

A BELT
SON

Singapore.

PATENT SPECIFICATION

(11) 1436849/

1436849

- (21) Application No. 22033/73 (22) Filed 9 May 1973
(31) Convention Application No. 74214/72 (32) Filed 26 July 1972 in (19)
(33) Japan (JA)
(44) Complete Specification published 26 May 1976
(51) INT CL² E04B 1/58
(52) Index at acceptance

E1W 2A113 2A114 2A120 2A50 2A65 4A203 4A204



(54) A METHOD OF MAKING A RIGID JOINT FOR CONSTRUCTING PRECAST REINFORCED CONCRETE AND PRESTRESSED CONCRETE STRUCTURES

(71) We, PENTA-OCEAN CONSTRUCTION CO., LTD., a corporation organized under the laws of Japan, formerly of 1 Shibanishikubo Sakuragawa-cho, Minato-ku, Tokyo, Japan, and now of 13-1, Nihonbashi-1-chome, Chuo-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a method of connecting prefabricated reinforced concrete members or prestressed concrete members, and is especially applicable for use in erecting reinforced or prestressed concrete structure at the site of construction.

Recently, the so-called prefab-system is increasingly employed in the field of building construction. According to this prefab-system, structural members of a reinforced concrete structure are manufactured in a factory and transported to the site of construction to be assembled. The structural members manufactured in the factory, according to the prefab-system, include linear members such as columns and beams, flat member such as wall slabs and floor slabs, and members, which may be of a larger scale, such as room units. The reinforced concrete members manufactured in the factory are transported to the site of construction for assembling, but in order that the assembled structure can withstand external forces as a sound unitary structure, the structural members must be sufficiently rigidly connected to each other at the site of construction. Furthermore, in order to fully realise the minimization of human labor requirement and the rapidity of construction work at the site, which are advantages offered by the prefab-system, it is desirable that the connections made between the structural members obey simple and reliable principles of dynamics.

It has previously been proposed to connect prefabricated reinforced concrete members by manufacturing the members in a factory in

such a manner that concrete is not cast at portions adjacent to the joint portions of the members, so as to expose the reinforcing steel bars at such portions, and after subjecting the reinforcing steel bars exposed at the joint portions of the members to welding at the site of construction, casting concrete to cover the portions including the welded reinforcing steel bar portion. However, such a method may not be fully reliable as it includes welding work on the exposed reinforcing steel bar portions and casting of concrete on the joint portions at the site of construction. Further, the desired rapidity of construction work cannot be satisfactorily realised with such a method.

In order to overcome the difficulties of the above method, various proposals, some of which are described later in the specification, have been made for obtaining simple and reliable joints by introducing prestress in the portions to be jointed to each other. These proposals, however, do not necessarily overcome the difficulties in providing a suitable joint.

The invention provides a method of joining together two or more prestressed or reinforced concrete members, each concrete member having a plane surface where it is to be joined to another concrete member, the method comprising bringing the concrete members together such that a plane surface of each concrete member is substantially parallel to and in close proximity to a plane surface of the concrete member or members adjacent to it, the plane surfaces at which the concrete members are to be joined lying parallel to each other, curing mortar which has been applied in such a manner so as to lie between and in contact with each surface of the pair or pairs of adjacent parallel plane surfaces, applying a compressive force across the or each joint between adjacent parallel plane surfaces by imparting tension to tension means extending through the said concrete members in a direction perpendicular to the plane or planes in which the pair or pairs of adjacent parallel plane surfaces lie, and maintaining the tension

in the tension means by anchoring the tension means at the two concrete members through which the end portions of the tension means pass.

- 5 The invention also provides a joint between prefabricated reinforced or prestressed concrete members, when made in accordance with the method of the invention.

