

SPECIFICATION

Improvements in or Relating to Wall Segments

This invention relates to wall segments such as tunnel lining segments, liquid container segments and the like.

The invention provides a wall segment formed in a cast material of high compressive strength and having joining means at each of a pair of opposite ends of the segment for joining the segment ends to the corresponding ends of similar segments, the joining means at each end of the segment comprising at least two grooves formed in the segment end at spaced locations along the end and extending part-way only across the end from one side thereof and stopping short of the other side, tensile elements cast in the ends of the segment adjacent each groove having a part-circular hoop or hoops projecting from the end of the segment across the respective grooves for overlapping with corresponding hoops on an adjacent segment end, the axis of the or each hoop lying in a plane containing the respective segment end from which the tensile elements project and fastening devices to be driven into opposing pairs of grooves on adjacent segment ends through the overlapping hoops for pulling the segment ends into abutting engagement and to hold the segment ends together in compression.

At least one slot may be formed in each end of the segment adjacent each hoop and extending across the groove to receive a hoop projecting from an end of an adjacent segment to which the first segment is to be secured.

More specifically the segment at one end may have two hoops projecting from the segment end and spaced apart along the groove with a slot extending across the groove between the hoops and, at the other end, a single hoop bridging the groove at that end with a pair of slots extending across the groove on either side of the hoop.

The following is a description of some specific embodiments of the invention, reference being made to the accompanying drawings in which:

Figure 1 is an end view of a ring or arcuate concrete tunnel lining segments according to the invention,

Figure 2 is a plan view of part of a joint between two adjacent segments with the segments separated;

Figure 3 is a perspective view of part of a joint between adjacent segments with the segments separated;

Figure 4 is a perspective view of the ring shown in Figure 1 with part of an additional ring shown in an exploded view;

Figures 5 to 12 show further forms of fastening device for connecting the segments together;

Figure 13 shows a further form of joint, and

Figures 14 to 17 show mould parts for moulding the segments.

Referring firstly to Figure 1 of the drawings, there is shown a ring of pre-cast concrete tunnel lining segments 10, joined at the top of the ring

by a key segment 11.

The segments have axially extending end faces 12 which are secured together and to the key segment 11 by similar joints which will now be described with reference to Figures 2 and 3 of the drawings.

Each pair of adjacent end faces 12 has a resilient "Bitumastic" gasket 13 between the end faces and two joints indicated generally at 14 at spaced locations across the axially extending end faces 12.

Each joint 14 comprises opposing part cylindrical grooves 15 extending down the respective end faces 12 from the inner sides of the segments towards but stopping short of the outer sides of the segments. Mid-way down the groove 15 in one of the faces 12a there is a projecting steel hoop 16 which bridges the grooves 15, the hoop having legs embedded in the segment. The opposing end face 12b has two similar hoops 17 spaced apart along the groove to receive between them the hoop 16. The first end face 12a has slots 18 spaced above and below the hoop 16 to receive the hoops 17 and, similarly, the other end face 12b has a slot 19 between the hoops 17 to receive the hoop 16.

The joint is completed by a steel pin 20 having a tapered end 21 and a head 22. The pin is driven through an axial bore formed by the grooves 15 through the over-lapping hoops 16, 17 from the inside of the segments. The inner surfaces of the segments are formed with recesses 23 around the ends of the grooves 15 to receive the head 22 of the pin.

The other joint 14 between the end faces of the segments is generally similar to that described above except that the pair of hoops 17 and single hoop 16 are reversed so that the pair of hoops 17 are formed on the one axial end face and the single hoop 16 is provided on the other axial end face.

As best seen in Figure 4 of the drawings, the gasket 13 has cut outs 24 in the regions of the two joints 14.

In assembling a pair of segments, the two segments are lined up and two pins 20 are driven into the openings formed by the grooves 15 of each joint. The arrangement is such that the inter-engaging of the pins with the hoops 16, 17 draws the ends 12 of the segments together compressing the gasket 13 between the ends. The pins 20 can simply be hammered into place or suitable pneumatic tools can be used for driving the pins into place. The joint described above applied to the connection between two segments 10 and a similar joint is provided between the uppermost segments 10 and the key segment 11. Once a ring of segments has been completed, the pins may, in certain circumstances, be extracted and the resulting voids filled with grout. Normally, however, the pins are left in situ to maintain the joints between the segments in compression.

