

IMPROVED STOP-END SYSTEM FOR USE IN
DIAPHRAGM WALL CONSTRUCTION

The present invention relates to diaphragm wall construction and in particular, but not exclusively, to the design and the withdrawal process of a steel shutter, known as a stop-end, which is used when constructing a diaphragm wall.

A diaphragm wall is made by casting a series of discrete concrete panels, which may be reinforced, in excavated trenches as described, for example, in EP 0 101 350. In some cases, alternate 'primary' panels are constructed first, followed by infill (i.e. closing) 'secondary' panels. The installation sequence would be, for example, panels 1, 3, 5, 7, 9, 11 etc. followed by panels 2, 4, 6, 8, 10 etc. In other cases, only a few 'primary' panels are first constructed, for example panels 1, 10 and 20. Following this, a series of 'continuity' panels 2, 11, 3, 12 etc. are installed, with the diaphragm wall being completed by 'closing' panels 9 and 19. All primary panels require the use of shutters at each edge of their respective trenches in order to provide well-defined edges to each panel so as to ensure that the joins between adjacent panels may be made watertight. Continuity panels, in contrast, require only one shutter at the edge of the trench furthest away from the previously cast panel. No shutters are required for closing panels. The shutters are conventionally known as 'stop-ends', and provide the concrete at each vertical edge of the panels with a predetermined shape.

Stop-ends have historically been cylindrical with a diameter nominally equal to the width of the diaphragm wall, although several other forms with, for example, a rectangular cross-section or composed of a row of cylinders, have been used. All these types of

stop-ends are removed by vertical extraction shortly after the concrete has been poured. A delay of a few hours is allowed in order to enable the concrete to gain some early strength, but even so, the timing and vertical rate of removal must be carefully judged so as to cause as little damage to the concrete as possible. If extraction is carried out before the concrete has gained adequate strength, there is a risk that the concrete will 'slump' when the stop-end is removed, thereby causing an obstruction in the trench for the adjacent panel. This method of extraction precludes the introduction of a water-bar and/or metal connector across the joint between two panels, a water-bar being a strip of rubber, PVC or metal, typically 150mm wide and 10mm thick, with one half cast into the first concrete pour and the other half into the following pour. The process of removing the stop-ends vertically would dislodge or tear the water-bars.

Alternatively, the stop-ends may be removed horizontally once the concrete has set, which can take several days or even weeks. These types of stop-ends, which are generally made of steel with a box or substantially planar cross-section, are not removed until the trench for an adjacent panel has been excavated. The removal procedure is difficult, since the stop-end has a tendency to become strongly adhered to the concrete.

In general, such stop-ends are removed by driving a wedge between the concrete and the stop-end, for example as disclosed in EP 0 101 350. This has the disadvantage that damage may be caused to the concrete, particularly since the wedges are shaped so as to wrap around the stop-end, which means that the stop-end must be narrower in width than the excavated trench and hence the diaphragm wall panel. As a result of this configuration, there is an inevitable risk of damage as

the wedges cut or break parts of the vertical edges of the diaphragm wall panel upon removal of the stop-end. Furthermore, in this method of horizontal removal, it is necessary to apply a beating force to the wedges, which can result in further damage to the concrete.

In some applications, the beating force is applied to the wedges by way of the excavator grab when excavating a trench adjacent to a set diaphragm wall panel. When the wedges are attached to the grab and fitted over the stop-end to be removed, the grab then follows the line of the stop-end in a downwards direction. This helps to reduce misalignment of the edges of adjacent panels at the joint area. One consequence, however, of fitting the wedges to the grab is that during excavation of a secondary panel trench, the stop-end is forced away from the concrete of the primary panel each time the grab is lowered in order progressively to excavate the secondary trench. When the grab is withdrawn, the stop-end often springs back onto the concrete, which can result in damage to the concrete and/or any water-bar which may be fitted. Since a grab will only excavate a depth of around 200 to 300mm on each 'bite', it is apparent that for a diaphragm wall of, say, 20m depth, around 100 bites are required, each bite carrying the risk of damage to the previously-cast panel.