10 Methods and joints in accordance with the invention will now be described, by way of example, with reference to the accompanying drawings, in which:—

Fig. 1 is a side elevation of a joint formed by a prior art method;

15 Fig. 2 is a section taken along the line II—II in Fig. 1;

Fig. 3 is a side elevation of a joint formed by a second prior art method;

20 Fig. 4 is a section taken along the line IV—IV in Fig. 3;

Fig. 5 is a side elevation of a joint formed by a third prior art method;

25 Fig. 6 is a section taken along the line VI—VI in Fig. 5;

Fig. 7 is a side elevation of a joint formed by a fourth prior art method;

30 Fig. 8 is a section taken along the line VIII—VIII in Fig. 7;

Fig. 9 is a partly cut-away side elevation of a joint formed by a fifth prior art method employing tension bars tensioned perpendicularly with respect to the plane of framework;

35 Fig. 10 is a section taken along the line X—X in Fig. 9;

Fig. 11 is a schematic view illustrating the basic principle of the present invention;

40 Fig. 12 is a side elevation of a joint formed by the method of the present invention in which a single beam is jointed to a single column;

Fig. 13 is a section taken along the line XIII—XIII in Fig. 12;

45 Fig. 14 is an enlarged perspective view of the joint shown in Fig. 12;

Fig. 15 is a side elevation of a second joint formed by the method of the present invention in which a pair of parallel beams are jointed to a single column;

50 Fig. 16 is a section taken along the line XVI—XVI in Fig. 15;

Fig. 17 is an enlarged perspective view of the joint shown in Fig. 15;

55 Fig. 18 is a section taken along the line XVIII—XVIII in Fig. 19 and shows a third joint formed by the method of the present invention in which a pair of T-shaped beams are jointed to a single column;

60 Fig. 19 is a section taken along the line XIX—XIX in Fig. 18;

Fig. 20 is an enlarged perspective view of the joint shown in Fig. 18;

Fig. 21 is a side elevation of a fourth joint formed by the method of the present

invention in which a pair of constructed parallel beams are jointed to a single column;

Fig. 22 is a section taken along the line XXII—XXII in Fig. 21;

Fig. 23 is an enlarged perspective view of the joint shown in Fig. 21;

70 Fig. 24 is a side elevation of a fifth joint formed by the method of the present invention, the joint being suitable for transmission of a large moment;

75 Fig. 25 is a section taken along the line XXV—XXV in Fig. 24;

Fig. 26 is an enlarged perspective view of the joint shown in Fig. 24; and

80 Fig. 27 is a perspective view of a sixth joint formed by the method of the present invention in which a pair of slab panels provided with a beam are jointed to a single column.

Some typical prior art methods for forming joints are shown in Figs. 1 to 8, so that the present invention can be more clearly understood. In Figs. 1 to 8, the reference numerals 1 and 2 designate a first member such as a column, and a second member, such as a beam, respectively.

Referring to Figs. 1 and 2, tension bars 3 in a pair of beams 2 are extended through a column 1 utilizing a plurality of couplers 4 and tension is imparted to the tension bars 3 so as to obtain a rigid joint. Referring to Figs. 3 and 4, tension bars 3 in a pair of column 1 are extended into a beam 2 so as to obtain a rigid joint. Thus, the application of the method shown in Figs. 1 and 2 or Figs. 3 and 4 is limited to the case in which the column 1 or beams 2 are prestressed concrete members, and cannot be used in making a joint between reinforced concrete members.

85 Figs. 5, 6 and Figs. 7, 8 show an application of a method similar to that above described to a joint between reinforced concrete members. The methods shown in Figs. 5, to 8 have in common the attribute that the tension bars 3 are disposed in a direction parallel to the plane of a frame to be constituted, and this inevitably imposes limitations on the applicability of this method, due to the disposition of the tension bars 3 in such a direction, since when the tension bars 3 are disposed as to provide a desired joint between the reinforced concrete members, cut-outs or projections must be formed on the members for anchoring the tension bars 3 in position as seen in Figs. 5 to 8.