The axial end faces of the segments also have part-cylindrical grooves 25 extending part-way

into the faces from the circumferential sides 26 of the segments. Each circumferential side face 26 also has three bores 27 extending into the segment; the bores 27 being equi-spaced from each other and from the grooves 25. The part-cylindrical grooves 25 between adjacent segments and the bores 27 are intended to receive steel dowels 28 for locating the newly erected ring of segments circumferentially with respect to the previously erected ring of segments. When a ring of segments has been completed and the next ring is to be started, one dowel 28 is placed in bore 25 or 27 in the previously erected ring where the end of the first segment of the newly erected ring is required to be located. The ends of the segment of the new ring can be in line with the ends of a segment in the previously erected ring in which case the dowels are located in the bores 25 or may be staggered with respect to the ends of the previously erected segment in which case the dowels are located in bores 27. When the first segment has been erected, the further dowel 28 is inserted in the appropriate bore around the previously erected ring and the next segment is erected and so on until the ring is completed. The gaskets 13 provide between adjacent axial ends of the segments have cut-outs 29 to line up with the grooves 25 and permit insertion of the dowels 28.

The number of bores 27 and the positions of the bores may be varied from that described above to suit the stagger required between adjacent segments. Thus one or more bores 27 may be provided in each segment as required. Further, where no stagger is required between adjacent segments, the bores 27 may be omitted altogether.

The segments 10 may be parallel sided or one or both circumferential sides of the segments may be tapered towards the other side. The use of tapering segments permits the ring to be rotated either in a horizontal or vertical direction to correct for any deviation in the required path of the tunnel or to take the tunnel around a bend or up or down a gradient.

As can be seen in Figure 1 of the drawings the pitch between bores 25 and 27 is such that there is a bore 27 at the centre of the key segment but no bores are provided at the joints between the key segment and its adjacent segment.

Figures 5 to 12 to which reference is now made show alternative fastening devices to the pin 20 to be driven through the hoops of the segments to make the joints between the segments. Figure 5 shows a coarse threaded taper screw 30 having a square section socket 31 at one end to receive a tool for driving the screw into the aligned hoops of two adjacent segments. In this case the loops are inclined or twisted slightly as viewed looking end on to the segment to suit the lead angle of the thread of the screw 30 to be driven through the loops. The screw 30 illustrated has a square section socket but could be provided with a square section head to receive

a spanner is required. Figure 6 shows a split wedge formed in two parts 32, 33 which may be initially tack welded or clipped together one staggered with respect to the other to enable the assembly to be inserted through the aligned hoops of adjacent segments. When the assembly has been located between the hoops, the wedges are driven into alignment breaking the tack weld and the radial expansion of the assembly acting between the aligned hoops draws the segments together.

Figure 7 shows a split sleeve 34 to be inserted in the aligned hoops between two adjacent segments and a tapered pin 35 to be driven through the split sleeve to expand the sleeve and thereby draw the segments together.

Figure 8 shows a simple tapered pin 36 to be driven between the aligned hoops.

Figure 9 shows a cylindrical sleeve 37 split into four sectors and having a tapered bore 38 into which a solid tapered pin 39 is driven to expand the sleeve.

Figure 10 shows a roller spring steel dowel 40 which is driven between the aligned hoops of adjacent segments to hold the segment together.

Figure 11 shows a self tapping tapered screw 43 to be driven through the aligned openings in the hoops of abutting segments to draw the segments together. The screw may be part or wholly tapered.

Figure 12 shows a modified version of the split sleeve of Figure 9 in which the sleeve 37 has an internal screw thread 41 to receive a tapered screw 42 for expanding the sleeve.

Figure 13 of the drawings shows a modified form of segment in which each segment 10 has a rebate 44 extending along the end 12 of the segment forming a tongue 45 projecting at the end of the segment. Bars 46 are cast into the ends of the segment and are exposed on the surface of the tongue 45 in the rebate 44. The exposed portions of the bars are formed with slots 47. Each segment is formed with a tongue 45 on the inner side at one end and on the outer side at the other end. The tongues on the inner side have slots 48 extending from the inner surface of the segment through the tongue to the bars 46 and the tongue 45 on the outer side of each segment is formed with a shallow recess 49 above each bar. The ends 12 of two segments are located together in the manner of a half lap joint with a strip of "Bitumastic" gasket material 51 located between the end face of one tongue and the bottom of the rebate 44 in the other segment.

The apertures 47 in the bars 46 of one segment are aligned over the corresponding apertures in the bars of the other segment and tapered ended pins 52 are driven through the aligned apertures through the slots 48 to draw and clamp the segments together.

Figure 14 of the drawings shows part of a mould 55 for moulding the arcuate segment as described in Figures 1 to 4. One end 56 of the mould which forms the end 12 of the segment can be seen which is formed with two semi-

cylindrical recesses 57 to receive two semi-cylindrical liners 58 one of which is shown in Figure 15. Shaped die parts 59 and 60 are located in the liner and hold the hoops 16 in place during the moulding operation and provide the cavities for the grooves 18, 15 as required. The die parts 59, 60 and the semi-cylindrical liner 58 are held in place by studs 61 extending through the end wall 56 of the die and the liner 58 and screwed into the die parts 59 and 60 to support the die parts at the required positions. When the moulding operation has been completed, the studs 61 are removed and this enables the moulded segment to be lifted out of the die drawing with it the die parts 59 and 60 which can be broken away separately. This arrangement enables the mould to be provided with side faces for accurately casting the side faces of the segment so that all the important faces of the segment, that is the inner surface, the side and end faces are formed in the mould leaving only the outer surface to be shaped by trowelling.

