylaniline, N,N-diethylaniline, toluidine, N,N-dimethyl p-toluidine, N,N-di(hydroxyethyl) toluidine and para-dimethylamino-benzaldehyde. In embodiments of the invention, a preferred polymerisation catalyst system is
10 a mixture of benzoyl peroxide and N, N-dimethyl p-toluidine.

In embodiments of the invention, a polyurethane resin which is used for leakage prevention contains an isocyanate/polyurethane prepolymer and at least one low molecular weight fluid aromatic hydrocarbon resin. In some
15 embodiments of the invention, the polyurethane resin is in a one-part (one-package) system and in other embodiments of the invention the composition of the polyurethane resin is in a two-part (two-package) system. The prepolymer is any suitable polyurethane-forming isocyanate/polyurethane prepolymer having
20 a low viscosity liquid at room temperature and having a molecular weight between 1000 g/mol and 12000 g/mol. Such a prepolymer is a reaction product of known organic isocyanates, such as low molecular weight (liquid stage) diisocyanates, triisocyanates and polyisocyanates for example, and two or
25 more hydroxy groups of an organic molecule such as a polyol for example. The prepolymer is a low viscosity liquid at room temperature and has a molecular weight between 1000 g/mol and 12000 g/mol. Example polyols include a polyester polyol, a polylactone polyol, a polyesteramide polyol, castor-oil polyols
30 and mixtures thereof. Preferably, the polyurethane-forming isocyanate/polyurethane prepolymer is a reaction product of toluene diisocyanate and diols or triols. For one-part systems, the prepolymer has an isocyanate (NCO) content of less

than or equal to 10% by weight of the prepolymer, and preferably less than 5% by weight of the prepolymer, in order to avoid excess foaming. Furthermore, in one-part systems, the prepolymer has a molecular weight in the range of 2000 g/mol to 5 3000 g/mol. For two-part systems, the NCO content of the polyurethane-forming isocyanate/polyurethane prepolymer is less than or equal to 20% by weight of the prepolymer.

In regards to the fluid aromatic hydrocarbon resin contained in the polyurethane resin, in some embodiments of the 10 invention a single aromatic hydrocarbon resin is used. In other embodiments of the invention, a mixture of two or more aromatic hydrocarbon resins is used. Regardless of whether a single aromatic hydrocarbon resin or a multiple number of aromatic hydrocarbon resins are used, a liquid aromatic 15 material results having a low viscosity in the range 700 to 2000 cps at 25°C. In embodiments of the invention, the composition of the aromatic hydrocarbon resins includes hydroxyl groups, which are preferably aromatic hydroxyl groups. Preferably, the hydroxyl group content of each aromatic 20 hydrocarbon resin is in the range from 2% to 5% by weight of a respective one of the aromatic hydrocarbon resins. Furthermore, the aromatic hydrocarbon resins are preferably free of water and solvents.

In some embodiments of the invention, some of the 25 other resins which are used for leakage prevention include epoxy vinyl ester resins containing styrene monomers which are free in the resins. The epoxy vinyl ester resins are reaction products of other epoxy resins and methacrylic acid and have a very low viscosity, for example, between 90 cps and 135 cps. 30 Polymerisation catalyst systems are used with the epoxy vinyl ester resins as curing agents. In particular, the polymerisation catalyst systems which are used with the epoxy vinyl ester resins are the same as those described above with

reference to the unsaturated polyester resins. In some
embodiments of the invention, one or more initiators of a
polymerisation catalyst system initiates a polymerization
reaction of the styrene monomers with the epoxy vinyl ester
5 resins and in other embodiments of the invention one or more
catalysts of another polymerisation catalyst system catalyses
the polymerisation reaction of the styrene monomers with the
epoxy vinyl ester resins. A preferable polymerisation catalyst
is a mixture of an organic peroxide and one or more aromatic
10 amines and a most preferable polymerisation catalyst is a
mixture of benzoyl peroxide and N, N-dimethyl p-toluidine.
Furthermore, in some embodiments of the invention, the aromatic
amines are used in small amounts with the organic peroxides and
generally accelerate the action of the peroxide. In
15 particular, in one embodiment of the invention, a mixture of
the aromatic amines has a percentage by weight of unsaturated
polyester in the range from approximately 0.1% up to
approximately 5%.