90 The problems which arise in using the methods described above with reference to Figs. 1 to 8 may be avoided by making a joint by imparting a prestress in a direction perpendicular to the plane of a frame. A method described with reference to Figs. 9 and 10 has been proposed and put into practical use from the viewpoint of obviating defects of the previously described methods. The proposed method comprises preparing a column

1 having a cut-out portion 6, preparing a pair of beams 2, placing the members 1 and 2 at predetermined relative positions, casting a mass of concrete 5 in the space between the members 1 and 2, and after curing the concrete, tensioning a plurality of tension bars 3 and 3' to obtain a tight joint. In this case, due to the fact that the tension bars 3 are disposed in spaced apart relation on opposite sides of the column 1, it can be easily considered that the tension bars 3 cooperate with the tension bar 3' to impart an initial compressive force to the cast-in-place concrete block 5. However, the effect of this arrangement on the function of the joint is not yet clear and especially the mechanism of transmission of the moment between the beams 2 and the column 1 is indistinct.

A further method of jointing between prestressed or reinforced concrete members for use in assembling a building framework, is described in patent specification no. 1084094. In this case, the tension means passing through the joints extend substantially across the complete width of the building framework. It has been found that, when a second concrete block is cast in contact with one of the side faces of an already cured first concrete block, and after curing of the second concrete block, these concrete blocks are fastened together in a direction perpendicular to their engaging surfaces, and a strong frictional resistance, which is very stable against the slip along the engaging surfaces, can be obtained at the engaging surfaces. This principle is illustrated in Fig. 11. In Fig. 11, the symbols A, B, N and Q designate a first concrete block, a second concrete block cast in contact with the first concrete block A, a fastening force (compressive force), and a force tending to cause slip of the blocks A and B relative to each other, respectively. The effect similar to that above described can be attained by previously preparing these two concrete blocks A and B in lieu of casting the second concrete block B in contact with the first concrete block A and filling the space therebetween with a mass of mortar adhesive to these blocks.

The slip resistance Q_r , when adhesion of the mortar adhesive at the joined surfaces is disregarded, is proportional to the fastening force N and is given by

$$Q_r = \mu_{\max} \cdot N$$

Experiments have shown the maximum apparent coefficient of friction $\mu_{\max}$ to be greater than 1. Thus, when an apparent coefficient of friction obtained by multiplying the above value by a suitable safety factor is employed in providing joints, the effect of jointing based on the above principle can be evaluated by a calculation formula similar to

that employed in calculating the effect of a high-strength bolted joint in a steel structure.

The present invention based on such a basic principle as described above will now be described, by way of example, with reference to Figs. 12 to 27.

Referring first to Figs. 12, 13 and 14 showing an embodiment of the method according to the present invention, members 1 and 2 are reinforced concrete or prestressed concrete members manufactured in a factory and are provided with a plurality of holes 8 formed in perpendicular relation to the jointed surfaces thereof. After these members 1 and 2 are disposed at predetermined relative positions spaced from each other at the site of construction, steel tension bars 3 are inserted into the holes 8 and are anchored at their opposite ends to fix the members 1 and 2 in the relative positions. Then, a mass of stiff or dry mortar is poured in the space 7 between the members 1 and 2. (Alternatively, the tension bore 3 may be inserted into the holes 8 after mortar has been poured into the space 7, although before the mortar has cured). According to the results of tests carried out by the inventors on models as large as the actual size, the space 7 is desirably of the order of 20 to 50 millimeters. Further, the weight composition ratio between cement and sand and the percentage of water relative to cement of the poured-in-place mortar are preferably about 1:1 and 30%, respectively. High-early-strength cement is preferably used in the mortar for improving the working efficiency at the site of construction. A non-shrinkage additive may be mixed in the mortar for preventing undesirable contraction of the mortar. After the poured-in-place mortar is cured, the tension bars 3 are subjected to a predetermined tension for completing the joint. Better results can be obtained in respect of protection of the steel bars and stabilization of the slip resistance when grouting mortar is poured into the holes 8 for filling the gaps between the steel bars 3 and the inner wall surface of the holes 8.