Figure 14 of the drawings illustrates hoops 16 for casting into a segment and in such a case it would usually be necessary to cast separate reinforcement into the segment.

Figures 16 and 17 illustrate an alternative to the hoops and separate reinforcement in which two hoops for projecting at either end of the segment and the reinforcement for the segment are combined in a single bent rod 60 in the shape of a paper clip. The two loops at one end of the bent rod are made of equal length to provide two hoops at one end of the segment and a single hoop is provided at the other end of the segment. The shaped die pieces 61 and 62 used with this arrangement are illustrated and are held in place by studs during the moulding operation similar to those used with the mould shown in Figure 14.

It will be understood that many modifications may be made to the above described embodiments without departing from the scope of the invention. For example the Bitumastic gasket disposed between the adjacent segments may be replaced by a suitable gasket material applied to the end faces of the segments. For example an epoxy based material can be used. Also, in some cases, the plain ends of the segments can be abutted without any form of gasket or end face coating particularly where ingress of water through the joint is not a problem, where the joints are to be grouted in a conventional manner or where the connecting device itself holds the end faces the segment together with sufficient compressive force to render any gasket or equivalent inessential.

The invention is also applicable to wall segments other than those for tunnel linings. For example the invention is particularly applicable to wall segments for liquid storage containers.

The arrangements described above provide methods of jointing together concrete segments particularly quickly and no special tools are required other than a hammer or spanner to suit

the particular fastening device being used. The method is thus particularly useful in confined and difficult working conditions such as those encountered in tunnels. In the case of tunnel linings, the joints are substantially concealed within the thickness of the segments and so a smooth internal surface is produced. Thus the need for a secondary lining as required in the case of flanged segments to provide a smooth internal surface is obviated and substantial costs savings result from the saving of the material of the secondary lining and also the labour in erecting the secondary lining. Also the smooth internal surface provided by the lining makes the tunnel easy to clean out when erection has been completed. Furthermore the joining arrangements between segments enable a tunnel lining to be erected in any ground conditions (whatever the degree of wetness) in which a tunnel can be excavated.

The engagement of the fastening devices in the loops between adjacent segments accurately aligns one segment with the next to avoid or minimise "lipping" between adjacent segments both around and along the tunnel and the tunnel lining is built with a much truer circularity than is the case with conventional bolted linings. The latter feature is of particular advantage in that it avoids the need to use extra apparatus for forcing the rings of segments into true circularity.

The tensile loops transfer the stresses back into the body of the segments and loads are distributed across the whole width of the segment. In the case where the tensile loops are formed integrally with the segment reinforcement, the reinforcement and loops form a continuous hoop for withstanding stress extending around the whole ring. The latter arrangement is of particular value for tunnels required to conduct a fluid under pressure and also for upstanding silos formed from segments according to the invention.

Claims

1. A wall segment formed in a cast material of high compressive strength and having joining means at each of a pair of opposite ends of the segment for joining the segment ends to the corresponding ends of similar segments, the joining means at each end of the segment comprising at least two grooves formed in the segment end at spaced locations along the end and extending part-way only across the end from one side thereof and stopping short of the other side, tensile elements cast in the ends of the segment adjacent each groove having a part-circular hoop or hoops projecting from the end of the segment across the respective grooves for overlapping with corresponding hoops on an adjacent segment end, the axis of the or each hoop lying in a plane containing the respective segment end from which the tensile elements project and fastening devices to be driven into opposing pairs of grooves on adjacent segment ends through the overlapping hoops for pulling



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cylindrical recesses 57 to receive two semi-cylindrical liners 58 one of which is shown in Figure 15. Shaped die parts 59 and 60 are located in the liner and hold the hoops 16 in place during the moulding operation and provide the cavities for the grooves 18, 15 as required. The die parts 59, 60 and the semi-cylindrical liner 58 are held in place by studs 61 extending through the end wall 56 of the die and the liner 58 and screwed into the die parts 59 and 60 to support the die parts at the required positions. When the moulding operation has been completed, the studs 61 are removed and this enables the moulded segment to be lifted out of the die drawing with it the die parts 59 and 60 which can be broken away separately. This arrangement enables the mould to be provided with side faces for accurately casting the side faces of the segment so that all the important faces of the segment, that is the inner surface, the side and end faces are formed in the mould leaving only the outer surface to be shaped by trowelling.

