

A Collar, A Concrete Pipe Section, and Methods of Manufacturing the Same

5 FIELD OF INVENTION

The present invention relates to a collar for attaching to a concrete pipe section, an integrated collar and concrete pipe section, and methods of manufacturing the same.

10 BACKGROUND

Concrete pipes are conventionally used for drainage purposes, in particular, for draining sewage or sewage/water mixtures. Concrete pipes used in deep tunnel sewage systems are manufactured in pipe sections and joined to one another at the
15 installation site to form a sewage pipeline for draining sewage from one geographic location to another.

Sewage pipelines can be formed using a slurry pipe-jacking system. Slurry pipe-jacking is a method for non-disruptive construction of underground pipelines in
20 sewage systems. Basically, the system involves pushing or thrusting a rotating tunnel drilling head forward by jacking concrete pipes connected one after the other in the forward direction such that the formed pipeline pushes the drilling head forward.

Typically, the design of each pipe section comprises a collar end and a spigot end. The pipe sections are joined by fitting the collar end of one pipe section into the spigot end of another pipe section. Conventionally, the collar end is made entirely of mild steel or stainless steel extending from the concrete body of the pipe section. However, although mild steel is capable of taking abrasion and stresses in a slurry
25 pipe-jacking process, it is susceptible to corrosion. Stainless steel on the other hand can take abrasion and stresses and is less susceptible to corrosion but is a costly material to use. Both types of steel are relatively heavy and less corrosion resistant compared to other materials such as plastics.
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In addition, with prior art pipe sections, the collar end may not seal together properly with the spigot end, thus causing leaks in the system. These leaks can be particularly bad if the system is pressurized in any way.

5 SUMMARY

In accordance with one aspect of the present invention, there is provided a collar for attaching to a concrete pipe section, the concrete pipe section comprising a spigot formed on a tubular concrete body, the collar comprising: an abrasion resistant layer;
10 and a corrosion resistant layer, wherein the collar is configured to mesh with the spigot of the concrete pipe section.

The abrasion resistant layer may be on an outside surface of the collar and the corrosion resistant layer may be on an inside surface of the collar.

15 The abrasion resistant layer may completely cover the corrosion resistant layer.

The abrasion resistant layer of the collar may comprise mild steel or stainless steel.

20 The corrosion resistant layer of the collar may comprise one of High Density Polyethylene (HDPE), Polyvinylchloride (PVC) and High Alumina cement.

The collar may further comprise one or more protective layers.

25 Exposed surfaces of the collar may be externally coated with one or more protective materials.

The collar may further comprise recesses on the corrosion resistant layer for engaging protrusions on the tubular concrete body for preventing movement of the
30 corrosion resistant layer and the tubular concrete body with respect to each other.

The collar may further comprise one or more bars extending from the abrasion resistant layer into the corrosion resistant layer for preventing movement of the abrasion resistant layer and the corrosion resistant layer with respect to each other.

In accordance with another aspect of the present invention, there is provided a concrete pipe section comprising: a tubular concrete body having a first end and a second end, said second end disposed opposite to the first end; a collar disposed
 5 on the first end of the tubular concrete body, the collar comprising: an abrasion resistant layer; and a corrosion resistant layer; and a spigot formed on the tubular concrete body at the second end, wherein the collar is configured to mesh with a spigot of an adjoining concrete pipe section.

10 The abrasion resistant layer may be on an outside surface of the collar and the corrosion resistant layer may be on an inside surface of the collar.

The abrasion resistant layer of the collar may comprise mild steel or stainless steel.

15 The abrasion resistant layer of the collar may comprise a steel fishtail structure to firmly secure the abrasion resistant layer to the tubular concrete body.

The corrosion resistant layer of the collar may comprise one of High Density Polyethylene (HDPE), Polyvinylchloride (PVC) or High Alumina cement.

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The collar may further comprise one or more protective layers.

The exposed surfaces of the collar may be externally coated with one or more protective materials.

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The collar may further comprise recesses on the corrosion resistant layer for engaging protrusions on the tubular concrete body for preventing movement of the corrosion resistant layer and the tubular concrete body with respect to each other.

30 The collar may further comprise one or more bars extending from the abrasion resistant layer into the corrosion resistant layer for preventing movement of the abrasion resistant layer and the corrosion resistant with respect to each other.

