

LAPPED JOINT BETWEEN CONCRETE STRUCTURES, METHOD FOR FORMING THE SAME, AND GROUTING MONITOR USED DURING GROUTING

Field of the Invention

5 [0001] The present invention provides various techniques for joining concrete structures together, including a systematic construction technology which enables precast elements that can be quickly assembled at a construction site and used together, thereby assembling elements at the construction site cleanly, quickly and simply.

Background of the Invention

10 [0002] Precast concrete structures are commonly used in modern construction to enable rapid erection of multi-storey buildings, such as high-rise apartments and office towers. Precast concrete structures are made with off-construction-site, such as in a factory. Reinforcements are often used in a precast concrete structure and extend from the structure, so as to connect
15 reinforcements of adjacent structures.

[0003] One common construction method for connecting precast structures is called the grouted pipe sleeve method which includes:

1. A metal corrugated sleeve is placed in an end of a precast concrete element to form a void duct, or an aperture space is formed in a precast element by other methods.
- 20 2. Reinforcement (e.g., a reinforcing metal bar, "rebar") protrudes outward from another precast or cast in situ concrete element. Such reinforcement is called as a connecting reinforcement, and the length of the protruding portion thereof is called as the anchorage length which depends on the size of reinforcement. For a reinforcement having a diameter over 25mm, the anchorage length thereof often exceeds 1m.
- 25 3. When the precast element is placed into a final position, all the connecting reinforcements are positioned within the metal corrugated pipe sleeve.
4. Non-shrink cement grout is injected in to fill up all space between the reinforcements and the metal corrugated pipe sleeve until the cement grout overflows from a grouting outlet hole, such that the connection is completed.
- 30 5. After the connection, the main reinforcement in the precast element is lapped with the connecting reinforcement in the metal corrugated pipe sleeve. Tension and compression

stresses in the main reinforcement can be transferred to the connecting reinforcement, and therefore the two precast elements are connected together.

[0004] Some disadvantages of the above connection system are:

1. The reinforcement length protruding from the concrete element is very long, whether 400mm or more than 1m, and it makes inserting the connecting reinforcement into the metal corrugated pipe sleeve of another precast element very difficult and thus accurately aligning is necessary. The exposed connecting reinforcement is easily bent out of position during the transportation, which would result in dislocation and difficult installation. Labor at the construction site often needs to bend the connecting reinforcement back to the correct position.

2. The protruding portion of the reinforcement adds to the total length of the precast element such that the space needed for transportation increases, which will reduce efficiency of the transportation.

3. For high-rise buildings, wall columns have high reinforcement content, and there will be many connecting reinforcements. It is difficult to make all the connecting reinforcements align with the metal corrugated pipe sleeves.

4. The function of the metal corrugated pipe is to form a shaped space so as to insert a connecting reinforcement, and it may not provide a structural function after grouting. The precast structure needs to use many metal corrugated pipes, which will result in wastage of material.

5. In the grouting method, the cement overflow from the grouting outlet hole is used as an indication to determine that the space between the reinforcement and the metal corrugated pipe sleeve is fully filled, which wastes the overflow cement and is disadvantageous to the environmental management of the construction site.

[0005] Therefore, for connecting concrete structures, such as precast walls, columns, beams, and slabs, it is necessary to improve the existing technology of connecting concrete structures, so as to achieve faster and safer construction, to reduce transportation costs, and to simplify the connected structures.

Summary of the Invention

[0006] A first aspect of the present invention is to provide an improved connection method of concrete structures (e.g., precast concrete structures). In the present method, the method includes:

forming a first shaped void in a first concrete structure, wherein the first shaped void is disposed to be adjacent to a first main reinforcement of the first concrete structure;

placing a movable reinforcement in the first shaped void, wherein the movable reinforcement has a length shorter than a length of the first shaped void such that the movable reinforcement is wholly contained within the first shaped void;

placing a second concrete structure adjacent to the first concrete structure, wherein the second concrete structure has a second shaped void adjacent to a second main reinforcement of the second concrete structure, and the second shaped void is disposed as being substantially coaxial to the first shaped void of the first concrete structure;

moving the movable reinforcement to a position that allows the movable reinforcement to have a portion present within the first shaped void and another portion present within the second shaped void, such that the movable reinforcement partially laps over main reinforcement bars of the first main reinforcement and the second main reinforcement; and

grouting the first shaped void and the second shaped void.

