

## A WALL JOINT, METHOD AND SYSTEM TO FORM THE WALL JOINT WITH A MECHANICAL CONNECTOR

### Technical Field

- 5 The present invention relates to a mechanical connector and its use to form a wall joint. Particularly, the present invention may be used to join walls and prefabricated construction modules.

### Background

- 10 Prefabricated walls and construction modules are increasingly used in the construction of buildings as they provide better control of the quality in a controlled environment and to reduce on site production time leading to cost savings in manpower and resources. Further, this leads to reduced noise and dust from the on-site construction activities.
- 15 However, there is a need to transport the prefabricated parts to the construction site and lift the prefabricated parts into position. To avoid the use of specialised equipment that may not be readily available and increases the costs of construction, the dimensions and weights of the prefabricated parts are typically restricted. For example, the prefabricated part needs to be sized (like its height and width) to be transported on a single lane of a normal road to
- 20 avoid needing special transport arrangements. The length of the prefabricated part is also limited by the transportation means, for example the trailer length and turning angle of the trailer. In addition, a crane used to position the prefabricated parts has limitations to the maximum weight it can carry. As such there is a need to develop methods and equipment to join the prefabricated parts on site.
- 25 An existing method used to join the prefabricated walls uses a pair of steel loops (or guides) from two facing walls to form a channel. A steel rod is inserted into the channel after which grout is poured in and allowed to cure to join the walls. However, the steel loops may be dis-aligned or out of position and therefore affect the formation of the channel and
- 30 installation of the linking rod on site. This leads to delays in the assembly of the prefabricated walls and increased costs.

### Description

- 35 In a first aspect of the invention, there is provided a wall joint comprising a pair of walls, each wall comprises a first surface and at least one stud protruding from the first surface, wherein the first surfaces face each other with a gap in between; a mechanical connector having at least one pair of slots, wherein the at least one pair of slots are engaged with the at least one stud of each wall; and cured grout in the gap.
- 40 The term "wall joint" refers to a fixed connection between two walls. The wall joint may be applicable to form a composite structural wall or a non-composite structural wall.

The term "pair of walls" refers to two walls which may be or may not be symmetrical or identical.

5 Preferably, the at least one pair of slots physically and directly contact the at least one stud of each wall in the engagement.

Preferably, a groove is arranged on the first surface of each wall, and the at least one stud protrudes from the groove.

10 Preferably, the wall joint further comprises a support structure in each wall, wherein a first end of the at least one stud is attached to the support structure and a second opposing end of the at least one stud is a head. For example, the support structure includes a rod or a steel plate.

15 Preferably, the slot is linear or bent.

Preferably, the mechanical connector comprises a pair of vertical plates attached together by a connecting element, each vertical plate having at least one slot to form the at least one pair of slots. The vertical plates preferably abut respective first surface of the walls when  
20 the studs are engaged in the slots. In other words, the vertical plates are juxtaposed between the walls and may be in contact with the walls.

Preferably at least one edge of each slot forms an angle with a vertical edge of one of the vertical plates.

25

Preferably, the connecting element is any one selected from the group consisting of a connecting plate, a bolt and nut system, and a cable system.

Preferably, the connecting element is attached to the pair of vertical plates at the middle of each vertical plate, an edge of the vertical plate, or opposites edges of the pair of plates.  
30 This provides the mechanical connector with a H-shaped cross-section, a U-shaped cross-section and a hollow core cross-section respectively.

Preferably, a length of each plate in the pair of plates is substantially the same as a height  
35 of the first surface.

Preferably, the mechanical connector comprises a first plate attached substantially perpendicularly to the pair of vertical plates, the first plate having a pair of slits, each slit is configured to receive a rod extending out of a top surface of one of the walls.

40

Preferably, the wall joint further comprises at least one gap rod in the gap.

In an embodiment, the first surfaces are front faces and the wall joint joins the pair of walls to form a composite structural wall. In another embodiment, one of the first surfaces is a front face and the other of the first surfaces is an end face. In another embodiment, the first surfaces are end faces. Advantageously, the wall joint is versatile and may be used to join  
5 walls at their different faces e.g. two front faces, two end faces, or a front face and an end face.

Preferably, each wall is part of a prefabricated construction module.

10 In a second aspect of the invention, there is provided a building structure comprising at least one wall joint according to the first aspect.

In a third aspect of the invention, there is provided a method of assembling a wall joint. The method comprises providing a pair of walls, each wall comprises a first surface and at least  
15 one stud protruding from the first surface; arranging the first surfaces to face each other with a gap in between; inserting a mechanical connector into the gap, the mechanical connector comprises at least one pair of slots; engaging the studs with the at least one pair of slots; dispensing grout into the gap; and curing the grout to join the walls to form the wall joint.

20 Preferably, at least one edge of each slot forms an angle with a vertical axis of the walls, and engaging the studs with the at least one pair of slots comprises aligning the opening of the slots to the studs and receiving the studs into the slots.

25 Preferably, the mechanical connector comprises a pair of vertical plates attached together by a connecting element, each vertical plate having at least one slot to form the at least one pair of slots.

In a fourth aspect of the invention, there is provided a wall comprising a first surface and at  
30 least one stud protruding from the first surface, wherein the at least one stud is configured to engage with at least one slot of a mechanical connector to form a wall joint with an opposing wall.

35 Preferably, a groove is arranged on the first surface and the at least one stud protrudes from the groove.

Preferably, the wall further comprises a support structure in the wall, wherein a first end of the stud is attached to the support structure and a second end of the stud is a head. For example, the support structure may be steel rod or plate.

40 Preferably, the wall is part of a prefabricated construction module.

In a fifth aspect of the invention, there is provided a mechanical connector for securing a pair of walls arranged with a gap therebetween, each wall comprises a first surface and at least one stud protruding from the first surface, the mechanical connector comprises at least one pair of slots configured to engage with the at least one stud of the pair of walls.

5

Preferably, the mechanical connector further comprises a pair of vertical plates attached together by a connecting element, each vertical plate having at least one slot to form the at least one pair of slots.

- 10 Preferably, the connecting element is any one selected from the group consisting of a connecting plate, a bolt and nut system, and a cable system.

Preferably, the connecting element is attached to the pair of vertical plates at the middle of each vertical plate, or opposite edges of the pair of vertical plates.

15

Preferably, the mechanical connector further comprises a first plate attached perpendicularly to the pair of vertical plates, the first plate having a pair of slits, each slit is configured to receive a rod extending out of a top surface of one of the walls.

- 20 Advantageously, the mechanical connector and studs provide greater control of the alignment and makes it faster and simpler to join the walls. Further, the slots and studs physically engage each other and is in contact with each other making it easier to engage each other, compared to the alignment of the steel loops.

- 25 In the Figures:

Figure 1 shows a perspective view of an embodiment of a wall joint;

Figure 2 shows a side view of a wall used in the wall joint of Figure 1;

Figures 3a and 3b show perspective views of two embodiments of a wall that may be used in the wall joint of Figure 1;

- 30 Figure 4 shows a top plan view of the walls arranged to form the wall joint of Figure 1;

Figure 5 shows a perspective view of Figure 4;

Figure 6 shows an embodiment of the mechanical connector used in the wall joint of Figure 1;

Figure 7 shows a top plan view of the mechanical connector of Figure 6;

- 35 Figure 8 shows a side view of the mechanical connector of Figure 6;

Figures 9a to 9c show a perspective view, side view and top plan view, respectively, of another embodiment of the mechanical connector;

Figure 10 shows a perspective view of the mechanical connector of Figure 9 engaged with the wall;

- 40 Figure 11 shows a top plan view of the wall joint with the mechanical connector of Figure 9;

Figures 12a to 12c show a perspective view, side view and top plan view, respectively, of another embodiment of the mechanical connector;