From EP 0 402 247 and EP 0 462 010 it is known to remove a stop-end horizontally without the use of wedges, but by attaching the excavator grab to a groove running down the free side of the stop-end and applying a beating or shock force by opening and closing the grab. Although the damage caused to the concrete in these systems is less than that caused by a system which uses wedges, there is still the risk of damage caused by the stop-end springing back onto the concrete and/or the water-bar each time the grab is raised or

closed.

According to a first aspect of the present invention, there is provided an extractor tool for removing a shuttering element from a concrete panel during the construction of a diaphragm wall, the extractor tool comprising a main body provided with attachment means for slidable attachment to a free face of the shuttering element, characterised in that the attachment means comprises at least upper and lower portions which are arranged relative to each other so as, in use, to impart a bending force to the shuttering element in order to peel the shuttering element away from the concrete panel without allowing the shuttering element to spring back onto the concrete panel in an uncontrolled manner.

According to a second aspect of the present invention, there is provided a method of removing a shuttering element from a concrete panel during the construction of a diaphragm wall, the method comprising the steps of slidably attaching an extractor tool to a free face of the shuttering element and progressively lowering the extractor tool along the length of the shuttering element, the extractor tool having a main body and being provided with attachment means for slidable attachment to the free face of the shuttering element, characterised in that the attachment means comprises at least upper and lower portions which are arranged relative to each other so as, in use, to impart a bending force to the shuttering element in order to peel the shuttering element away from the concrete panel without allowing the shuttering element to spring back onto the concrete panel in an uncontrolled manner.

The shuttering element, or stop-end, is advantageously provided with runners along the length of its free face, into which runners the attachment

means of the extractor tool may be slidably engaged. In some embodiments of the present invention, two runners are provided, one down each side of the free face of the stop-end. However, when installing a relatively thick diaphragm wall (with a thickness greater than, say, 1200mm) using wide stop-ends, it may be advantageous to provide more than two runners on the free face of the stop-end in order to ensure that the bending force upon removal is applied relatively evenly across the width of the stop-end. The stop-end may be formed as a continuous length of steel or other suitable material, or may be made up out of sections which are connected together by way of welding or a mechanical linkage in order to achieve the desired length. In one embodiment of the present invention, the extractor tool comprises a main body provided with upper and lower attachment means wherein, upon attachment of the extractor tool to the stop-end, the upper and lower attachment means are respectively located on the free side of the stop-end in first and second planes parallel to the plane of the interface between the concrete panel and the stop-end, the first plane being more remote from the interface than the second plane. Because the upper attachment means are more remote from the interface than the lower attachment means, the upper attachment means will tend to pull the stop-end away from the concrete panel by imparting a bending force which is reacted by the lower attachment means. Preferably, the lower attachment means has at least two points of attachment to the stop-end, the points of attachment being spaced from one another along the length of the stop-end. This helps to keep the extractor tool substantially parallel to and at a substantially constant distance from the interface between the concrete panel and the stop-end as the tool is progressed along the length of the stop-

end. Advantageously, the positions of the upper and lower attachment means are adjustable with respect to the main body of the extractor tool.

In order completely to remove the stop-end, the extractor tool is progressed along the length of the stop-end. This may be done by repeatedly raising and lowering or dropping the extractor tool, or by using a vibrator or hammer device. In certain embodiments, the extractor tool may form part of an excavator grab. It is apparent that each time the extractor tool is raised, the stop-end does not spring back onto the concrete panel in an uncontrolled way, but is guided in a controlled manner by the attachment means of the extractor tool. In contrast to the known systems outlined above, the present invention allows the stop-end to be removed from the concrete panel without introducing a wedge or suchlike between the panel and the stop-end and without allowing the stop-end to spring back onto the concrete or any water-bar which may have been installed.

It is also possible with the present invention to use the runners on the free face of the stop-end as guides for an excavator grab without removing the stop-end itself. This is done by providing means on the excavator grab which fit snugly between, but do not engage with, the runners on the stop-end, thereby keeping the excavator grab properly aligned upon excavation of an adjoining trench without pulling the stop-end from the concrete of the preceding panel.