[0007] In an embodiment, the present method further comprises disposing a centering element on and near the movable reinforcement to center the movable reinforcement within the first shaped patterned void. The centering element may be a metal spring coil.

[0008] In another embodiment, the present method further comprises using a wire to hold the movable reinforcement within the first shaped void.

[0009] In another embodiment, the present method further comprises using a void duct disposed between the first shaped void and a side of the first concrete structure to receive grout. The method further comprises using a wire having an end that passes through the void duct, so as to hold the movable reinforcement within the first shaped void.

[0010] In another embodiment, the method further comprises using a void duct disposed between the first shaped void and a side of the first concrete structure to receive grout. In such embodiment, the method further comprises using a wire having an end that passes through the void duct, so as to hold the movable reinforcement within the first shaped void. The lapped joint further comprises a second shaped void disposed between the second patterned void and a side of the second concrete structure. The lapped joint further comprises a grouting monitor placed on a critical path of the second shaped void and providing showing of completed grouting, so as to prevent grout from overflowing. In a specific embodiment, a plurality of grouting channels is provided behind the grouting monitor, and a plurality of through holes are

provided on a surface of the monitor. The grouting channels have widths narrowed as approaching a monitoring surface, and a surface of the grouting monitor is transparent.

[0011] In another embodiment, the second shaped void of the second concrete structure can be canceled and replaced by a mechanical coupler facing the first shaped void of the first concrete structure. In such embodiment, when the second shaped void of the second concrete structure is replaced by the mechanical coupler, the movable reinforcement and the mechanical coupler respectively have threads, such that the reinforcement is turned to the mechanical coupler by moving and rotating the reinforcement.

[0012] In another embodiment, an internal former is formed by using combinations of one or more circular rods, square rods, or rods in other shape; a release layer is using to wrap around the internal former in an approximate spiral pattern, and the internal former is pulled out after casting concrete. The release layer is pulled out finally such that a shaped void or a void duct is formed in a concrete structure.

[0013] A second aspect of the present invention is to provide a grouting monitor applied to a concrete structure during grouting, which comprising:

a housing connected to a void duct; and

a plate covering the housing and having a plurality of holes provided thereon, wherein one or more grouting channels allowing grout to pass therethrough are provided behind the plate;

wherein a size of each of the holes is designed to allow air to pass therethrough but disallow the grout to pass therethrough.

[0014] In an embodiment, the grouting monitor is placed on a grouting outlet and a critical path in grouting such that a speed of grouting is observable.

[0015] In another embodiment, the grouting monitor is provided to show the completed grouting, so as to prevent grout from overflowing.

[0016] In an embodiment, the grouting channels have widths narrowed as approaching a monitoring surface, and a surface of the grouting monitor is transparent.

[0017] In an embodiment, the housing is made of plastic or metal.

[0018] In an embodiment, the plate is made of plastic.

[0019] A third aspect of the present invention is to provide a method applied to a concrete structure for forming a shaped void or a void duct, comprising:

forming an internal former by using combinations of one or more circular rods, square rods, or rods in other shape;

using a release layer to wrap around the internal former in an approximate spiral pattern;

pulling out the internal former after casting concrete; and

pulling out the release layer finally such that a shaped void or a void duct is formed in a concrete structure.

[0020] In an embodiment, the wrapping release layer is made of plastic, Teflon, silicone strip, or steel cable.