Several types of joints obtained by the method according to the present invention are shown in Figs. 15 to 27. A joint shown in Figs. 15, 16 and 17 is formed between a single column 1 and a pair of beams 2. In another joint shown in Figs. 18, 19 and 20, a pair of T-shaped beams 2 are combined with a single column 1. Each beam 2 consists of a member 2-1 and a member 2-2 extending perpendicularly from the member 2-1. In this joint, stress is transmitted in the direction of the members 2-2 under the same principle as that described with reference to Figs. 5 and 6. A further joint as shown in Figs. 21, 22 and 23 is preferably employed in the case in which inconvenience is encountered when two members 2 run in parallel with each other while defining a considerable space therebetween.

In this joint, the members 2 are constricted so as to define a narrow space 9 therebetween on opposite sides of a member 1. In this case, it is important that the space 9 should be filled with mortar after impartation of tension to the tension bars 3.

Another joint as shown in Figs. 24, 25 and 26 is preferably employed in the case in which the value of the moment transmitted between members 1 and 2 is excessively large to an extent that it cannot be dealt with by merely providing steel bars extending through the member 1.

Referring to Figs. 24, 25 and 26, the member 1 is formed with a pair of side extensions 10 and prestress steel bars 3 extend through these side extensions 10 so as to obtain a strong resisting moment.

The jointing method according to the present invention is similarly effectively applicable to a joint as shown in Fig. 27 in which a pair of slab panels 2 provided with a beam are fixed to a column 1.

It will be understood from the foregoing description that two three or more reinforced concrete or prestressed concrete members can be rigidly and simply jointed to each other by the method according to the present invention.

WHAT WE CLAIM IS:—

1. A method of joining together two or more prestressed or reinforced concrete members, each concrete member having a plane surface where it is to be joined to another concrete member, the method comprising bringing the concrete members together such that a plane surface of each concrete member is substantially parallel to and in close proximity to a plane surface of the concrete member or members adjacent to it, the plane surfaces at which the concrete members are to be joined lying parallel to each other, curing mortar which has been applied in such a manner so as to lie between and in contact with each surface of the pair or pairs of adjacent parallel plane surfaces, applying a compressive force across the or each joint between adjacent parallel plane surfaces by imparting tension to tension means extending through the said concrete members in a direction perpendicular to the plane or planes in which the pair or pairs of adjacent parallel plane surfaces lie, and maintaining the tension in the tension means by anchoring the tension means at the two concrete members through which the end portions of the tension means pass.

2. A method as claimed in claim 1, wherein the said concrete members have a plurality of previously-formed holes extending there-

through in a direction perpendicular to the said parallel plane surfaces, the method comprising disposing a plurality of tension means so as to extend through the said holes after applying the mortar so that it lies between and in contact with each surface of the pair or pairs of adjacent parallel plane surfaces, and before curing the mortar.

3. A method as claimed in claim 1, wherein the said concrete members have a plurality of previously-formed holes extending there-through in a direction perpendicular to the said parallel plane surfaces, the method comprising disposing a plurality of tension means so as to extend through the said holes before applying the mortar so that it lies between and in contact with each surface of the pair or pairs of adjacent parallel plane surface.

4. A method as claimed in any one of claims 1 to 3, wherein the mortar comprises a mixture of cement, sand and water in the approximate weight ratio of 10:10:3, respectively.

5. A method as claimed in any one of claims 1 to 4, wherein a high-early-strength cement is included in the mortar.

6. A method as claimed in any one of claims 1 to 5, wherein a non-shrinkage additive is included in the mortar to prevent contraction of the mixture as it is cured.

7. A method as claimed in any one of claims 1 to 6, wherein the or each space between the pair or pairs of parallel plane surfaces is approximately 2 to 5 centimetres.

8. A method as claimed in any one of claims 1 to 7, wherein grouting mortar is applied to the spaces between the tension means and the inner surfaces of the holes formed to receive the tension means.

9. A method of providing a joint substantially as hereinbefore described with reference to Figure 11, or Figures 12, 13 and 14, or Figures 15, 16 and 17, or Figures 18, 19 and 20, or Figures 21, 22 and 23, or Figures 24, 25 and 26, or Figure 27 of the accompanying drawings.

10. A joint between at least two prefabricated reinforced concrete or prestressed concrete members made in accordance with a method as claimed in any one of claims 1 to 9.