The collar may be formed integrally with the pipe section.

The concrete pipe section may further comprise a spigot formed at the first end, and wherein the collar is attached to the spigot at the first end.

- 5 In accordance with yet another aspect of the present invention, there is provided a method of manufacturing a collar for a concrete pipe section having a spigot formed on a tubular concrete body, the method comprising the steps of: fabricating an abrasion resistant layer; fabricating a corrosion resistant layer; and assembling the collar by joining the abrasion resistant layer to the corrosion resistant layer.

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The abrasion resistant layer may be on an outside surface of the collar and the corrosion resistant layer may be on an inside surface of the collar.

- 15 The method may further comprise the step of fabricating one or more protective layers for the collar and assembling the collar by joining the one or more protective layers together with the abrasion resistant layer and the corrosion resistant layer.

The step of fabricating the corrosion resistant layer may comprise forming at least one recess on the corrosion resistant layer.

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The step of fabricating the collar further may comprise welding one or more bars extending from the abrasion resistant layer into the corrosion resistant layer for preventing movement of the abrasion resistant layer and the corrosion resistant layer with respect to each other.

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The abrasion resistant layer of the collar may comprise mild steel or stainless steel.

The corrosion resistant layer of the composite collar may comprise one of High Density Polyethylene (HDPE), Polyvinylchloride (PVC) and High Alumina cement.

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In accordance with a further aspect of the present invention, there is provided a method of manufacturing a concrete pipe section, the concrete pipe section comprising a tubular concrete body having a first end and a second end opposite to the first end, a collar attached to the first end and a spigot formed on the second end

such that the collar and spigot are configured to mesh with a spigot of an adjoining concrete pipe section, the method comprising the steps of: fabricating the collar, the collar comprising at least an abrasion resistant layer and a corrosion resistant layer; assembling a reinforcement cage for the concrete pipe section; assembling a mould for the concrete pipe section; positioning said collar and said reinforcement cage into said mould; pouring concrete into said mould; allowing the concrete to harden within said mould to produce said concrete pipe section; and removing the concrete pipe section from said mould.

10 The step of fabricating the collar may further comprise fabricating an abrasion resistant outer layer; fabricating a corrosion resistant inner layer; and assembling the collar by joining the abrasion resistant layer to the corrosion resistant layer.

15 The method may further comprise the step of fabricating one or more protective layers for the collar and assembling the collar by joining the one or more protective layers together with the abrasion resistant layer and the corrosion resistant layer.

The step of fabricating the corrosion resistant layer may comprise forming at least one recess on the corrosion resistant layer, and the step of assembling said mould is accomplished such that at least one protrusion is formed on the first end.

The at least one protrusion may be positioned to engage said at least one recess.

The abrasion resistant layer of the collar may comprise mild steel or stainless steel.

25 The corrosion resistant layer of the collar may comprise one of High Density Polyethylene (HDPE), Polyvinylchloride (PVC) or High Alumina cement.

30 The concrete pipe section may further comprise a spigot on the first end and wherein the step of positioning the collar is eliminated, the method further comprising a step of: attaching the collar to the spigot on the first end to form a concrete pipe section.

In accordance with another aspect of the present invention, there is provided a concrete pipe formed by connecting a plurality of concrete pipe sections, each

- concrete pipe section comprising: a tubular concrete body having a first end and a second end, said second end disposed opposite to the first end; a collar disposed on the first end of the tubular concrete body, the collar comprising: an abrasion resistant layer; and a corrosion resistant layer; and a spigot formed on the tubular
- 5 concrete body at the second end, wherein the collar is configured to mesh with a spigot of an adjoining concrete pipe section.

The collar may be formed integrally with the pipe section.

- 10 The concrete pipe section may further comprise a spigot formed at the first end, and wherein the collar is attached to the spigot at the first end.