In a particularly preferred embodiment of the present invention, the lower attachment means is passive, in that it is set at a predetermined position relative to the main body of the extractor tool, and the upper attachment means is active, in that it is provided with drive means which serves to pull the attachment means, and hence the stop-end, away from the

edge of the concrete panel. The drive means may be hydraulic or pneumatic rams, electric motors, or any other suitable means. The upper attachment means may initially be located in an initial plane, which may be substantially the same plane as the lower attachment means, and the extractor tool lowered onto the top of the stop-end. With the extractor tool held at the top of the stop-end, the drive means is activated so as to pull the top of the stop-end away from the concrete. The drive means is then driven in reverse so as to return the upper attachment means to its original position, and the extractor tool is then lowered by a predetermined amount before reactivating the drive means. This process is repeated until the stop-end has been completely sprung from the concrete panel.

In an alternative embodiment, there may be provided an active attachment means at both the top and the bottom of the main body of the extractor tool and at least one passive attachment means therebetween. This allows for greater bending of the stop-end during removal, and extractor tool can be made shorter than that of the previous embodiment, which is useful when there is distortion of the stop-end.

Preferably, the active attachment means are in the form of rocker arms which may be operated by drive means so as to pull the stop-end and the main body of the extractor tool together at the at the top and bottom points of attachment.

The attachment means may take the form of pegs or lugs or similar means which are engageable with runners provided on the free face of the stop-end. Because the attachment means engage on the free face of the stop-end, it is possible, in contrast to the system disclosed in EP 0 101 350, for the stop-end to have a width equal to or slightly greater than that of the trench in which the concrete panel is to be cast. This

helps to avoid overspill of concrete which would otherwise have to be scraped away, with the risk of damaging the main body of the concrete panel, upon removal of the stop-end.

For a better understanding of the present invention, and to show how it may be carried into effect, reference will now be made by way of example to the accompanying drawings, in which:

FIGURE 1 shows a perspective view of a stop-end suitable for use in the present invention;

FIGURE 2 shows a horizontal cross-section through the stop-end of Figure 1 after installation;

FIGURES 3, 4, 5, 6, 7 and 8 show the steps in casting a panel as part of a straight diaphragm wall;

FIGURES 9, 10, 11, 12, 13 and 14 show the steps in casting a panel as part of a curved diaphragm wall;

FIGURE 15 shows a side elevation of an extractor tool according to the present invention mounted on the stop-end of Figures 1 and 2;

FIGURE 16 shows a horizontal cross-section through Figure 15;

FIGURES 17, 18 and 19 show how the extractor tool of Figures 15 and 16 is used to remove a stop-end from a concrete panel;

FIGURE 20 shows a horizontal cross-section through an alternative design of stop-end suitable for use with the present invention;

FIGURE 21 shows a side elevation of the stop-end of Figure 20;

FIGURE 22 shows a side elevation of an alternative extractor tool according to the present invention;

FIGURE 23 shows a front elevation of the extractor tool of Figure 22;

FIGURE 24 shows a horizontal cross-section of the extractor tool of Figures 22 and 23 mounted on the stop-end of Figures 20 and 21;

FIGURES 25, 26 and 27 show a side elevation of a further alternative extractor tool according to the present invention; and

FIGURE 28 shows a horizontal cross-section of the extractor tool of Figures 25, 26 and 27 mounted on a stop-end.

Figure 1 shows a stop-end 1 provided with two guide runners 2 on its free face 3. If the stop-end 1 is relatively wide, it is advantageous to provide additional runners 2 down the central region of the free face 3 of the stop-end 1. For a stop-end 1 with a width greater than, for example, 1200mm, a runner with a 'T'-section (not shown) may be provided between the two edge runners 2. As shown in Figure 2, the stop-end 1 is placed vertically at one edge of a trench 4 in which a concrete panel is to be formed. Before the concrete 5 is poured, a backplate 6 may be placed between the runners 2 so as to form a void 7 into which a filler material 8, such as aerated plastic granules, gravel or other suitable material may be poured in order to help avoid accidental overspill of concrete 5 onto the free face 3 of the stop-end 1. In order to allow the backplate 6 later to be easily removed, the filler material 8 may be poured into a bag 33 located within the void 7. The bag 33 will generally have a perimeter greater than the perimeter of the void 7 so as to allow the bag 33 to extend outwards and fill any local voids behind the stop-end 1. The bag 33 may be made of hessian or other suitable material.