- Figure 13 shows a perspective view of the mechanical connector of Figure 12 engaged with the wall;
- Figure 14 shows a top plan view of the wall joint with the mechanical connector of Figure 12;
- 5    Figures 15a to 15c show a perspective view, side view and top plan view, respectively, of another embodiment of the mechanical connector;
- Figure 16 shows a perspective view of the mechanical connector of Figure 15 engaged with the wall;
- Figure 17 shows a top plan view of the wall joint with the mechanical connector of Figure 10    15;
- Figures 18a to 18c show a perspective view, side view and top plan view, respectively, of another embodiment of the mechanical connector;
- Figure 19 shows a perspective view of the mechanical connector of Figure 18 engaged with the wall;
- 15    Figure 20 shows a top plan view of the wall joint with the mechanical connector of Figure 18;
- Figures 21a and 21b show a perspective and a front view, respectively, of a wall used in the formation of a wall joint, and Figure 21c shows a top plan view of two walls of Figure 21a arranged to form the wall joint;
- 20    Figure 22 shows a perspective view of another embodiment of the mechanical connector;
- Figure 23 shows a perspective view of the mechanical connector of Figure 22 engaged with the walls of Figure 21;
- Figure 24 shows a top plan view of the mechanical connector of Figure 22 engaged with two walls of Figure 21 to form the wall joint;
- 25    Figure 25 shows a perspective view of another embodiment of the mechanical connector;
- Figure 26 shows a perspective view of the mechanical connector of Figure 25 engaged with the walls of Figure 21;
- Figure 27 shows a top plan view of the mechanical connector of Figure 25 engaged with two walls of Figure 21 to form the wall joint;
- 30    Figure 28 shows a perspective view of another embodiment of the mechanical connector;
- Figure 29 shows a perspective view of the mechanical connector of Figure 28 engaged with the walls of Figure 21;
- Figure 30 shows a top plan view of the mechanical connector of Figure 28 engaged with two walls of Figure 21 to form the wall joint;
- 35    Figures 31a to 31d show the assembly and joining of prefabricated construction modules to construct a multi-storey building structure;
- Figure 32 shows a top plan view of an embodiment of a wall joint with one example of the mechanical connector;
- Figure 33 shows a perspective view of the wall joint of Figure 32;
- 40    Figure 34 shows a top plan view of an embodiment of a wall joint with one example of the mechanical connector;
- Figure 35 shows a perspective view of the wall joint of Figure 34;

Figure 36 shows a top plan view of an embodiment of a wall joint with one example of the mechanical connector;

Figure 37 shows a perspective view of the wall joint of Figure 36;

Figure 38 shows an enlarged side view of the slot.

5

In the following description, numerous specific details are set forth in order to provide a thorough understanding of various illustrative embodiments of the invention. It will be understood, however, to one skilled in the art, that embodiments of the invention may be practiced without some or all of these specific details. Embodiments described in the context of one of the methods or devices (e.g. the wall) are analogously valid for the other methods or devices (e.g. the prefabricated construction module) and vice versa. Similarly, embodiments described in the context of a method are analogously valid for a device, and vice versa.

15 Features that are described in the context of an embodiment may correspondingly be applicable to the same or similar features in the other embodiments. Features that are described in the context of an embodiment may correspondingly be applicable to the other embodiments, even if not explicitly described in these other embodiments. Furthermore, additions and/or combinations and/or alternatives as described for a feature in the context of an embodiment may correspondingly be applicable to the same or similar feature in the other embodiments.

As used herein, the articles "a", "an" and "the" as used with regard to a feature or element include a reference to one or more of the features or elements. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. As used herein, the terms "first," "second," and "third," etc. are used merely as labels, and are not intended to impose numerical requirements on their objects. As used herein, the terms "top", "bottom", "upper", "lower", "left", "right", "side", "vertical" and "horizontal" are used to describe relative arrangements of the elements and features. As used herein, the term "each other" denotes a reciprocal relation between two or more objects, depending on the number of objects involved.

As used herein, terms such as "length" and "width" are not intended to impose relative dimensional requirements on their objects, i.e. a length of an object may be greater than its width; alternatively, a length of an object may be smaller than or equal to its width.

Figure 1 shows a perspective view of a wall joint 100 comprising a pair of walls 5 with a gap 45 between the walls 5, and a mechanical connector 50 securing (or connecting) the walls 5. Cured grout (or other cementitious material) is present in the gap 45 and joins the walls 5 to form a secure joint between the pair of walls 5, but is omitted in Figure 1 to show the features of the walls 5 and mechanical connector 50 more clearly. The walls 5 while

described as a pair need not be identical or symmetrical, so long as it contains the features described herein and are able to function as required.

The wall 5 in Figure 1 may be viewed as having six surfaces (or faces) in a general cuboid shape. In an example, the wall 5 is a rectangular cuboid with a top surface 7, a bottom surface, opposing long faces (or front faces) and opposing short faces (or end surfaces). It will also be appreciated that the wall 5 (and a cuboid in general) may be understood to have a height ( $h$ ) corresponding to its vertical standing when assembled into the wall joint 100, a length ( $l$ ), and a width ( $w$ ) or thickness of the wall 5 as seen in Figures 2 and 4. It will be appreciated that the description of the top, bottom, and opposing are meant to be relative to allow easier understanding of the examples described herein, in particular the wall 5 and wall joint 100. The height of the wall 5 may be sized appropriately to be used to build a single storey of a building structure. For example, the height of the wall 5 may be at least 3 metres, or at least 3.5 metres, or at least 4 metres, up to a maximum of 5 metres, 6 metres or 7 metres. It would be understood that the wall 5 described in Figure 1 may be part of a larger wall structure, for example the wall 5 may be one part of an L-shaped wall, C-shaped wall, T-shaped wall, or other shape, and thus the dimensions and shapes described herein apply to the part of the wall to be joined.

In an example, it is the long or front face (defined by the height and length of the wall 5) of each wall 5 that are arranged to face each other (or arranged adjacently) with a gap 45 between the walls 5 as shown in the Figures. In another example, it is the short or end face (defined by the height and width of the wall 5) of each wall 5 that are arranged to face each other, and the mechanical connector may work similarly as for the long face. In yet another example, it is the long or front face of one wall which is arranged to face a short or end face of another wall. In these examples, the top surface 7 (and bottom surface) is substantially perpendicular to the opposing long faces and opposing short faces. When the wall joint 100 is constructed along the long face (or front face) of the wall 5, the wall 5 may be called a wall panel in certain circumstances, and the resultant wall formed is a composite structural wall which acts as a single wall (or unit). On the other hand, a non-composite wall is a wall formed when separate walls although joined or bound together behave as separate and independent walls. A composite wall may possess equivalent or (much) greater strength and stiffness than a non-composite wall of similar wall thickness and material. The wall joint 100 described herein may be particularly useful to form the composite structural wall. The wall joint 100 may also be used to form non-composite structural walls, or join the end faces of two walls to extend the walls. The wall joint 100 may also possibly be used as a T-shaped joint connector.

The wall comprises a first surface which, in different examples, may refer to a long face (front face), or short face (end face), or possibly both. The wall 5 and the first surface 25 in Figures 1 to 20 are applicable to both a long face (front face) and a short face (end face) of the wall, and may be viewed as a simplified and general version of the wall joint 100.

Accordingly, description of the wall 5, mechanical connector 50 and wall joint with respect to Figures 1 to 20 apply to the other examples and Figures. Figures 21 to 30 show examples of a wall joint 100 and wall 5 with the long face (front face) as the first surface 25. Figure 31 shows the wall 5 as part of a prefabricated construction module 200 and the joining of the prefabricated construction modules 200 via the wall joint 100. Figures 32 to 37 show examples of a wall joint 100 and wall 5 with the short face (end surface) as the first surface 25.