Brief Description of the Drawings

[0021] FIG. 1 is a schematic diagram depicting how multiple shaped voids are formed at ends of a first concrete element and a second concrete element by an approach of precast or cast in situ according to a method of an embodiment of the present invention, in which the shaped voids are configured to vertically connect the ends of the two concrete elements;

[0022] FIG. 2 is a schematic diagram depicting two concrete elements connected horizontally or non-vertically according to a method of an embodiment of the present invention;

[0023] FIG. 3 illustrates a set of reinforcement mechanical couplers and reinforcement bars with threads at ends thereof, in which the reinforcement bars inserted into shaped voids are rotated into the mechanical couplers, so as to connect two precast concrete elements according to another embodiment of the present invention;

[0024] FIG. 4 illustrates a method for forming shaped voids corresponding with reinforcement bars according to the present invention;

[0025] FIG. 5 is a schematic diagram depicting an internal former and a wrap used in a method for forming shaped voids according to the present invention;

[0026] FIG. 6 illustrates a grouting monitor disposed at a grouting outlet hole (at a top position) according to an embodiment of the present invention, so as to show a grouting status; and

[0027] FIG. 7 illustrates an enlarged cross-section of the grouting monitor in FIG.6 taken at the grouting outlet hole.

Detailed Description

[0028] The present invention is to provide a novel type of a precast concrete structural system which is configured to avoid the disadvantages of the connecting reinforcement protruding from the structure as described. The method of the present invention can be applied to an individual precast concrete element, including columns, walls, bracing, beams and slabs or large structures such as concrete modules. In the technique of the present invention, shaped voids are provided in the precast elements and serve as accommodation temporarily holding connecting reinforcements (such as straight reinforcements). In general, for a precast element, no reinforcement protrudes out from the end of the structure.

[0029] Referring to FIGS. 1-2, multiple shaped voids 1 are formed in an end of a first concrete element by an approach of precast or cast in situ. The formation of the shaped voids 1 may be performed by conventional means, such as using metal corrugated pipes or using a void former such as a dowel or rod wrapped with a shaped release sheet. The shaped voids/void ducts 1 are disposed in close proximity to main reinforcements 8 of the concrete elements. Another set of shaped voids/void ducts 2 are formed in an end of a second concrete element. The first concrete element is placed in a final predetermined position firstly. When cast in situ, the first concrete element is cast in the first priority. When the ends of the two concrete elements are joined, the two sets of shaped voids are located at positions matching one another in accordance with the design. Prior to the installation of the second concrete precast element, a connecting reinforcement 3 is inserted into the shaped void of the first or second concrete element as appropriate. As shown in the illustrations, although the connecting reinforcement 3 is placed in the shaped void 2, it may be positioned in the other shaped void/void duct as well.

[0030] For connecting horizontal elements, as shown in FIG. 2, the connecting reinforcement 3 can be held in place by a wire 5 or other suitable connector secured to one end of the reinforcement 3, which is furthest from the open end of the shaped void. The wire 5 passes through the shaped void 2 and emerges from a gap between the two concrete elements. In some cases, centering devices 4 can be placed at intervals along the length of the reinforcements such that the connecting reinforcement 3 is maintained at the center of the shaped void. The centering devices 4 may be metal spring coils fixed to the reinforcements and spaced along the length of the reinforcements. The reason for choosing the metal spring coils is that they have flexibility, low cost, and porosity for grout to pass therethrough. However, any device which can center the movable reinforcement may also be used.

[0031] The second precast element is hoisted into place such that the shaped voids/void ducts of the two elements can match in position; generally, the two shaped voids are approximately coaxial.

[0032] For vertical precast elements connection, a connecting reinforcement can be temporarily held in the upper element and can be lowered into the shaped void of the lower precast element by releasing the wire holding the connecting reinforcement 3. The connecting reinforcement 3 will drop into the shaped void of the lower precast element.

[0033] For precast elements in horizontal or non-vertical connection (e.g., inclined connection), as shown in FIG. 2, under a situation where gravity is not available to move a connecting reinforcement, a wire can be tied to securely connect to an end of a connecting reinforcement in which the wire passes through the gap between the precast elements, such that the connecting reinforcement is pulled and correspondingly moved into the shaped void of the opposing precast element (see FIG. 2). Furthermore, it is also possible to move the connecting reinforcement temporarily held in the void duct 2 to another void duct 2 by using a flexible bar or device which can push an end of the reinforcement via a small conduit 7, in which the small conduit may be a hole used in the precast element for the grouting operation. The consideration for designing the length of the connecting reinforcement is that the connecting reinforcement and the main reinforcements 8 have sufficient lapped lengths 9 when the connecting reinforcement is pulled or dropped into a final position. After the non-shrink grout is pumped in and fully fills all the void ducts, the connecting reinforcement can effectively lap with the main reinforcements in the precast elements. Compression and tension forces in the main reinforcements can be transferred to the grouted reinforcements by bond stress.