Given below are example formulations of the self-
20 levelling polymer 30. As shown in Table I in a first example,
the self-levelling polymer 30 includes an epoxy resin EEW~188,
and a Polyoxypropyleneamine (Jeffamine) D-230 in approximately
32% by weight of the epoxy resin.

Formulation	% by wt of EEW~188
Epoxy Resin: EEW~188	100
Polyoxypropyleneamine (Jeffamine) D-230	32
Characteristics	
Viscosity of mixture at 25 °C: (cps)	600
Gel time: (minutes)	280
Self-levelling:	Excellent
Surface rms roughness after curing: (µm)	< 30
Compressive yield strength: (MPa)	100

Ultimate compressive strength: (MPa)	245
Bond strength: (ASTM D4541-95e1), (MPa)	4.2

Table I: Formulation and characteristics of the self-levelling polymer 30 in the first example formulation; "ASTM D4541-95e1" is a standard test method for pull-off strength of coatings using portable adhesion testers.

EEW~188 is a standard general-purpose bisphenol-A based epoxy resin and its viscosity ranges from 11000 to 14000 cps at 25 °C. D-230 is a hardener for the epoxy resin EEW~188. In particular, D-230 is a Polyoxypypropyleneamine product by Jeffamine and its viscosity is 9 cps at 25 °C. As shown in Table I, the viscosity of the self-levelling polymer 30 containing a mixture of epoxy resin EEW~188 and the hardener D-230 is approximately 600 cps at 25 °C before curing. The gel time is approximately 280 minutes and once cured, a surface finish having an rms roughness less than 30 µm results. Furthermore, once cured the self-levelling polymer 30, according to this first example, has a compressive yield strength of approximately 100 MPa, an ultimate compressive strength of approximately 245 MPa and a bond strength of approximately 4.2 MPa, which is a pressure at which concrete fails.

In a second example, an accelerator is added to the mixture for self-levelling polymer 30 of the first example. The accelerator being added is referred to as accelerator 399 and it is another product by Jeffamine. The accelerator 399 is used to reduce the cure time of the self-levelling polymer 30. Results are shown in Table II for two different concentrations of the accelerator 399. In particular, in columns B and C the percentages of the accelerator 399 by weight of the epoxy resin

EEW~188 are 5% and 10%, respectively. Column A of Table II shows results for the case in which there is no accelerator added.

	A	B	C
Formulation	% by wt	% by wt	% by wt
Epoxy: EEW~188	100	100	100
Polyoxypropyleneamine (Jeffamine) D-230	32	32	32
Accelerator 399		5	10
Characteristics			
Brookfield viscosity of mixture at 25 °C: (cps)	600	700	700
Gel time: (minutes)	280	65	25
Self-levelling:	Excellent	Excellent	Excellent
Surface rms roughness after curing: (μm)	< 30	< 30	< 30
Compressive yield strength: (MPa)	100	95	88
Ultimate compressive strength: (MPa)	245	210	160
Bond strength: (ASTM D4541- 95e1), (MPa)	4.2	4.0	4.0

5 Table II: Formulation and characteristics of the self-levelling polymer 30 according to the second example formulation.

As shown in Table II, with the addition of the accelerator 399, the gel time is significantly reduced from approximately 280 minutes down to approximately 25 minutes; however, the reduction in the gel time is accompanied by a change in other characteristics of the self-levelling polymer 30. In particular, the addition of the accelerator 399 causes a slight increase in the viscosity from approximately 600 cps

up to approximately 700 cps at 25°C; a slight decrease in the compressive yield strength from approximately 100 MPa down to approximately 88 MPa; a decrease in the ultimate compressive strength from approximately 245 MPa down to approximately 160 MPa; and a slight decrease in the bond strength from approximately 4.2 MPa down to approximately 4.0 MPa.

In a third example, a formulation of the self-levelling polymer 30 includes an unsaturated polyester resin and a polymerization catalyst which is made of a mixture of benzoyl peroxide and N, N-dimethyl p-toluidine. In particular, as shown in Table III, the concentrations of the benzoyl peroxide and the N, N-dimethyl p-toluidine are approximately 0.2% and 2%, respectively, by weight of the unsaturated polyester resin. The unsaturated polyester resin contains polyester polymers and styrene monomers having a concentration of approximately 30% by weight of the polyester polymers.