11. A joint as claimed in claim 10, wherein the said parallel planar surfaces are vertical.

ABEL & IMRAY,
Chartered Patent Agents,
Northumberland House,
303—306 High Holborn,
London, WC1V 7LH.

In this joint, the members 2 are constricted so as to define a narrow space 9 therebetween on opposite sides of a member 1. In this case, it is important that the space 9 should be filled with mortar after impartation of tension to the tension bars 3.

Another joint as shown in Figs. 24, 25 and 26 is preferably employed in the case in which the value of the moment transmitted between members 1 and 2 is excessively large to an extent that it cannot be dealt with by merely providing steel bars extending through the member 1.

Referring to Figs. 24, 25 and 26, the member 1 is formed with a pair of side extensions 10 and prestress steel bars 3 extend through these side extensions 10 so as to obtain a strong resisting moment.

The jointing method according to the present invention is similarly effectively applicable to a joint as shown in Fig. 27 in which a pair of slab panels 2 provided with a beam are fixed to a column 1.

It will be understood from the foregoing description that two three or more reinforced concrete or prestressed concrete members can be rigidly and simply jointed to each other by the method according to the present invention.

WHAT WE CLAIM IS:—

1. A method of joining together two or more prestressed or reinforced concrete members, each concrete member having a plane surface where it is to be joined to another concrete member, the method comprising bringing the concrete members together such that a plane surface of each concrete member is substantially parallel to and in close proximity to a plane surface of the concrete member or members adjacent to it, the plane surfaces at which the concrete members are to be joined lying parallel to each other, curing mortar which has been applied in such a manner so as to lie between and in contact with each surface of the pair or pairs of adjacent parallel plane surfaces, applying a compressive force across the or each joint between adjacent parallel plane surfaces by imparting tension to tension means extending through the said concrete members in a direction perpendicular to the plane or planes in which the pair or pairs of adjacent parallel plane surfaces lie, and maintaining the tension in the tension means by anchoring the tension means at the two concrete members through which the end portions of the tension means pass.

2. A method as claimed in claim 1, wherein the said concrete members have a plurality of previously-formed holes extending there-

through in a direction perpendicular to the said parallel plane surfaces, the method comprising disposing a plurality of tension means so as to extend through the said holes after applying the mortar so that it lies between and in contact with each surface of the pair or pairs of adjacent parallel plane surfaces, and before curing the mortar.

3. A method as claimed in claim 1, wherein the said concrete members have a plurality of previously-formed holes extending there-through in a direction perpendicular to the said parallel plane surfaces, the method comprising disposing a plurality of tension means so as to extend through the said holes before applying the mortar so that it lies between and in contact with each surface of the pair or pairs of adjacent parallel plane surface.

4. A method as claimed in any one of claims 1 to 3, wherein the mortar comprises a mixture of cement, sand and water in the approximate weight ratio of 10:10:3, respectively.

5. A method as claimed in any one of claims 1 to 4, wherein a high-early-strength cement is included in the mortar.

6. A method as claimed in any one of claims 1 to 5, wherein a non-shrinkage additive is included in the mortar to prevent contraction of the mixture as it is cured.

7. A method as claimed in any one of claims 1 to 6, wherein the or each space between the pair or pairs of parallel plane surfaces is approximately 2 to 5 centimetres.

8. A method as claimed in any one of claims 1 to 7, wherein grouting mortar is applied to the spaces between the tension means and the inner surfaces of the holes formed to receive the tension means.

9. A method of providing a joint substantially as hereinbefore described with reference to Figure 11, or Figures 12, 13 and 14, or Figures 15, 16 and 17, or Figures 18, 19 and 20, or Figures 21, 22 and 23, or Figures 24, 25 and 26, or Figure 27 of the accompanying drawings.

10. A joint between at least two prefabricated reinforced concrete or prestressed concrete members made in accordance with a method as claimed in any one of claims 1 to 9.

11. A joint as claimed in claim 10, wherein the said parallel planar surfaces are vertical.

ABEL & IMRAY,
Chartered Patent Agents,
Northumberland House,
303—306 High Holborn,
London, WC1V 7LH.