BRIEF DESCRIPTION OF THE DRAWINGS

- 15 Embodiments of the invention will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example only, and in conjunction with the drawings, in which:

Figure 1 shows a perspective view of a concrete pipe section according to an

20 example embodiment of the present invention;

Figure 2 shows a cross sectional view of the concrete pipe section of Figure 1 according to the example embodiment;

- 25 Figure 3 is a cross-sectional view of the top part of two adjoining pipe sections that are built according to the example embodiment;

Figure 4 is a cross-sectional view of a ring gasket according to the example embodiment of the present invention;

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Figure 5 is a flowchart of one process involved in the manufacturing of a concrete pipe section according to the example embodiment;

Figure 6 shows a perspective view of a concrete pipe section according to a second example embodiment of the present invention;

Figure 7 shows a cross sectional view of the concrete pipe section of Figure 6
5 according to the second example embodiment;

Figure 8 is a perspective view of two adjoining pipe sections and a collar that are built according to the second example embodiment;

Figure 9 is a cross-sectional view of the top part of two adjoining pipe sections that are
10 built according to the second example embodiment;

Figure 10 is a cross-sectional view of the top part of a collar built according to the
15 second example embodiment;

Figure 11 is a flowchart of one process involved in the manufacturing of a collar
according to the second example embodiment; and

Figure 12 is a flowchart of one process involved in the manufacturing of a concrete pipe
20 section according to the second example embodiment.

DETAILED DESCRIPTION

Figure 1 shows a sewage pipe section 100 of a first example embodiment of the
25 present invention. The pipe section 100 is tubular, substantially cylindrical in shape and has a hollow centre for passing oil, chemicals, soil/water mixture, sewage, sewage/water mixtures, other liquids or liquid/solid mixtures. Connecting a number of such pipe sections together forms, for example, a sewage pipeline. Each pipe section 100 comprises a collar 102 and a spigot 104 at opposing ends. During
30 pipeline connection in a slurry pipe-jacking process, the spigot end is meshed into the collar end through the use of a pipe-jacking machine and the first pipe section in the pipeline formed is pushed against the back of a moving tunnel drilling bit, thereby enabling the tunnel drilling bit to drill forward. For illustration purposes only, the slurry pipe-jacking process is described, however, it is appreciated that the pipe

section may be connected through other methods such as an Auger boring method, other Microtunneling pipe jacking techniques, or the like. The pipe section 100 in Figure 1 is viewed from the collar side.

- 5 In the first example embodiment, the collar 102 is attached to the concrete body 110 of the pipe section 100 and extends outwards from the concrete body 110, thus forming an opening for receiving the spigot 104 of an adjacent concrete body during pipeline construction. The collar 102 can include two layers, a thinner mild steel abrasion resistant layer 106 and a thicker High Density Polyethylene (HDPE) corrosion resistant layer 108. It is appreciated that stainless steel or the like can be used for the abrasion resistant layer 106 and various polymer materials, e.g. Polyvinylchloride (PVC), High Alumina cement, or the like can be used for the corrosion resistant layer 108. It is further appreciated that the thickness of the abrasion resistant layer 106 and the corrosion resistant layer 108 may vary according to the environmental demands at the site of the pipe installation. Advantageously, the abrasion resistant layer 106 can resist abrasion and stress during, for example, the slurry pipe-jacking process. As the abrasion resistant layer 106 can fully cover the corrosion resistant layer 108, it protects the corrosion resistant layer 108 against abrasion and stress during the pipe jacking process. The corrosion resistant layer 108 provides an extended life to the pipeline.

The spigot 104 is part of the concrete body 110 and can be shaped such that it can be fitted into the opening formed by the collar 102. There is a groove or indentation 116 on the spigot 104 for placing an annular ring gasket 118, which can be made of a resilient flexible material i.e. rubber. It is appreciated that other resilient flexible materials may be used. The purpose of the ring gasket 118 is to provide joint tightness at the connection between adjoining pipe sections to prevent leakage from within the pipeline.

- 30 The concrete body 110 contains four lifting anchors 112 that are strategically positioned on the concrete body 110 based on weight distribution. Two of the four lifting anchors are shown in Figure 1. The other two anchors (not shown) are located at the same distance from the top on the opposite side of the two illustrated anchors 112 on the pipe section 100. The purpose of the lifting anchors 112 is to ensure safe

handling of the pipe section 100 and to eliminate the risk of handling damage to the pipe section 100 and the collar 102. During, for example, the slurry pipe-jacking process, pipe sections are lowered into a jacking pit where the jacking machine resides. To lower a pipe section, four cables of equal length are hooked to a centralized point on a crane at one end and hooked onto the lifting anchors at the other end. Based on the weight distribution of the pipe section, the lifted pipe section remains horizontally stable and is safely positioned for pipe jacking when the pipe section is lowered into the pipe-jacking machinery for jacking at the installation site.