Formulation	% by weight of polyester
Normal unsaturated polyester:	100
styrene monomers:	30
Benzoyl peroxide:	2
N, N-dimethyl p-toluidine:	0.2
Characteristics	
Viscosity of mixture at 25 °C: (cps)	1100
Gel time: (minutes)	25
Self-levelling:	very good
Surface rms roughness after curing: (μm)	< 30

Table III: Formulation and characteristics of the self-levelling polymer 30 according to the third example formulation.

The formulation of the self-levelling polymer 30 in the third example has a viscosity of approximately 1100 cps at 25°C. The gel time is approximately 25 minutes and once cured a surface finish having an rms roughness less than 30 μm results.

5 In a fourth example, a formulation of the self-levelling polymer 30 includes a mixture of a polyurethane prepolymer and a polyesterpolyol-1. As shown in Table IV, the concentrations of the polyurethane prepolymer and the polyesterpolyol-1 are approximately 62% and 38%, respectively,
 10 by weight of the mixture. The polyurethane prepolymer is a reaction product of toluene-diisocyanate and polyols. The polyurethane prepolymer has a content of NCO of approximately 13% by weight of the prepolymer and a viscosity of about 2000 cps at 25 °C. The polyesterpolyol has a content of hydroxyl of
 15 approximately 4.8% by weight of the polyesterpolyol and a viscosity of approximately 350 cps at 25 °C. Together, the polyurethane prepolymer and the polyesterpolyol form a mixture which has a viscosity of approximately 1100 cps at 25°C.

Formulation	% by weight of mixture
Polyurethane prepolymer	62
Polyesterpolyol-1	38
Characteristics	
Viscosity of mixture at 25 °C: (cps)	1100
Gel time: (minutes)	120
Self-levelling:	very good
Surface rms roughness after curing: (μm)	< 30

20 Table IV: Formulation and characteristics of the self-levelling polymer 30 according to the fourth example formulation.

The gel time is approximately 120 minutes and once cured a surface finish having an rms roughness less than 30 μm results.

In a fifth example, a formulation of the self-levelling polymer 30 includes an epoxy vinyl ester resin and a polymerization catalyst which is made of a mixture of benzoyl peroxide and N, N-dimethyl p-toluidine. As shown in Table V, the concentrations of the benzoyl peroxide and of the N, N-dimethyl p-toluidine are approximately 0.2% and 2%, respectively, by weight of the epoxy vinyl ester resin. Furthermore, the epoxy vinyl ester resin is a Dow Chemical product named Derakane-411.

Formulation	% by weight of vinyl ester resin
Epoxy vinyl ester resin	100
Benzoyl peroxide	2
N, N-dimethyl p-toluidine	0.2
Characteristics	
Viscosity of mixture at 25 °C: (cps)	90 to 135
Gel time: (minutes)	25
Self-levelling:	Excellent
Surface rms roughness after curing: (μm)	< 30

Table V: Formulation and characteristics of the self-levelling polymer 30 according to the fifth example formulation.

The formulation of the self-levelling polymer 30 in the fifth example has a viscosity in the range from approximately 90 cps to approximately 135 cps at 25°C. The gel time is approximately 25 minutes and once cured, a surface finish having an rms roughness less than 30 μm results.

Numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practised otherwise than
5 as specifically described herein.

WE CLAIM:

1. Use of a self-levelling polymer for smoothing a first surface of a first concrete body which is to be jointed to a second body, the self-levelling polymer comprising:
 - 5 a thermosetting resin adapted to flow before curing and adapted to bond to concrete when cured.
2. Use of a self-levelling polymer according to claim 1 wherein the thermosetting resin comprises a base epoxy and at least one of a hardener and an accelerator.
- 10 3. Use of a self-levelling polymer according to claim 2 wherein the hardener comprises at least one of primary and secondary polyamines.
4. Use of a self-levelling polymer according to claim 3
15 of said at least one of primary and secondary polyamines.
5. Use of a self-levelling polymer according to claim 1 wherein the thermosetting resin comprises an unsaturated polyester resin.
6. Use of a self-levelling polymer according to claim 5
20 wherein the thermosetting resin comprises vinyl monomers and a polymerisation catalyst system adapted to initiate or catalyse a polymerisation reaction of the vinyl monomers with said unsaturated polyester.
7. Use of a self-levelling polymer according to claim 1
25 wherein the thermosetting resin comprises an isocyanate/polyurethane prepolymer and a fluid aromatic hydrocarbon resin containing at least one hydroxyl group.