[0034] Referring to FIG. 3, another aspect of the present invention is to provide multiple reinforcement bars 8 cast into an end of a first concrete element. Ends of the reinforcement bars 8 are threaded so as to connect into mechanical couplers 9. The mechanical coupler 9 has an open exposed end configured to receive a threaded reinforcement bar. A set of void ducts 10 are formed in an end of a second concrete element, in which at least one of the two concrete elements is precast. The void ducts may be formed by conventional means such as using corrugated metal pipes, aperture formers, or a novel method as described below. The void ducts are formed to be adjacent to main reinforcements 11 of the concrete element.

[0035] The first concrete element is placed in a predetermined position firstly. The mechanical couplers are cast into the first concrete element. In view of one skilled in the art, it is understood that the mechanical couplers can also be cast into the second concrete element. If one of the elements is cast in situ, it is cast in position first. The positions of the void ducts

10 are configured such that the concrete element is positioned to correspond with the positions of the mechanical couplers 9 when the two concrete elements are in an end-to-end connection.

[0036] Prior to positioning the second precast element, connecting reinforcements 12 are inserted into the shaped voids 10 of the concrete element. The connecting reinforcements 12 are held in place with wires tied to their ends. The connecting reinforcements 12 are maintained in the center of the void ducts by using one or more centering devices arranged with intervals along the length of the reinforcements.

[0037] The second precast element is placed such the void ducts thereof align with the mechanical couplers; there is a gap 13 of approximate 20mm maintained between the ends of the two concrete elements. The temporarily held reinforcements are then pushed forward into the 20mm gap to contact the mechanical couplers by using a flexible bar or device inserted into small conduits 14, in which the small conduits may be holes used in the precast element for the grouting operation. A wrench sized to fit for inserting into the gap 13 is configured to turn the threaded connecting reinforcement bars 12 into the mechanical couplers. The length of the connecting reinforcement bar 12 is set such that when the connecting reinforcement bar is fully screwed into the mechanical coupler, it has sufficient lapped length with the main reinforcement 11.

[0038] Finally, non-shrink grout is pumped in to fill the void ducts 10 and the gap 13 between the two connected precast elements. The connecting reinforcement bars 12 effectively lap with the main reinforcements 11 in the concrete element, and compressive and tensile forces in the main reinforcements 11 of the first concrete element can be transferred to the connecting reinforcement bars 12 by bond stress. The internal force can be further transferred to the main reinforcements 11 of the second or other concrete elements through the mechanical couplers. The above completes the structural connection between the two elements.

[0039] The advantages of the novel method provided by the present invention are as follows:

1. The problem of a reinforcement protruding outward from a precast element is avoided, such that transportation is more efficient and cost is reduced.
2. As compared with inserting a long reinforcement into a void duct, the novel method is much easier because it is performed by aligning void ducts.
3. In view of the existing methods, connection in inclined precast structural elements is difficult, because hoisting a heavy precast element in a position in order to insert a long reinforcement into a void duct at an angle is very difficult. The connection method of the present invention can resolve this problem and can be applied to beams, columns, slabs, and inclined elements.

4. By applying the present invention to connect basic structural elements such as columns, walls, bracing, beams, and slabs, construction of a whole building can be completed.

5. The connection of precast elements has a gap of only approximately 20mm as installation tolerance, and it does not require any site formwork or concreting at the construction site.

6. Formwork, rebar binding, and concreting is not required on site, and only the connection operation of the precast elements is needed such that the construction time is speeded up and the need for site labor is drastically decreased.

7. All reinforcement work can be completed at the factory, which reduces wastage of material, and carbon footprint is greatly reduced due to more efficient transportation.