Alternatively, instead of using a granular filler material 8, the void 7 may be filled with bentonite and a downpipe (not shown) inserted so as to allow further bentonite to be pumped to the base of the stop-end 1. Accidental inclusions of concrete 5 may then be washed away by the bentonite. The face 9 of the stop-end 1 which will be in contact with concrete 5 may be

provided with one or more slots or keyways 10 extending the full length of the stop-end 1. These slots or keyways 10 may be used to accommodate a water-bar and/or metal connector 11 such that one half of the water-bar and/or metal connector 11 will be surrounded by the concrete 5 making up a first panel, the other half remaining free until surrounded by concrete upon installation of a second, adjacent panel. The water-bar 11 may be made of rubber, plastics or metal.

Figures 3, 4, 5, 6, 7 and 8 show in horizontal cross-section the steps of installing a panel of a diaphragm wall. Firstly, as shown in Figure 3, a trench 12 is excavated in the ground 13. A stop-end 1 is then placed at one end of the trench 12 (Figure 4), and the void 7 is filled with a filler material 8 before the trench 12 is filled with concrete 5 (Figure 5). Once the concrete 5 has set, which will generally be after a few days or weeks, a second trench 12' is excavated next to the first trench 12 on the other side of the stop-end 1, and the filler material 8 is removed (Figure 6). When excavating the second trench 12', the excavator grab may be provided with alignment means (not shown) which fit snugly between, but do not engage with, the runners 2 of the stop-end 1 in order to ensure a good alignment of the two trenches 12 and 12'. An extractor tool 14 is then fitted into the runners 2 of the stop-end 1 (Figure 7) and progressed to the base of the stop-end 1, either by alternately dropping and raising the extractor tool 14, by applying vibration or hammer blows, or by using the excavator grab (not shown), until the stop-end 1 has been completely sprung from the concrete 5 (Figure 8). The stop-end 1 may then be placed at the end of the second trench 12' and the process repeated.

A similar procedure is followed where a curved diaphragm wall is required, except in that a specially-

shaped stop-end 1' is used. Figures 9, 10, 11, 12, 13 and 14 show the steps involved, and illustrate the use of a stop-end 1 with an extension flange 15 provided on one side.

The extractor tool 14 is shown in more detail in Figures 15 and 16. The main body 16 of the extractor tool 14 is generally of substantial mass, preferably several tonnes. Projecting from the main body 16 is the lower attachment means, which comprises two pairs of lugs 17 mounted on adjustable lug supports 18 which enable the spacing of the lugs 17 from the main body 16 to be altered as required. Typically, the lugs 17 are spaced from the main body at a distance of 200mm, although the precise spacing will depend on the particular application. The upper attachment means comprises a further pair of lugs 19 mounted on adjustable lug supports 20. The lugs 17, 19 are adapted to fit into the runners 2 of a stop-end 1, and may be constructed of hardened steel and provided with rollers or bearings (not shown) to reduce friction.

In a first embodiment of the invention, the lugs 19 are passive, in that they may be set at a predetermined spacing from the main body 16 for the duration of the stop-end removal process, the spacing being less than that of the lower lugs 17. Typically, the upper lugs may be spaced from the main body 16 at a distance of 170 to 185mm. To remove the stop-end 1 from the concrete 5 (Figures 17, 18, 19), the upper lugs 19 may initially be set at the same spacing from the main body 16 as the lower lugs 17, the extractor tool 14 fitted into the runners 2 of the stop-end 1 (which will project to some extent from the concrete 5), and the upper lugs 19 then adjusted, for example by screw means, so that they are closer to the main body 16. Alternatively, the runners 2 at the top of the stop-end 1 may be chamfered, as shown more clearly in