8. Use of a self-levelling polymer according to claim 1 wherein said thermosetting resin comprises an epoxy vinyl ester resin.

9. Use of a self-levelling polymer according to claim 8
5 wherein said thermosetting resin further comprises styrene monomers and a polymerisation catalyst system adapted to initiate or catalyse a polymerisation reaction between said epoxy vinyl ester resin and the styrene monomers.

10. Use of a self-levelling polymer according to any one
10 of claims 8 and 9 wherein the epoxy vinyl ester resin has a viscosity between 90 cps and 135 cps.

11. Use of a self-levelling polymer according to any one of claims 8 to 10 wherein the epoxy vinyl ester resin is a reaction product of an epoxy resin and a methacrylic acid.

15 12. A first concrete body jointable to a second body, the first concrete body comprising:

a first surface;

a layer of a self-levelling polymer for smoothing the first surface of the first concrete body, the self-levelling
20 polymer comprising:

a thermosetting resin adapted to flow before curing and adapted to bond to the first surface when cured.

13. A first concrete body according to claim 12 adapted to be jointed to the second body with a sealing device located
25 therebetween.

14. A method of smoothing said first surface of said first concrete body of claim 12, the method comprising the steps of:

providing the thermosetting resin over the first surface of the first concrete body;

allowing the thermosetting resin to wet the first surface of the first concrete body; and

5 allowing the thermosetting resin to cure.

15. A method according to claim 14 further comprising the step of providing one or more backing strips on a periphery of the first concrete body with the backing strips extending above the first surface of the first concrete body, wherein the one
10 or more backing strips allow a layer of the thermosetting resin to form above the first surface of the first concrete body.

16. A joint between a first concrete body and a second body, the joint comprising:

a sealing device located between the first concrete
15 body and the second body; and

a thermosetting resin located between the sealing device and a first surface of the first concrete body, the thermosetting resin being adapted to smooth the first surface of the first concrete body.

20 17. A joint according to claim 16 wherein the second body is a second concrete body, the joint further comprising:

a thermosetting resin located between the sealing device and a second surface of the second concrete body, the thermosetting resin being adapted to smooth the second surface
25 of the second concrete body.

18. A joint according to claim 16 comprising means for coupling together the first concrete body and the second body.

19. A joint according to claim 18 wherein means for coupling together the first concrete body and the second body causes compression of the sealing device to provide at least one of a pressure-tight joint and a vacuum-tight joint.

5 20. A method of jointing a first concrete body and a second body, the method comprising the steps of:

smoothing a first surface of the first concrete body with a layer of a thermosetting resin;

10 aligning the first body and the second body in a manner that the first surface and a second surface of the second body substantially face each other;

providing a sealing device between the first surface and the second surface; and

15 compressing the sealing device between the first concrete body and the second body.

21. A method according to claim 20 wherein the compressing the sealing device comprises coupling together the first concrete body and the second body.

20 22. A method according to any one of claims 20 and 21 wherein the step of smoothing the first surface comprises the sub-steps of:

providing a thermosetting resin over the first surface;

25 allowing the thermosetting resin to wet the first surface; and

allowing the thermosetting resin to cure.

23. A method according to any one of claims 20 and 21 for jointing the first concrete body and the second body wherein the second body is a second concrete body, the method further comprising the step of:

5 smoothing the second surface of the second concrete body with a thermosetting resin.

24. A method according to claim 22 for jointing the first concrete body and the second body wherein the second body is a second concrete body, the method further comprising the step
10 of:

 smoothing the second surface of the second concrete body with a thermosetting resin, the step of smoothing the second surface comprising the sub-steps of:

 providing a thermosetting resin over the second
15 surface;

 allowing the thermosetting resin to wet the second surface; and

 allowing the thermosetting resin to cure.