8. The completed building is constructed by assembling the precast elements, in which only the grout joint is present between the precast elements. Therefore, lining bricks, fair faced concrete, and colored concrete can be completed in the factory, such that there is only completing the connection work needed at the construction site.

[0040] Turning to FIGS. 4 and 5, a method for forming void ducts for corresponding reinforcement bars is described as follows. As shown in FIG. 4, a dowel/mandrel that serves as an internal former 1 may be a steel bar, cylinder, or a circular tube. Other shapes can be achieved by combining more than one steel bar or circular hollow sections together. A layer of grease or lubricating oil may be applied on the internal former. A polymeric release layer wraps around the internal former 1 from the inner end to the outer end of the internal former 1 in an approximate spiral pattern, so as to serve as a release wrapper; the materials may be plastic, Teflon, or silicone strip 2. Alternatively, a steel cable can be used as strips to wrap around the internal former 1, in which a plurality of the strips overlaid upon each other can form an aperture having an arbitrary profile. The wrapped former is placed into a mold and cast in the precast concrete element 3. After the concrete hardens, the internal former 1 is pulled out from the precast element. Because the friction between the greased internal former and the wrapper is much less than that between the wrap and the concrete, the internal former 1 can be pulled out easily, leaving the polymeric release layer in the concrete. The polymeric release layer may be manufactured by an extrusion process and has a shape profile designed as ribs or other desired structure for further reducing the friction (see FIG. 5). The profile of the strip in contact with the concrete is designed to facilitate bond stress transfer between the reinforcements and the concrete in the future.

[0041] After the internal former is removed, one end of the strip that is exposed from an open end can be pulled out of the void. Since the wrap is formed by spiral wrapping, the strip can be gradually peeled off from the internal surface of the concrete element, in which a profiled

void 6 is thus formed in the precast concrete element. The profile of the strip can be selectively designed as a pattern of ribs or recesses formed in the internal wall of the void, thereby enhancing the stress transferring between the embedded reinforcement and the main body of precast element. If cables are used as the wrapper, a raised rib profile would be formed in the internal wall of the void, thereby also enhancing the friction and stress transfer. The void formed by using the present method has effect equivalent to that of a corrugated pipe used in conventional methods and has the following advantages:

1. Larger voids can be formed by using multiple internal formers; more than one reinforcement bar can be placed inside the larger void for connection of precast elements.
2. Apart from a circular shape, other shapes such as square, rectangular can be formed by using the present method, so as to suit the structural design.
3. The internal former, the polymeric release layer, or the cable can be reused.
4. Forming a void in a precast concrete by using the present method is a more economical and flexible method.

[0042] In the connection techniques of the present invention, grouting is performed to fill the void with the reinforcement bar disposed therein. The purpose of the grouting is to fill up the void duct to ensure effective internal stress transfer between the reinforcement and the concrete. In a conventional approach, grout is pumped from one end of a void duct and then overflows from another end of the void duct. Thereafter, both the inlet and outlet are sealed. When the two ends of the void duct are at different levels, a grout inlet is placed at the lower position so that rising grout would drive out air in the void duct until the grout overflows from a grout outlet.

[0043] When there are multiple duct voids to be filled, they are connected at one end by a gap, such as connection by a typical column precast element. Grout can be pumped in from the gap at the base and rise up in the individual duct voids, and the rising grout emerges from the grout outlet at the top of the duct void.

[0044] The disadvantages of the such system are:

1. The overflowing grout results in wastage of material. With multiple grout outlets in some cases, the outlet may not be sealed in time and results in more wastage.
2. The hardening of the overflowing grout requires manual labor to remove and clear. Such work is laborious especially if site control is poor, which leads to extensive grout overflowing.
3. A grout tube protruding from an outlet has to be trimmed off after the grouting operation is completed.

4. A worker must be stationed on site for monitoring an outlet of the duct void and for sealing up the outlet in time when the grout overflows. This is not possible in some situations

[0045] Turning to FIGS. 6 and 7, a grouting monitor may be positioned at an outlet of a void duct to avoid wastage of material from grout overflow and avoid the need for site cleanup.