Figure 22, which allows the extractor tool 14 to be fitted onto the stop-end 1 even when the upper lugs 19 are in their working setting. In order to remove the stop-end 1 from the concrete 5, the extractor tool 14 is progressed down the length of the stop-end either by alternately lowering and raising the extractor tool 14 by means of a crane or suchlike, or by using a vibrator or hammer or even an excavator grab (not shown). Because the upper lugs 19 are closer to the main body 16 of the extractor tool 14, which in turn is held rigidly parallel to the stop-end 1 by means of the lower lugs 17, it can be seen that the upper lugs 19 will apply a bending force to the stop-end 1 such as to peel the stop-end 1 away from the concrete 5 without introducing any separation means between the concrete 5 and the stop-end 1. Furthermore, as the extractor tool 14 is raised, the stop-end 1 is not allowed to spring back onto the concrete 5 in an uncontrolled manner, but is instead allowed to bend back to its original position under the guidance of the lugs 17, 19. This helps to avoid damage both to the concrete 5 and to any water-bar 11 which may be fitted.

In an alternative embodiment of the invention, the upper lugs 19 are active, in that they are provided with drive means (not shown) which may be activated so as to move the lugs 19 closer to or further away from the main body 16 of the extractor tool 14. The drive means may be hydraulic or pneumatic rams, electric motors or any other suitable means. In this embodiment, the extractor tool 14 is mounted on the stop-end 1 by way of the runners 2 as before, except in that the upper lugs 19 may initially be spaced from the main body 16 by the same distance as the lower lugs 17 in order to avoid the need for chamfered runners 2 at the top of the stop-end 1. The drive means is then activated so as to pull the upper lugs 19 towards the

main body 16, thereby pulling the stop-end 1 away from the concrete 5. The upper lugs 19 are then returned to their initial position before the extractor tool 14 is lowered to a predetermined level at which the drive means is again activated so as to pull the upper lugs 19 and hence the stop-end 1 away from the concrete 5. This process is repeated until the entire stop-end 1 has been peeled from the concrete.

In order to clear excess soil or debris from the free face 3 of the stop-end 1, the excavator tool 14 may be provided with a scraper blade and/or teeth 20 at its bottom edge.

Figures 20 and 21 show an alternative stop-end 21 suitable for use with the present invention. This stop-end 21 is provided with runners 22 on its free face 23, and incorporates a slot or keyway 24 into which a water-bar may be inserted. The stop-end is also provided with a removable backplate 25 which may be inserted between the runners 22 so as to isolate a void 26 into which filler material may be poured upon installation of a diaphragm wall. As shown best in Figure 21, the runners 22 at the top of the stop-end 21 may extend away from the free face 23 so as to provide a lead section to ease the mounting of the extractor tool 26 shown in Figures 22 and 23.

The extractor tool 26 is provided with adjustable passive lower mounts 27, and an active upper mount 28. The active upper mount 28 may be moved closer to or further from the main body 29 of the extractor tool 26 by way of drive means 30, which may be hydraulic or pneumatic rams, electric motors or any other suitable means. The procedure for removing this type of stop-end 21 is as described above and illustrated further in Figure 24 which shows a horizontal cross-section through the lower part of the extractor tool 26 mounted in the runners 22 of a stop-end 21. The lower mounts

27 are attached to the main body 29 of the extractor tool 26 by way of bolts 31 and lock nuts 32, which may be adjusted so as to vary the separation of the lower mounts 27 from the main body 29. The main body 29 of the extractor tool 26 is generally made of a massive material, the mass of the extractor tool 26 preferably being at least one tonne. In some embodiments, the mass may be considerably greater depending on the length of the extractor tool 14, 26, the width of the stop-end 1, 21 and the stiffness of the stop-end section.

A further alternative extractor tool 34 is shown in Figures 25, 26 and 27. This extractor tool 34 is provided with active mounts 35 and 36 at its upper and lower ends, and a passive mount 37 therebetween. The active mounts 35, 36 are in the form of rocker arms 38, 39 operated by rams 40, 41. The rocker arms 38, 39 are operated so as to pull the stop-end 42 and the upper and lower ends of the extractor tool 34 together, with the passive mount 37 acting as a fulcrum. This extractor tool 34 allows for greater bending of the stop-end 42, and is particularly useful where deformation of the stop-end 42 means that there are few extensive straight sections, since the extractor tool 34 may be shorter in length than the extractor tools 14 and 26 previously described while still providing an effective bending force.