Figures 2 and 3a respectively show the side view and perspective view of a general example of a wall 5 that may be used to form the wall joint 100. Each wall 5 has a first surface 25 such that the first surfaces 25 of both walls are arranged to face each other in the wall joint 100 as may be seen in Figures 1, 4 and 5. A gap 45 may be arranged between the first surfaces 25 of the walls 5. At least one stud 10 protrudes from the first surface 25 of each wall 5. In Figures 2 and 3, two studs 10 are provided in each wall 5. The stud 10 may comprise a shaft 17 having an embedded portion arranged in the wall 5, and a protruded portion extending from the first surface 25 and terminating at a head portion 15 (or head) which is enlarged relative to the shaft portion 17. In another example (not shown), the stud 10 may comprise a shaft 17 having an embedded portion arranged in the wall 5, and a protruded portion extending from the first surface 25 and terminating at a head portion 15, wherein the protruded portion tapers towards the embedded portion. The shaft 17 may be cylindrical, conical, frustoconical in shape or a combination thereof. In particular, for the conical or frustoconical shaft, the head 15 may be fused with the shaft 17. The stud 10 may be made of any suitable material, for example steel. In the gap 45, there may be a part of a shaft 17 and a head 15 both protruding from the first surface 25. This allows for engagement of the stud 10 with a slot 56 of a mechanical connector 50 as will be described later. In particular, the head 15 provides a more secure engagement between the stud 10 and the slots 56. In particular, the engagement refers to a physical and direct contact (or a physical and direct interlocking) between the stud 10 and the slot 56. The term interlocking includes a reference to a secure fitting together of the stud 10 and slot 56, without limitation to there being an actual locking and/or unlocking mechanism.

In an example, a groove 20 may be provided in a non-edge portion, for example middle portion, of the first surface 25 of the wall 5 and may extend substantially the entire height of the wall 5. In other words, with reference to at least Figures 1 to 4, the groove 20 extends along a vertical direction of the first surface 25 and wall 5. The groove 20 may be formed by having sloped surfaces 27 (as seen in Figures 2 to 4) slope from a substantially flat side surface 26 to a substantially flat middle surface 28 to create a depression to form the groove 20. The sloped surfaces 27, substantially flat side surfaces 26 and middle surface 28 form at least part of the first surface 25 or all of the first surface 25 as shown in Figures 2 to 4. In addition, more than one groove 20 may be provided in particular when the first surface is the long face to provide additional connecting joints 100 between the opposing walls 5 as may be seen in Figure 21. The studs 10 may be positioned within the groove, for example

in the centre of the groove 20 (or middle surface 28), and as such the groove 20 should be wide enough to allow the mechanical connector 50 to be inserted in the groove 20 vertically downwards and subsequently laterally (or horizontally) to allow engagement of the studs 10 by the slots 56. It will be appreciated that the directions provided are relative and describe the motion of the mechanical connector 50 and walls 5 as they would be assembled. In particular, it will be appreciated that the walls 5 are to be arranged standing on the ground and thus substantially perpendicular to the ground, and a vertical direction refers to the axis substantially perpendicular to the ground. The horizontal direction thus refers to one of the two axes parallel to the ground. In particular, the downward motion is described relative to the placement of the walls 5 (and prefabricated construction module 200) on the ground or other structure (which are not shown in the Figures), for example foundation piles, support platform, and another prefabricated construction module. Advantageously, the grooves 20 of the opposing walls 5 provide more space to accommodate the mechanical connector 50 thereby easing the installation of the mechanical connector 50 during assembly of the wall joint 100. It is to be appreciated that in some examples (not shown), the first surface may not be provided with a groove and therefore the studs may be provided on an un-grooved first surface.

A support structure may be provided within the wall 5 and attached to the studs 10 to securely attach the studs 10 to the wall 5. Examples of the support structure include a rod 35 and a plate 102, for example steel plate, which are illustrated in Figures 3a and 3b. A rod 35 may be partially embedded within the wall 5 in a vertical direction (relative to the ground when the wall joint 100 is assembled) and partially protruded from the top surface 7. The stud 10 may be attached to the rod 35 to provide securement of the stud 10, for example by welding the embedded portion of the stud 10 to the rod 35. In particular, the attachment of the stud 10 and rod 35 may be substantially perpendicular. Alternatively, the rod 35 may be provided by one of a mesh of rods. Hence, one end of the stud 10 is attached to the rod 35 while the opposite end is the head portion 15. The rod 35 may extend through a substantial height of the wall 5, preferably at least 80%, 90%, 95%, and 100% of the height of the wall 5. The rod 35 may further extend out of the top surface 7 of the wall 5. The extended portion of the rod 35 may be joined to another or upper wall 5 placed on top of or overlaying the existing wall, for example the extended portion may be received into a recess in the upper wall. Advantageously, this allows for multi storey structures to be constructed.

Figure 3b shows another example of a wall 5 with a plate 102 as the support structure. The plate 102 may be attached to the studs 10 by welding or integrally made with the studs 10.

Accordingly, the wall 5 may include a recess (not shown) at the bottom surface of the wall 5 to receive the support structure, for example rod 35 or steel plate 102, of a wall 5 below it. This allows pairs of walls to be stacked to form a multi-storey structure. Additional recesses may be provided as necessary.

A reinforcement structure may be provided in the wall 5 in both Figures 3a and 3b. For example, the reinforcement structure may be a cross network of horizontal steel rods 104 and vertical steel rods 106. The wall 5 in Figures 3a and 3b may be prepared by placing the support structure with studs 10 attached thereto and reinforcement structure if required into an appropriately-prepared mould, and casting with concrete or grout. After curing, the pre-cast wall 5 is formed with the studs 10 protruding from the first surface 25 of the wall 5. The support structure may extend out of the top surface 7 of the wall 5 to be received into a recess of another or upper wall 5 stacked above.

10

Figures 4 and 5 show the top and perspective views of the pair of walls 5 respectively without the mechanical connector 50 and show the gap 45 with the walls 5 spaced apart. A gap rod 40 may be provided in the gap 45 and may vertically extend through a space of the mechanical connector 50 or on one or both sides of the mechanical connector 50 (see Figures 11 and 31). As the mechanical connector 50 may not have sufficient space to allow the gap rod 40 to pass through, it may be more feasible to have the gap rod 40 on either or both sides of the mechanical connector. The gap rod 40 may extend at least substantially along the full height of the wall 5 or prefabricated construction module 200 described later and may overlap with another gap rod 40 from the wall 5 or prefabricated construction module 200 of the upper and/or lower storey. Advantageously this allows for multi storey structures to be constructed.

General dimensions of the wall 5, mechanical connector 50 and wall joint 100 are provided in millimetres as an example. Figures 2 and 4 illustrate the dimensions around the groove 20 area, the wall 5 may have the following dimensions: a length ( $l$ ) of 300 mm, a width ( $w_1$ ) of 90 mm to the side surfaces 26, a width ( $w_3$ ) of 60 mm at the middle surface 28 of the wall 5, and a height ( $h$ ) of 600 mm. The walls 5 may be spaced apart to provide a gap of 20 mm width ( $w_2$ ). The groove 20 may have the following dimensions: a length ( $l_4$ ) of 160 mm at the middle surface 28, and a depression depth of 30 mm, and therefore a length ( $l_i$ ) of each side surface 26 may be 60 mm. Hence, the width of the gap 45 between the two middle surfaces 28 of the walls may be 80 mm ( $w_4$ ). The width ( $w_2$ ) of the gap 45 may be as narrow as practically possible to minimise the grouting on site while allowing for construction tolerances. For example, a typical width ( $w_2$ ) of the gap 45 may be about 20 mm and above. The width ( $w_3$ ) of the wall 5 at the middle surface 28 should not be overly narrow such that any rebars within the wall 5 are overly congested which affects casting of the wall. Width ( $w_3$ ) may be a minimum of about 60 mm. The length from the edge of the side wall 5 to the start of the middle surface 28 may be 70 mm ( $l_3$ ), thus the length between the two side surfaces 26 is 180 mm ( $l_2$ ). The width ( $w_4$ ) of the gap 45 between the middle surfaces 28 and length ( $l_4$ ) of the middle surfaces 28 should not be overly narrow such that it affects the installation of the mechanical connector 50 and gap rods 40. For example, the width ( $w_4$ ) of the gap 45 between the middle surfaces 28 may be a minimum of around 80 mm and the length ( $l_4$ ) of the middle surfaces 28 may be a minimum of around 160mm.