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The engagement of the fastening devices in the loops between adjacent segments accurately aligns one segment with the next to avoid or minimise "lipping" between adjacent segments both around and along the tunnel and the tunnel lining is built with a much truer circularity than is the case with conventional bolted linings. The latter feature is of particular advantage in that it avoids the need to use extra apparatus for forcing the rings of segments into true circularity.

The tensile loops transfer the stresses back into the body of the segments and loads are distributed across the whole width of the segment. In the case where the tensile loops are formed integrally with the segment reinforcement, the reinforcement and loops form a continuous hoop for withstanding stress extending around the whole ring. The latter arrangement is of particular value for tunnels required to conduct a fluid under pressure and also for upstanding silos formed from segments according to the invention.

Claims

1. A wall segment formed in a cast material of high compressive strength and having joining means at each of a pair of opposite ends of the segment for joining the segment ends to the corresponding ends of similar segments, the joining means at each end of the segment comprising at least two grooves formed in the segment end at spaced locations along the end and extending part-way only across the end from one side thereof and stopping short of the other side, tensile elements cast in the ends of the segment adjacent each groove having a part-circular hoop or hoops projecting from the end of the segment across the respective grooves for overlapping with corresponding hoops on an adjacent segment end, the axis of the or each hoop lying in a plane containing the respective segment end from which the tensile elements project and fastening devices to be driven into opposing pairs of grooves on adjacent segment ends through the overlapping hoops for pulling

the segment ends into abutting engagement and to hold the segment ends together in compression.

2. A wall segment as claimed in Claim 1 wherein at least one slot is formed in each end of the segment adjacent each hoop and extending across the groove to receive a hoop projecting from an end of an adjacent segment to which the first segment is to be secured.

3. A wall segment as claimed in Claim 2 wherein the segment at one end has two hoops projecting from the segment end and spaced apart along one of said grooves with a slot extending across the groove between the hoops and a single hoop bridging the other groove at that end with a pair of slots extending across the groove on either side of the hoop.

4. A wall segment as claimed in any of the preceding claims wherein a gasket layer is provided at each end of the segment for receiving the ends of other segments.

5. A wall segment as claimed in Claim 4 wherein the gasket layer comprises a separate gasket at each end of the segment.

6. A wall segment as claimed in Claim 4 wherein the gasket layer comprises a layer of gasket material applied to the ends of the segment.

7. A wall segment as claimed in any of the preceding claims wherein each fastening device comprises a pin to be driven through two aligned tensile elements of two abutting segments.

8. A wall segment as claimed in Claim 7 wherein the pin is tapered so that as the pin is driven into place the segment ends are drawn together.

9. A wall segment as claimed in any of Claims 1 to 6 wherein each fastening device comprises a coarse threaded tapered screw.

10. A wall segment as claimed in any of Claims 1 to 6 wherein each fastening device comprises a pair of co-operating wedges.

11. A wall segment as claimed in any of Claims 1 to 6 wherein each fastening device comprises a split sleeve and a tapered pin.

12. A wall segment as claimed in any of Claims 1 to 6 wherein each fastening device comprises a split sleeve having a thread tapered bore and a tapered bolt to engage in the bore.

13. A wall segment as claimed in any of Claims 1 to 6 wherein each fastening device comprises a rolled spring steel dowel.

14. A wall segment as claimed in any of Claims 1—6 wherein each fastening device comprises a self-tapping part or wholly tapered screw.

15. A wall segment as claimed in any of the preceding claims wherein the cast segment has reinforcement elements.

16. A wall segment as claimed in Claim 15 wherein the reinforcement elements are formed integrally with the projecting tensile elements located at the ends of the segment.

17. A wall segment as claimed in Claim 16 wherein each reinforcement element comprises an elongate loop extending from end to end of the segment, one end of the loop providing two co-axial hoops projecting from one end of the segment and the other end of the loop providing a single hoop projecting from the other end of the segment.

18. A wall segment formed in a cast material of high compressive strength, opposed ends of the segment having tensile elements cast therein which have openings exposed at and extending across the ends of the segment, rebates being formed along the ends of the segment to form tongues projecting at the segment ends and the tensile elements being embodied in the tongues, in which, in use, form half-lapped joints with adjacent segments to be secured together by fastening devices driven through the openings on the tensile elements.

19. A wall segment as claimed in any of the preceding claims in the form of an arcuate tunnel lining segment, the tensile elements being formed at the circumferential ends thereof.

20. A wall segment as claimed in any of the preceding claims wherein the segment is cast in concrete.

21. An arcuate tunnel lining segment substantially as described with reference to and as illustrated in Figures 1 to 4 of the accompanying drawings.

22. An arcuate tunnel lining segment substantially as described with reference to and as illustrated in Figures 1 to 4 as modified by Figures 5 to 13.