5 As shown in FIG. 7, a plastic or metal housing 1 is connected to a void duct 2 to process monitoring of grout. Generally, the monitoring position is away from a grouting inlet (see inlet 6 in FIG. 6) or is set along a path of grouting, or is located at another end of the void duct. As shown in FIG. 7, a plastic end disc 3 covers a plastic housing 1 and has a plurality of holes 4. The size of the holes is designed such that air can pass therethrough but grout cannot pass therethrough. Behind the plastic end disc 3, one or more channels 5 are provided for allowing grout to flow therethrough. The width of the channel 5 reduces as it approaches the plastic end disc 3. The grouting monitor may be made of transparent plastic so that grout flowing into the grouting monitor can be clearly monitored. The grouting monitor may be cast into a precast element at the factory or be installed on site by drilling a hole connecting to a void duct before grouting. The plastic end disc shall be flush with a surface of a precast concrete and be observable. An open end of the grouting monitor is connected to a void duct to be grouted.

10 [0046] During a grouting operation, grout fills up a void duct gradually and pushes air toward a grouting monitor. By the design as described above, air can pass out of the grouting monitor via the reducing channels and the holes of the end disc. When the grout has fully filled up the void duct and at the position of the grouting monitor, the grout would be forced into the channels 5 of the grouting monitor. The reducing channels 5 impede the movement of the grout and reduces the hydraulic head in the grout, and finally the holes 4 of the end disc 3 block exit of the grout, except for a small amount of water in the grout. The blocked grout stays behind the end disc 3 and can be observed through the end disc 3.

20 [0047] As shown in FIG. 6, an example for a precast column grouting operation is shown. Multiple void ducts and reinforcement bars are connected to and located inside a column base. The grouting operation is planned such that grout is pumped from the base through an inlet 6, and the grout would go along the void duct to move up to the top. Grouting monitors 7 can be placed at the top of the void ducts. Transparent end discs of the grouting monitors 7 show the status of the grouting filling. When the transparent discs have been filled up by the grout, the pumping of the grout is terminated.

25 [0048] The advantages of using the grout monitor are:

1. Wastage of the grout is reduced or avoided.

2. Worker attendance at the grout outlet and removing the wastage grout are not required, thereby saving labor.

3. Without overflowing grout, the precast element can be made with final finishes.

4. The grouting monitor end discs are flush with a surface of the precast concrete, such that the monitor can be left in place and concealed by painting over the end discs.

5. By placing the grout monitors at strategic locations, a complex grouting operation involving multi-path grouting can be monitored and verified.

[0049] The present disclosure is not limited to the specific systems, devices and methods as described above, because there are able to be varied. The terms used in the specification are only for the purpose of describing a specific statement or an embodiment, rather than for limiting the scope.

[0050] In the above detailed description, reference is made to the attached drawings that serve as a part of the present disclosure. In the drawings, unless the context otherwise indicates, similar symbols typically identify similar components, the embodiment of the illustration described in the detailed description, drawings, and claims does not mean a restrictive purpose. Without departing from the spirit or scope of the present disclosure, other embodiments may be used and changes may be made. It will be easy to understand that, as generally described herein and illustrated in the accompanying drawings, aspects of the present disclosure may be arranged, substituted, combined, separated, and designed in a wide variety of different configurations, all of which are explicitly considered in the present disclosure.

[0051] The present disclosure of the particular embodiments described in the present application is not limited and is intended to illustrate for various aspects. For one skilled in the art, many clear modifications and changes can be made without departing from the spirit and scope of the present disclosure. Within the scope of the present disclosure, the functionally equivalent methods and devices, in addition to those listed herein, are clear to one skilled in the art from the foregoing descriptions. Such modification and change intention will fall within the scope of the appended claims. This disclosure is limited only by the terms of the appended claims and the full scope that is equivalent to the rights granted by such claims. It will be understood that the present disclosure is not limited to specific methods, reagents, compounds, compositions or biological systems, which can be changed certainly. It will also be understood that the terms used herein are intended only for the purpose of describing a particular embodiment, but not intend to become restrictive.