The protruding portion of the stud 10 is preferably approximately equal to or greater than the depth of the groove 20. In other words, the head 15 of the stud 10 may be in line or beyond the line with the side surfaces 26 respectively. An imaginary plane may be envisioned to form across the side surfaces 26 and head when the head 15 is in line with the side surfaces 26. This imaginary plane may also be viewed as the front face of the wall 5 without the groove 20. The two studs 10 in Figure 2 may be spaced apart such that the upper stud 10 is 150 mm ( $h_1$ ) from the top surface 7 and the lower stud 10 is 300 mm ( $h_2$ ) below the upper stud 10 (i.e. the lower stud is 150 mm ( $h_3$ ) from the bottom of the wall) as measured from the centre of the head 15 of the stud 10. The rod 35 may extend 100 mm out of the top surface 7 of the wall 5. In some other examples, the protruding portion of the stud 10 may be less than the depth of the groove 20.

A mechanical connector 50 is used to engage with the studs 10 to secure the pair of walls 5. The mechanical connector 50 includes at least one pair of slots 56 configured to engage with the studs 10. The engagement may be a physical and direct contact between the slots 56 and studs 10 (it is not necessary or needed for the whole stud 10 to contact the slot 56 as explained below). The mechanical connector 50 may include a pair of plates 55 attached together by a connecting element with each plate 55 having at least one slot to form the at least one pair of slots 56. Examples of the connecting element include a connecting plate 75, a bolt and nut system, and a cable system.

The position and placement of the slots 56 should match or complement the position and placement of the studs 10. The slots 56 should be at least as wide as the diameter of the shaft 17 of the stud 10 but should be preferably less than the diameter of the head 15 to prevent disengagement of the stud 10. The width of the slots 56 may be at 100% to 200% of the diameter of the shaft 17, preferably 115% to 180% of the diameter of the shaft 17, or 130% to 170%, or 130% to 160%, or 130% to 150%, or 115% to 150%, or 115% to 130%, of the diameter of the shaft 17. Advantageously, by ensuring that the widths of the slots 56 are only slightly larger than the diameter of the shaft 17 this allows for some tolerance and variability in the manufacture of the wall 5 and mechanical connector as well as in the assembly or construction of the wall joint 100. Further by controlling the relative widths of the slots 56 and shaft, it allows the slots 56 and studs 10 to easily engage by providing a slightly larger width (based on the relative widths above) of the slots 56 than the diameter of the shaft 17, while ensuring that the studs 10 do not easily move out of position once within the slots 56 (or disengage from the slots 56) ensuring a secure fit between the studs 10 and slots 56. Figure 38 illustrates possible position tolerance of the shafts 17a, 17b of the opposing walls 5 with the width of the slots 56. It may be seen that even when the studs 10 are not exactly aligned with each other, by using a slot 56 with slightly larger width as described above, the slot 56 is able to accommodate and engage the shaft 17a of one wall 5 and the shaft 17b of the opposing wall 5. This takes into account minor variations in the pre-casting process and the on-site placement of the walls 5, and thus accommodates the

minor differences in the position of the studs 10 and shafts 17 (i.e. the position tolerance). The assembly is able to proceed even when the studs 10 are slightly misaligned and for the engagement of the studs 10 and slots 56 to be performed more easily

5 For a cylindrical shaped shaft, the diameter should be substantially identical or near identical along most of the shaft length. For a frustoconical shaped shaft 17, the shaft 17 needs to fit the slots 56. The diameter may be measured at the point where the engagement occurs, for example at the part of the shaft 17 protruding from the first surface 25. As shown in Figure 38, by restricting the width of the slots 56 relative to the diameter of the shaft 17  
10 (as provided above), it provides both a secure fit while allowing for minor variations (or imperfections) in the casting of the wall 5 from the required dimensions and make the on-site assembly easier with a larger tolerance of the slots 56 for the studs 10. It would be apparent that as the width of the slot 56 is larger than the diameter of the shaft 17, the shaft 17 and stud 10 may not contact the slot 56 entirely.

15 Slot 56 may include any appropriate shape or side cross-section which provides a linear profile, or a bent (or non-linear) profile, or a piecewise linear profile. A four sided shaped cross section, for example in the form of a parallelogram or trapezium shaped cross section as shown in Figure 8 has a linear profile due to its linear or straight edges. A dog-leg shaped  
20 cross section having a bent in the slot, as shown in Figures 9b, 12b, 15b and 18b has a bent profile due to incorporation of at least one bend or curve edge. The latter dog-leg shaped slot 56 may provide a more secure fit for the stud 10 as the bend in the slot profile makes it harder for the stud 10 to disengage with the slot 56. The slots 56 may be angled to a vertical axis perpendicular to the ground (i.e. a direction parallel to the height of the  
25 wall 5) and is explained in greater detail below. In other words, the upper and/or lower edges of the slot 56 forms an angle with a vertical edge of a vertical plate 55 of the mechanical connector 50.

Figure 6 shows an example of a mechanical connector 50. The mechanical connector 50  
30 includes a horizontal plate (or a first plate) 65, two vertical plates (or pair of plates or a second and third plate) 55, and a connecting plate 75. The plates 55, 65, 75 may be made of steel or other suitable material. The horizontal plate 65 and vertical plates 55 are generally perpendicular to each other. The vertical plates 55 each has an upper or proximal end, and a lower or distal end, in which the proximal end of each vertical plate 55 are  
35 attached to the horizontal plate 65, for example by welding or by moulding directly with a die. Each vertical plate 55 provides at least one slot 56 configured to engage with the stud 10 of the wall 5. In particular, the engagement physically and directly contacts the stud 10 with the slot 56. Together, the two vertical plates 55 provide at least a pair of slots 56 to engage the studs 10 of the pair of walls 5. The horizontal plate 65 may provide a pair of  
40 slits 70, each to receive a rod 35 extending out of the wall 5. The slits 70 may act as a guide, for example a visual guide unobstructed by the walls, to aid the mechanical connector 50 in engaging with the studs 10 and/or ascertain the position of the studs 10 relative to the

slots 56. The slits 70 may be positioned, shaped and dimensioned such that a position of the rod 35 along the slit 70 corresponds to a position of studs 10 along the slots 56. For example, when the rod 35 is positioned at the entry or opening of the slit 70, the studs 10 are positioned at the entry of the slot 56; when the rod 35 is positioned at the end of the slit 70, the studs 10 are positioned at the end of the slots 56 which may be the engaged position. Advantageously, this may allow an operator to ascertain the relative position of the studs 10 and slots 56 by visual inspection of the relative position of the rod 35 and the slits 70.

The connecting plate 75 attach to non-edge portions of the vertical plates 55, for example middle portion, near (or proximal) to the slots 56 or near to at the end of the slots 56. In Figure 6, each vertical plate 55 provides two slots 56 to provide a total of two pairs of slots 56 in the mechanical connector 50 to engage with the two pairs of studs 10 of the pair of walls 5.