As shown in Figure 28, the rocker arms 38, 39 are provided with lugs 43 which fit into runners 44 provided in the stop-end 42.



CLAIMS:

1. An extractor tool for removing a shuttering element from a concrete panel during the construction of a diaphragm wall, the extractor tool comprising a main body provided with attachment means for slidable attachment to a free face of the shuttering element, characterised in that the attachment means comprises at least upper and lower portions which are arranged relative to each other so as, in use, to impart a bending force to the shuttering element in order to peel the shuttering element away from the concrete panel without allowing the shuttering element to spring back onto the concrete panel in an uncontrolled manner.

2. An extractor tool as claimed in claim 1, wherein, upon attachment of the extractor tool to the stop-end, the upper and lower portions of the attachment means are respectively located on the free side of the stop-end in first and second planes parallel to the plane of the interface between the concrete panel and the stop-end, the first plane being more remote from the interface than the second plane.

3. An extractor tool as claimed in claim 1 or 2, wherein the lower portion of the attachment means has at least two points of attachment to the stop-end, the points of attachment being spaced from each other along an axis substantially parallel to the length of the main body of the extractor tool.

4. An extractor tool as claimed in any preceding claim, wherein the spacings of the attachment means from the main body of the extractor tool are adjustable.

5. An extractor tool as claimed in any preceding claim, wherein the upper attachment means is provided with drive means which serves to change the spacing between the upper attachment means and the main body of



the extractor tool.

6. An extractor tool as claimed in any preceding claim, wherein active attachment means are located at the upper and the lower ends of the main body of the extractor tool and are provided with drive means which serve to change the spacings between the active attachment means and the main body of the extractor tool, and wherein a passive attachment means is provided on the main body of the extractor tool at a location between the active attachment means.

7. An extractor tool as claimed in claim 6, wherein the active attachment means comprise rocker arms.

8. An extractor tool as claimed in claim 5, 6 or 7, wherein said drive means comprises a hydraulic or pneumatic ram.

9. A method of removing a shuttering element from a concrete panel during the construction of a diaphragm wall, the method comprising the steps of slidably attaching an extractor tool to a free face of the shuttering element and progressively lowering the extractor tool along the length of the shuttering element, the extractor tool having a main body and being provided with attachment means for slidable attachment to the free face of the shuttering element, characterised in that the attachment means comprises at least upper and lower portions which are arranged relative to each other so as, in use, to impart a bending force to the shuttering element in order to peel the shuttering element away from the concrete panel without allowing the shuttering element to spring back onto the concrete panel in an uncontrolled manner.

10. A method according to claim 9, wherein the upper attachment means is provided with drive means which, in use, are operated to change the spacing between the upper attachment means and the main body of



the extractor tool, thereby peeling the shuttering element away from the concrete panel.

11. A method according to claim 9, wherein active attachment means are located at the upper and the lower ends of the main body of the extractor tool and are provided with drive means which, in use, are operated to change the spacings between the active attachment means and the main body of the extractor tool, and wherein a passive attachment means is provided on the main body of the extractor tool at a location between the active attachment means so as, in use, to act as a fulcrum about which the shuttering element may bend when the drive means are operated.

12. A method according to claim 9, 10 or 11, wherein the extractor tool is repeatedly raised and lowered relative to the shuttering element.

13. A method according to any of claims 9 to 12, wherein the extractor tool is vibrated or beaten so as to assist removal of the shuttering element.

14. A method according to any of claims 10 to 13, wherein:

i) the attachment means are operated by the drive means so as to pull the shuttering element and the main body of the extractor tool towards each other, thereby peeling a section of the shuttering element away from the concrete panel;

ii) the drive means are driven in reverse so as to return the attachment means to their initial positions;

iii) the extractor tool is lowered by a distance relative to the shuttering element; and

iv) steps i) to iii) are repeated until the shuttering element has been released from the concrete panel.