[0052] Various of the above-disclosed and other features and functions, or alternatives thereof, may be incorporated into many other different systems or applications. One skilled in

the art can correspondingly make various substitutions, modifications, changes, or improvements therein that are currently unforeseeable or unpredictable, in which each intention would be encompassed by the disclosed embodiments.

Claims

1. A method for forming a lapped joint between concrete structures, comprising:

forming a first shaped void in a first concrete structure, wherein the first shaped void
5 is disposed to be adjacent to a first main reinforcement of the first concrete structure;

placing a movable reinforcement in the first shaped void, wherein the movable
reinforcement has a length shorter than a length of the first shaped void such that the movable
reinforcement is wholly contained within the first shaped void;

placing a second concrete structure adjacent to the first concrete structure, wherein the
10 second concrete structure has a second shaped void adjacent to a second main reinforcement
of the second concrete structure, and the second shaped void is disposed as being substantially
coaxial to the first shaped void of the first concrete structure, wherein alternatively a
mechanical coupler replaces the second shaped void and faces the first shaped space of the
first concrete structure;

15 moving the movable reinforcement to a position such that the movable reinforcement
has a portion present within the first shaped void and another portion present within the
second shaped void, such that the movable reinforcement partially laps the first main
reinforcement and the second main reinforcement; and

grouting the first shaped void and the second shaped void.

20 2. The method for forming the lapped joint between concrete structures of claim 1, further
comprising disposing a centering element on the movable reinforcement to center the
movable reinforcement within the first shaped void.

25 3. The method for forming the lapped joint between concrete structures of claim 2, wherein
the centering element is a metal spring coil.

4. The method for forming the lapped joint between concrete structures of claim 1, further
comprising using a wire to hold the movable reinforcement within the first shaped void.

30 5. The method for forming the lapped joint between concrete structures of claim 1, further
comprising using a void duct disposed between the first shaped void and a side of the first
concrete structure to receive grout.

6. The method for forming the lapped joint between concrete structures of claim 5, further comprising using a wire having an end that passes through the void duct, so as to hold the movable reinforcement within the first shaped void.

5 7. The method for forming the lapped joint between the concrete structures of claim 1, wherein when the second shaped void of the second concrete structure is replaced by a mechanical coupler, the movable reinforcement and the mechanical coupler respectively have threads, such that the reinforcement is attached to the mechanical coupler by moving and rotating the reinforcement.

10 8. The method for forming the lapped joint between concrete structures of claim 5, wherein the lapped joint further comprises a second void duct disposed between the second shaped void and a side of the second concrete structure.

15 9. A grouting monitor applied to a concrete structure during grouting, comprising:
a housing connected to a void duct; and
a disc covering the housing and having a plurality of holes provided thereon, wherein one or more grouting channels allowing grout to pass therethrough are provided behind the disc;

20 wherein a size of each of the holes is designed to allow air to pass therethrough but disallow the grout to pass therethrough.

10. The grouting monitor of claim 9, wherein the grouting monitor is positioned on a grouting outlet and a critical path in grouting such that a speed of grouting is observable.

25 11. The grouting monitor of claim 9, wherein the grouting monitor further displays completed grouting, so as to prevent the grout from overflowing.

30 12. The grouting monitor of claim 9, wherein the grouting channels have widths narrowed as approaching a monitoring surface, and a surface of the grouting monitor is transparent.

13. The grouting monitor of claim 9, wherein the housing is made of plastic or metal.

14. The grouting monitor of claim 9, wherein the disc is made of plastic.

15. A method for forming a shaped space or a void duct in a concrete structure, comprising:
forming an internal void former by using combinations of one or more circular rods,
square rods, or rods in other shape;

5 wrapping a release layer around the internal void former in an approximate spiral
pattern;

removing the internal former after casting concrete; and

removing the release layer such that a shaped void or void duct is formed in a concrete
structure.

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16. The method of claim 15, wherein the release layer is made of plastic, Teflon, silicone
strip, or steel cable.