Each slot 56 is a space which may be cut out of the vertical plate 55 or forged with dies to provide the requisite shape as shown in Figure 6. It will be apparent that the slot 56 needs to be suitably sized to receive the shaft 17 into the slot 56 and to interlock with the head 15 to prevent the head 15 from passing through the slot 56. Each slot 56 comprises an end surface, an upper surface, a lower surface and a slot opening 60 as may be seen in the perspective view in Figure 6, and correspondingly a side view of the slot 56 having an end edge 57, an upper edge 58, a lower edge 59 and the slot opening 60 as most clearly seen in Figure 8. The slots 56 may be angled to a vertical axis of the vertical plate 55 which is parallel to the vertical axis of the wall 5. In other words, slot 56 is not parallel to the vertical axis of the vertical plate 55 or wall 5. Angles 61, 62 of the slots 56 may be measured at the opening 60 of the slots 56 relative to the vertical axis as shown in Figure 8 (or vertical direction of the vertical plate 55). The angle 61 or 62 of the slot 56 may be measured between the upper edge 58 or lower edge 59 relative to a vertical edge of the vertical plate 55 where the opening 60 is placed. The vertical axis may be defined as being generally perpendicular to the ground upon assembly of the wall joint 100 and is a relative directional term. In particular, the slots 56 may be angled between 30° to 60°, inclusive of the end points. The angled slots 56 allow the slots 56 to engage more readily with the studs 10. Advantageously, the angled slots 56 allow the studs 10 to slide in (i.e. downwards angular movement), when the mechanical connector 50 is supportably arranged on the studs 10, by utilising gravity to aid the engagement between the studs 10 and slots 56 rather than utilising a pure or substantially horizontal motion.

In an example, both the upper angle (first angle) 61 and lower angle (second angle) 62 of the slot 56 may be the same, such that the slot 56 has a parallelogram cross section profile when the mechanical connector 50 is viewed from the side as in Figure 8. In an example, the slots 56 may be tapered, i.e. angles 61, 62 are different. Advantageously, this makes sliding the studs 10 into the slots 56 easier. Thus, the width of the slots 56 is not constant, but reduces from the opening 60 of the slot 56 to the end edge 57 such that the slot 56 has

a trapezoid cross section profile as seen in Figure 8 (i.e. the end edge 57 and edge of the opening 60 are parallel, and the upper edge 58 and lower edge 59 are not parallel). For example, the upper angle 61 of the slot 56 may be larger than the lower angle 62 of the slot 56. The difference between the upper angle 61 and lower angle 62 may not exceed 10° or preferably 5°. Each slot 56 may be made to its own dimensions to fit the stud 10. However, it will be preferred for the slot 56 at the same height in each vertical plate 55 to have substantially identical dimensions. More preferably, all the slots 56 have substantially identical dimensions to allow easy manufacturing of the mechanical connector 50. It is to be appreciated that in some examples the slot 56 may have other cross-section profile, for example polygon, other quadrilateral.

Figures 7 and 8 show the dimensions of an example of the mechanical connector 50. It will be apparent that the dimensions of the mechanical connector 50 correspond to or complement the dimensions of the walls 5 and the gap 45. The horizontal plate 65 may have a length of 180 mm ( $2 \times l_{11} + l_{12}$ ), a width of 60 mm and a thickness of 5 mm. The dashed lines in the horizontal plate 65 indicate the profiles of the vertical plates 55 and connecting plate 75. The distance ( $l_{12}$ ) between the two edges of the vertical plates 55 may be 80 mm or slightly less than 80 mm and corresponds to the gap between the middle surfaces 28 of the grooves 20 of mutually-facing walls 5. The distance ( $l_{12}$ ) may be slightly less than the width ( $w_4$ ) of the gap in the middle part of the gap 45 to fit. The length ( $l_{11}$ ) of the horizontal plate from its edge to the edge of the vertical plate 55 is thus more than 50 mm ( $l_{11}$ ) preferably slightly more than 50 mm and allows the horizontal plate 65 to sit on top of the walls 5 with sufficient contact area. The slits 70 may have a depth of 30 mm extending into the horizontal plate 65, in other words the depth of the slit 70 may be approximately half or slightly more than half of the width of the horizontal plate 65. The slit 70 should be sufficiently wide enough to accommodate the rod 35.

In Figure 8, the length of the vertical plates 55 may be 3000 mm and may be substantially equivalent to the height of the walls 5. This allows the vertical plates to substantially join and support the walls 5. The position of the slots 56 corresponds to the position of the studs 10 in the walls 5. Accordingly, the upper slot is positioned about 150-200 mm ( $l_{21}$ ) below the bottom of the horizontal plate 65 and the lower slot is positioned about 200-300 mm ( $l_{22}$ ) below the upper slot, i.e. 150-200 mm ( $l_{23}$ ) above the bottom end of the vertical plate 55. The height and position of the slots 56 should correspond to the height and position of the studs 10 for proper engagement and both of which may be adjusted as appropriate. After engagement of the mechanical connector 50 and slots 56 with the studs 10, one or more gap rods 40 may be inserted into the gap 45. The gap rods 40 may be inserted through a hole in the horizontal plate 65 of the mechanical connector 50 or on either or both sides of the mechanical connector 50.

For a wall 5 with a height of 3000 mm (3 metres), the topmost stud 10 may be positioned about 150 to 200 mm ( $l_{21}$ ) below the top edge of the vertical plate 55 (or horizontal plate if

present). Subsequent studs 10 may be spaced apart about 200 to 300 mm ( $l_{22}$ ). The bottommost stud 10 may be positioned about 150 to 200 mm ( $l_{23}$ ) above the bottom edge of the vertical plate 55. As an example, the wall 5 of height 3000 mm may have at least ten studs 10, and the number of studs 10 may be varied in other examples according to the specifications of the wall 5. The number of studs 10 for walls 5 of different heights may be adjusted accordingly to meet the required specification for the walls 5.

Figures 9a to 9c show another example of a mechanical connector 50. This is substantially similar to the mechanical connector described and shown in Figures 6 to 8. However, in this example, the horizontal plate 65 is removed and the slot 56 has a dog-leg or bent cross section as seen in Figure 9b. As may be seen the slot 56 in this example is also angled to a vertical axis, and the slot 56 bends from an angled direction, i.e. relative to a vertical direction, to a vertical direction upwards to provide the dog-leg cross section. The connecting plate 75 is similarly attached to non-edge portion, for example the middle, of the vertical plates 55. In this example, due to the expanded size of the slot 56, the connecting plate 75 may be positioned above the slot 56, but may alternatively be placed in other positions. This example may also be termed a H-shaped mechanical connector based on the plan view in Figure 9c which shows a H-shaped profile. Figure 10 shows the engagement of the mechanical connector 50 of Figures 9a to 9c with one wall 5 to show more clearly the engagement of the stud 10 in the slot 56. It may be seen that the dog-leg or bent slot 56 may make it more difficult for the stud 10 to disengage from the slot 56, which makes the assembly of the wall joint 100 safer.

Figure 11 shows the top view of the wall joint with grout (or cement) in the gap 45 and incorporating the mechanical connector 50 of Figures 9a to 9c. The wall 5 used is that shown in Figure 3b, with the steel plate 102 as the support structure attached to the studs 10. It may also be seen by the dotted lines that part of the shaft 17 is embedded within the wall 5, while another part protrudes from the first surface 25 and terminates at the head 15. In Figure 11, two gap rods 40 are provided on either side of the mechanical connector 50 in the gap 45.

Figures 12a to 12c show a mechanical connector 50 similar to that in Figure 9. Instead of a connecting plate 75, a bolt and nut system is used. A hole is provided in each vertical plate 55 to allow a bolt 76 to pass through which is secured with a nut 77 at each end of the bolt. This attaches the bolt 76 to the pair of vertical plates 75. A single nut 77 may alternatively be used with a bolt 76 with an opposing enlarged end. Figures 13 and 14 show the mechanical connector 50 of Figures 12a to 12c in engagement with the wall 5 and are similar views as Figures 10 and 11.

Alternatively, a cable system may be used instead of the bolt. The cable may be steel wire, or steel loop. The cable is passed through the hole in the vertical plate 55 and is looped to create enlarged opposite ends to secure the cable to the vertical plates 55. Alternatively, a

nut 77 may be attached to either or both ends of the cable to secure the cable to the vertical plates 75.

5 Figures 15a to 15c show another mechanical connector 50 with a connecting plate 75 as the connecting element between the pair of vertical plates 55. However, the connecting plate 75 is attached to the pair of vertical plates 55 at an edge of each of the vertical plate 55. As a result, the mechanical connector has a C or U-shaped profile as seen in Figure 15c (i.e. a C or U-shaped mechanical connector). The connecting plate 75 may be attached to either edge of the vertical plate 55. Figure 15 shows the connecting plate 75 attached at  
10 the edge opposite to that of the slot openings 60. However, it is also possible for the edge with slot openings 60 to be attached to the connecting plate 75, as described below.

Figures 18a to 18c show another mechanical connector 50 with connecting plates 75 attached to the edges of vertical plates 55 which are opposite to or remote from the slot  
15 openings 60. As a result, the mechanical connector 50 has a square shaped or O-shaped profile as seen in Figure 18c, i.e. O-shaped mechanical connector. This may also be referred to as a hollow core mechanical connector as the centre of the mechanical connector is essentially an empty space or channel.

20 Figures 16 and 19 show the engagement of the respective mechanical connector 50 with the studs 10 of one wall while Figures 17 and 20 show a resultant wall joint 100 formed. It may be seen that regardless of the mechanical connector 50, the engagement of the slots 56 and studs 10 is essentially the same.

25 These mechanical connectors 50 of Figures 9a to 9c, 12a to 12c, 15a to 15c, 18a to 18c provide slots 56 having dog-leg shaped cross-section, but it is to be appreciated that other slot profiles, including those described in the foregoing, may be provided instead.

Each of the mechanical connectors 50 described above may be fabricated by welding a  
30 plurality of plates or made integrally.

In another example (not shown), the vertical plates 55 may be replaced by a single metal block with the slots cut into the metal block. In other words, the core is not empty as the hollow core mechanical connector 50 of Figures 18a to 18c.  
35

In some examples, a hole 63 may be provided at the upper end or proximal end of each vertical plate 55 (as shown in Figures 22, 25, and 28). The holes 63 in the pair of vertical plates 55 may be used for lifting the mechanical connector 50 into position with a crane or other machine. This may be done by passing a cable, lifting rod, or equivalent) through the  
40 holes 63 and supporting it using a hook of a crane. The cable can be subsequently removed when the mechanical connector 50 is in place, or at least partly in engagement with the walls 5.

In various examples, it may be preferred for the studs 10 on the opposing first surfaces 25 to be at the substantially same height as shown in Figure 5, subject to construction tolerance, to provide symmetry which provides ease of fabrication of the mechanical connector 50 and installation on site. Accordingly, it may be preferred for the slots 56 to be at substantially the same heights in the vertical plates 55 as shown in Figure 6.

To assemble or construct the wall joint 100, the pair of walls 5 are arranged such that the first surfaces 25 face each other with a gap 45 between them. As a result, the studs 10 protrude from the first surfaces 25 into the gap 45. In the examples shown in the Figures, each first surface 25 preferably has at least a groove 20 from which the stud 10 protrudes, in particular the groove 20 may be formed in the non-edge portion of the first surface 25 and extends along at least partially the entire height, or substantially the entire height of the wall 5.

The mechanical connector 50 is lowered, for example inserted downwards, into the gap 45 from above the arranged pair of walls 5. As the openings 60 of the slots 56 approach the studs 10 and align to the studs 10, the mechanical connector 50 may be further brought to receive the studs 10 into the slots 56 through the slot openings 60 and to arrange the studs 10 in engagement with the slots 56. This may be achieved by pushing the mechanical connector 50 with a machine and/or by one or more workers in a horizontal direction, i.e. a direction generally perpendicular to the initial downward motion,) to allow the slots 56 to receive the studs 10, thereby engaging the studs 10 with the slots 56. It would be understood that the alignment of the slot openings 60 and studs 10 is for the correct stud 10 and slot 56 pairing. Using Figures 3a and 5 as an example, when the mechanical connector 50 is lowered or inserted into the gap 45, the lower pair of slots 56 of the mechanical connector 50 aligns with the upper pair of studs 10 first. However, this is not the "correct" alignment, and the mechanical connector 50 needs to be inserted further down to align the lower pair of slots 56 with the lower pair of studs 10, and the upper pair of slots 56 with the upper pair of studs 10. This is the correct alignment position required. If the number of slots 56 matches the number of studs 10, the correct alignment position is thus when the lowest and highest slots 56 align with the lowest and highest studs 10 respectively. However, this is not strictly necessary as there can be more slots 56 than studs 10, or vice versa with appropriate modifications, without affecting the function of the mechanical connector 50. This allows for flexibility in the fabrication of the walls 5 and mechanical connector 50.

Further, the engagement of the studs 10 and slots 56 requires a physical and direct contact of the studs 10 and slots 56. By moving in a downwards and horizontal manner, for example diagonally relative to the vertical axis, the studs 10 are moved along the slots 56 until the studs 10 reach the end of the slots 56. In examples where the slots 56 have a dog-leg shaped cross section, another downward motion moves the stud 10 around the bend and

into the end of the slot 56 to ensure a secured engagement. Having a head 15 (an enlarged end) aids in keeping the studs 10 within the slots 56 thereby ensuring a tight fit and preventing the studs 10 from disengaging from the slots 56. In the engaged position, the distal end of the vertical plates 55 of the mechanical connector 50 may be proximate to the lower edge of the first surface 25 of the wall 5 if the heights of vertical plate 55 and wall 5 are substantially similar. Subsequently, grout (or other cementitious material) may be dispensed or poured into the gap 45 and allowed to cure (or harden) to form the wall joint 100.

In some examples where a rod 35 extends or protrudes from the top surface 7 of the wall 5, each slit 70 in the horizontal plate 65 may receive the protruded portion of the rod 35 and may also serve as a guide to aid the engagement of the slots 56 and studs 10. The protruding end of the rod 35 may also be received into a recess of an upper wall 5 which is stacked on the lower wall 5 from which the rod 35 extends, or a composite wall comprising the wall joint 100, or a ceiling panel of the lower wall 5 or the composite wall.

In an example, a gap rod 40 (shown in Figures 11, 14, 17, 20, or a similar gap rod 240 shown in Figures 31c and 31d) may be inserted into the gap 45, either one or both sides of the mechanical connector 50 or through an opening in the mechanical connector 50 (not shown). The gap rod 40, 240 includes two opposed ends which are respectively extended at least partially through the wall joint 100 as illustrated in Figures 11, 14, 17, 20, 31c, 31d, and at least partially through another wall joint stacked thereupon and/or arranged thereunder. The gap rod 40 may be used to connect walls of different floors, or wall joints, to form a multi-storey structure.

Figures 21a and 21b show a perspective view and front view of a wall 5 where the first surface 25 is a long face (or front face) of the wall 5 and provides two grooves 20. By joining the pair of walls 5 along the first face 25, a composite structural wall may be formed which behaves as a single or monolithic wall rather than two individual separate walls. In this example, two grooves 20 are provided which extend substantially along the height of the wall 5. A plurality of studs 10 are arranged at intervals and protruding from the groove 20. It may be seen that the first surface 25 may similarly include the side surfaces 26, sloped surface 27 and middle surface 26 as described above. It is apparent that the terms "side surface" and "middle surface" are described relative to the groove 20. Figure 21c shows a top plan view of two walls 5 of Figures 21a and 21b which are arranged such that their first surfaces 25 face each other with a gap 45 in between and the studs 10 of each wall 5 protrude into the gap 45.

Figure 22 essentially shows the mechanical connector 50 of Figure 9 but with more slots 56 and connecting plates 75 to match the number of studs 10. The number of slots may equal or exceed the number of studs for each wall, otherwise if the connector 50 and wall 5 are of relatively similar height the unmatched or additional studs 10 may possibly obstruct

the vertical plate 55 when the mechanical connector 50 is inserted into the gap 45 for engagement with the studs 10. Figure 23 shows the engagement of the mechanical connector 50 of Figure 22 with one wall 5. Figure 24 shows the top plan view of a wall joint 100 which incorporates the mechanical connector 50 of Figure 22, and provides a composite wall. In Figure 24, grout is provided in the gap 45.

Similarly, the mechanical connector 50 shown in Figures 25 and 28 are similar to that shown in Figures 15 and 18 but with more slots 56. Figures 26 and 29 show the engagement of the respective mechanical connector 50 with one wall 5. Figures 27 and 30 show the top plan view of wall joints 100 which incorporate the mechanical connector 50 of Figures 25 and 28, respectively, and provide composite walls. Thus, the mechanical connector 50 may be made in several ways as long as it provides a connecting structure, to engage with the studs 10.

The wall 5 may be provided by one side of a prefabricated construction module 200 which may be empty within or may be a specific type of prefabricated construction module with at least some internal finishes, fixtures and/or fittings known as prefabricated prefinished volumetric construction (PPVC) modules. PPVC modules have an advantage in that many of the internal work in the modules are installed off site leading to better production control and reduction of on site activity thus leading to improvements in cost and quality.

Figures 31a to 31d show the sequential assembly of two pairs of prefabricated construction module 200 with one pair stacked on the other pair of modules 200 to construct a multi-storey building. Figures 31a and 31b show an embodiment of the walls 5 as part of a prefabricated construction module 200. The features of the wall 5 described above similarly apply even when the wall 5 is part of the prefabricated construction module 200. The first surface 225 is the long face of the wall 205. Each prefabricated construction module 200 includes at least one wall 205 to join with a wall 205 of an adjacent module 200. Figures 31a and 31b show prefabricated construction modules 200 having four walls 205 arranged along two opposite sides. At each side, the two walls 5 are arranged with a space or opening therebetween which may be used as a door or passageway between the modules 200 after assembly. The other two opposite sides of module 200 are shown as empty spaces but may be provided with a conventional wall or a wall 5 as described herein. Alternatively, each side may be viewed as a wall 5 with an opening in part of the wall 5. The module 200 may comprise a floor slab 280 and a ceiling slab 285. Each wall 205 comprises at least one stud 210 protruding from a first surface 225. It is to be appreciated that in other examples, the number of walls, studs, slabs, openings, and grooves as well as their placement may be modified as required.

The stud 210 may be similar to stud 10 and/or its examples as described above. Accordingly, the stud 210 may comprise a shaft 217 having an embedded portion and a protruded portion which terminates at a head portion 215 (or head).

In Figure 31a, each wall 205 is provided with three grooves 220 on the first surface 225 and studs 210 (as described above) protruding from each groove 220. A support structure, for example the rod 35 or steel plate 102 described above, for each groove may be embedded within the wall 205. The stud 210, at an end opposite to its head 215, may be attached to the support structure. A reinforcement structure may be provided within the wall 5, for example a network of horizontal rods 104 and vertical rods 106 may be used.

In Figure 31b, two modules 200 are arranged side by side with the walls 205, in particular their first surfaces 225, facing each other with a gap 245 in between. The mechanical connector 250 used in Figures 31a to 31d is that shown in Figure 22. From the enlarged inset of Figure 31b it may be seen that the mechanical connector 250 includes two vertical plates 255 or a pair of vertical plates 255, attached by a connecting element which is a connecting plate 275 in this example, and a plurality of pairs of slots 256 formed in the vertical plates 255, each vertical plate 255 having a slot 256 corresponding to another slot on the other vertical plate 255 to form the pair of slots 256. The connecting plate 275 may be attached to the vertical plates 255 at one or both of the edges. The other connecting elements as described above may also be used in place of the connecting plate 275, for example the bolt and nut system, and the cable system. The mechanical connector 250 may have a horizontal plate 265 (similar to horizontal plate 65 in Figures 6 & 7) which may have silts, each to accommodate a rod 235 which protrudes from the top surface 207 of the wall 205.

Each slot 256 may be similar to slot 56 and/or its examples as described above. Each slot 256 comprises an end surface, an upper surface, a lower surface and a slot opening 260.

In Figure 31b, the mechanical connector 250 is lowered (or inserted downwards) into the gap 245. When the openings of the slots 256 align with the studs 210, the mechanical connector 250 may be moved laterally and downwards (i.e. diagonally) to allow the studs to move within the slots 256 thereby allowing engagement therebetween. In examples where the grooves 220 are provided in the gap 245, and the studs 210 protrude from the grooves 220, the mechanical connector 250 is lowered into the gap 245, and the grooves 220 should be large enough to accommodate the lowered mechanical connector 250 being and subsequent horizontal or lateral movements of the mechanical connector 50 to allow the studs 210 to move in the slots 256. With the dog-leg shaped slot, there is a further downward movement of the mechanical connector 250 in order to move the studs 210 completely into and engage with the slots 256. Advantageously, this uses gravity to aid the engagement and makes the joining of the walls easier.

When the studs 210 are fully within the slots 256, the vertical plates 255 of the mechanical connector 250 may contact the first surface 225 along substantially or entirely the height of

the walls 205. In Figure 31b, three mechanical connectors 250 are used for each wall 205 to match the number of grooves 220.

Figure 31c shows a gap rod 240 for each inserted mechanical connector 250 arranged in the gap 245. One or more gap rods 240 may be inserted at a side of the mechanical connector 250, both sides of the mechanical connector, or in a space provided by the mechanical connector 250. Grout or other cementitious material is dispensed or poured into the gap 245 and allowed to cure or harden to form the wall joint 100 thereby joining the modules 200. In Figure 31c, the wall joint 100 is formed along the long face of the wall 205 and module 200. In particular, the wall joint 100 joins the pair of walls 205 to form a composite structural wall, which behaves as a single monolithic wall rather than two separate individual walls.

Figure 31d shows a second pair of modules 200 stacked on top of the first pair of modules 200 which are joined by the wall joint 100 between the first and second pair of modules assembled as described herein. The walls 205 in the second pair of modules 200 may each have at least one recess in the bottom surface of the walls 205 to receive the rod 235 which may optionally be extending out of the top surface 207 of a lower module 200. The gap rod 240 extending out of the gap 245 in the lower pair of modules 200 would be received in the gap 245 of the upper pair of modules 200.

The assembly of a second wall joint 100 and optionally composite structural wall between the upper (or second) pair of modules 200 stacked on top of the lower (or first ) pair of modules 200 follow essentially the same method as described above for Figures 31a to 31c.

Briefly, the second pair of modules 200 which may include features similar to the first pair of modules 200 are provided and arranged such that the first surfaces 225 of the second pair of modules 200 face each other with a second gap 245 in between. A second mechanical connector 250 having slots 256 as above is inserted into the second gap 245 to engage with the studs 210 protruding from the first surfaces 225. After the studs 210 are inserted into the slots and engaged, grout may be dispensed or poured into the second gap 245 and allowed to cure to join the second pair of modules 200 and form the second wall joint 100. The other features of the wall 5 and mechanical connector 50 similarly apply when they are used as part of the prefabricated construction module 200.

Figures 32 to 37 show the top plan views and perspective views of a wall joint 100 with the different mechanical connectors 50 joining the pair of walls 305 at their end faces. This allows the wall 305 to be joined with another wall 305 and provides a wall with a greater length and overcomes the limitations with the transportation and lifting of the prefabricated walls and modules.

Each wall 305 has at least one stud 10 protruding from the groove 20 of the end face (first surface 25) of the wall 305. A steel plate 402 is used as the support structure and is attached to the stud 10 at an end opposite to the head 15 of the stud 10. It may be seen that part of the shaft 17 of the stud is embedded in the wall 305 and another part extends out of the end face of the wall 305. A reinforcement structure made of a network of horizontal rods 404 and vertical rods 406 may be provided in the wall 305. The pair of walls 305 are arranged to allow the end or short faces (first surface 25) to oppose each other with a gap 345 between the pair of walls 305. In these examples, the end surfaces provide the first surface 25.

Figures 32, 34, and 36 show the plan views of the wall joint 100 with three different mechanical connectors 50. In these Figures, grout is shown in the gap 345 as the dotted area. Figures 33, 35 and 37 shows the perspective views of the wall joint 100 without grout in the gap 345.

Figures 32 and 33 show the mechanical connector 50 of Figure 9 being arranged in the wall joint 100 of the pair of walls 305. Figures 34 and 35 show the mechanical connector 50 of Figure 15 being arranged in the wall joint 100 of the pair of walls 305. Figures 36 and 37 show the mechanical connector 50 of Figure 18 being arranged in the wall joint 100 of the pair of walls 305. The mechanical connector 50 in these figures engages the studs 10 in the same manner as that for the front face of the wall 5 described above.

The mechanical connector 50 may also be used in a T-joint to join an end face of one wall to a front face of another wall. In this example (not shown), the first surface provided by one of the pair of walls is on the front face (or long face) while the other first surface is provided by the end face (or short face) of the other wall. This example may be considered a hybrid of the examples above where the first surfaces are either both front faces or end faces. The studs 10 and mechanical connector 50 would be as described above.

The mechanical connector 50, 250 described herein allows for the pair of walls 5, 205, 305 to be more readily and easily joined on the front face and/or end face of the walls 5, 205, 305. When joining the pair of walls 5, 205 along the front face, the resultant wall formed is preferably a composite structural wall, which behaves as a single monolithic wall (i.e. a composite wall) rather than two separate individual walls. Features of the wall 5, 205, 305 described in the context of one wall would be understood to be applicable to the other embodiments of the wall 5, 205, 305. Features of the mechanical connector 50, 250 described for use with the wall 5 alone or with the module 200 would similarly be applicable to the other. Further, the use of the mechanical connector 50, 250 provides a secured joining of the pair of walls 5, 205, 305 before the grout is poured or cured and provides a safer and more stable assembly. The use and engagement of the mechanical connector 50, 250 with walls 5, 205, 305 having studs 10, 210 provide greater accuracy and positioning control thus leading to a faster assembly of the prefabricated walls 5, 205, 305

and construction modules 200 on site thus leading to faster construction turnaround time and reduced costs.

5 It is to be understood that the embodiments, examples and features described above should be considered exemplary and not restrictive. Many other embodiments and examples will be apparent to those skilled in the art from consideration of the specification and practice of the invention. Furthermore, certain terminology has been used for the purposes of descriptive clarity, and not to limit the disclosed embodiments of the invention.

**Claims**

- [Claim 1] A wall joint comprising  
a pair of walls, each wall comprises a first surface and at least one stud protruding from the  
first surface, wherein the first surfaces face each other with a gap in between;  
5 a mechanical connector having at least one pair of slots, wherein the at least one pair of  
slots are engaged with the at least one stud of each wall; and  
cured grout in the gap.
- [Claim 2] The wall joint according to claim 1, wherein the at least one pair of slots  
10 physically and directly contact the at least one stud of each wall in the engagement.
- [Claim 3] The wall joint according to any one of claims 1 to 2, wherein a groove is  
arranged on the first surface of each wall, and the at least one stud protrudes from the  
groove.  
15
- [Claim 4] The wall joint according to any one of claims 1 to 3 further comprising a  
support structure in each wall, wherein a first end of the at least one stud is attached to the  
support structure and a second opposing end of the at least one stud is a head.
- 20 [Claim 5] The wall joint according to claim 4, wherein the support structure includes at  
least a rod or a plate.
- [Claim 6] The wall joint according to any one of claims 1 to 5, wherein each slot is  
25 linear or bent.
- [Claim 7] The wall joint according to any one of claims 1 to 6, wherein the mechanical  
connector comprises a pair of vertical plates attached together by a connecting element,  
each vertical plate having at least one slot to form the at least one pair of slots.  
30
- [Claim 8] The wall joint according to claim 7, wherein at least one edge of each slot  
forms an angle with a vertical edge of one of the vertical plates.
- 35 [Claim 9] The wall joint according to claim 7 or claim 8, wherein the connecting  
element is any one selected from the group consisting of a connecting plate, a bolt and nut  
system, and a cable system.
- [Claim 10] The wall joint according to any one of claims 7 to 9, wherein the connecting  
40 element is attached to the pair of vertical plates at the middle of each vertical plate, an edge  
of the pair of plates, or opposites edges of the pair of plates.

[Claim 11] The wall joint according to any one of claims 7 to 10, wherein a length of each vertical plate is substantially the same as a height of the first surface.

5 [Claim 12] The wall joint according to any one of claims 7 to 11, wherein the mechanical connector comprises a first plate attached substantially perpendicularly to the pair of vertical plates, the first plate having a pair of slits, each slit is configured to receive a rod extending out of a top surface of one of the walls.

10 [Claim 13] The wall joint according to any one of claims 1 to 12, further comprises at least one gap rod in the gap.

15 [Claim 14] The wall joint according to any one of claims 1 to 13, wherein the first surfaces are front faces and the wall joint joins the pair of walls to form a composite structural wall.

[Claim 15] The wall joint according to any one of claims 1 to 13, wherein one of the first surfaces is a front face and the other of the first surfaces is an end face.

20 [Claim 16] The wall joint according to any one of claims 1 to 13, wherein the first surfaces are end faces.

25 [Claim 17] The wall joint according to any one of claims 1 to 16, wherein each wall is part of a prefabricated construction module.

[Claim 18] A building structure comprises at least one wall joint according to any one of claims 1 to 17.

30 [Claim 19] A method of assembling a wall joint, the method comprises providing a pair of walls, each wall comprises a first surface and at least one stud protruding from the first surface;  
arranging the first surfaces to face each other with a gap in between;  
inserting a mechanical connector into the gap, the mechanical connector comprises at least one pair of slots;  
35 engaging the studs with the at least one pair of slots;  
dispensing grout into the gap; and  
curing the grout to join the walls to form the wall joint.

40 [Claim 20] The method according to claim 19, wherein at least one edge of each slot forms an angle with a vertical axis of the walls, and engaging the studs with the at least one pair of slots comprises aligning the opening of the slots to the studs and receiving the studs into the slots.

- [Claim 21] The method according to any one of claims 19 to 20, wherein the mechanical connector comprises a pair of vertical plates attached together by a connecting element, each vertical plate having at least one slot to form the at least one pair of slots.
- 5 [Claim 22] A wall comprises a first surface and at least one stud protruding from the first surface, wherein the at least one stud is configured to engage with at least one slot of a mechanical connector to form a wall joint with an opposing wall.
- 10 [Claim 23] The wall according to claim 22, wherein a groove is arranged on the first surface and the at least one stud protrudes from the groove.
- [Claim 24] The wall according to any one of claims 22 to 23 further comprises a support structure in the wall, wherein a first end of the stud is attached to the support structure and
- 15 a second end of the stud is a head.
- [Claim 25] The wall according to any one of claims 22 to 24, wherein the wall is part of a prefabricated construction module.
- 20 [Claim 26] A mechanical connector for securing a pair of walls arranged with a gap therebetween, each wall comprises a first surface and at least one stud protruding from the first surface, the mechanical connector comprises at least one pair of slots configured to engage with the at least one stud of the pair of walls.
- 25 [Claim 27] The mechanical connector according to claim 26 further comprises a pair of vertical plates attached together by a connecting element, each vertical plate having at least one slot to form the at least one pair of slots.
- [Claim 28] The mechanical connector according to claim 27, wherein the connecting
- 30 element is any one selected from the group consisting of a connecting plate, a bolt and nut system, and a cable system.
- [Claim 29] The mechanical connector according to claim 28, wherein the connecting element is attached to the pair of vertical plates at the middle of each vertical plate, an edge
- 35 of the pair of plates, or opposite edges of the pair of vertical plates.
- [Claim 30] The mechanical connector according to any one of claims 26 to 29 further comprises a first plate attached perpendicularly to the pair of vertical plates, the first plate having a pair of slits, each slit is configured to receive a rod extending out of a top surface
- 40 of one of the walls.