In the first example embodiment, there can be an internal lining 120 on the internal wall 122 in the hollow centre of the pipe section 100. Lining 120 can have a high resistance to chemical/biological degradation. Lining 120 can be, by way of example and not limitation, HDPE, Polyvinylchloride (PVC), High Alumina cement, or the like. Lining 120 is used to protect the concrete body 110 against highly corrosive acid formed from a mixture of gas (generated by sewer effluent) and moisture in the pipeline.

In addition, in the first example embodiment, one or more grouting holes 124 penetrate the internal wall 122 and the external wall 126 of the pipe section 100 for injecting lubricant during the pipe jacking process.

Figure 2 shows a cross sectional view of the concrete pipe section 100 in Figure 1.

As shown in Figure 2, the concrete body 110 of the concrete pipe section 100 can be reinforced with spiral and longitudinal reinforcements 204. In one example embodiment, the spiral and longitudinal reinforcements 204 can be steel. The reinforcements 204 are machine fabricated, uniformly spaced with strong welds and designed to withstand a large amount of crushing load. The external finish of the concrete body 110 can be smooth and dense so that there is less chance of ground water penetration, less abrasion damage and less jacking force required for pipe connection. The dimensional tolerance of the concrete body 110 is consistently fine so that the concrete body 110 is suitable for a water joint. Additionally, a fine dimensional tolerance ensures an even transfer of jacking forces during pipe connection. The density of the concrete body 110 can be uniformly high throughout

the pipe section length so that the concrete body 110 has high strength, corrosion resistance and very little segregation weakness.

At the left end of the concrete pipe section 100 in Figure 2 is the collar 102. In the first example embodiment, the corrosion resistant layer 108 of the collar 102 is attached to the concrete body 110. The corrosion resistant layer 108 has two recesses 210 for receiving two corresponding protrusions 212 from the concrete body 110. The purpose of the two recesses 210 and the corresponding protrusions 212 is to secure the collar 102 to the concrete body 110 by preventing movement of the collar 102 over the surface of the concrete body 110. It is appreciated that the recesses 210 and protrusions 212 may be annular or exist as disjointed ridges and corresponding recesses on the concrete body 110 and the corrosion resistant layer 108 respectively. The abrasion resistant layer 106 is firmly attached to the concrete body 110 by, for example, having a welded-on steel fishtail structure 202 embedded in the concrete body 110 to secure the abrasion resistant layer 106 firmly to the concrete body 110. In this case, the abrasion resistant layer 106 can fully cover the top outer surface of the corrosion resistant layer 108. There is a built-in collar seal 208 between the concrete body 110 and the corrosion resistant layer 108. The built-in collar seal 208 can be, for example, a hydrophilic sealant that is effective against differential contraction at the collar 102 and concrete body 110 interface.

At the opposite end from the collar end of the concrete pipe section 100 in Figure 2 is the spigot 104. In the first example embodiment, the protruding end of the spigot 104 has a smaller outer diameter compared with the outer diameter of the concrete pipe section 100 for the major length of the concrete pipe section 100. The protruding end of the spigot 104 terminates at a sloped portion 206 shaped to match an edge 216 of the collar of an adjoining pipe section. For instance, the sloped portion 206 and the edge of the collar 216 are shaped to slope away and be substantially parallel to one another. This forms a seat 218 for the collar 102 of an adjoining pipe to mesh with the spigot 104 during pipe connection. A groove 116 for placing the ring gasket (118 in Figure 1) is located on the seat 218 at the protruding end of the spigot 104.

Figure 3 is a cross-sectional view of the top part of two fully meshed pipe sections built according to the design of the pipe section in the above example embodiment. Figure 3 shows the collar 102 of one pipe section 302 meshing with the spigot 104 of another pipe section 304. The pipe sections 302, 304 are connected by pushing the spigot 104 of pipe section 304 in the direction 318 towards the receiving mouth of the collar 102 of pipe section 302 or alternatively by pushing the receiving mouth of the collar 102 of pipe section 302 in the direction 332 towards the spigot 104 of pipe section 304. For ease of pipe connection, the edge 216 of the corrosion resistant layer of the collar 102 and the first meshing contact point 309 of the rubber ring gasket 310 are shaped to slope away from and be substantially parallel to one another so as to facilitate the meshing of the collar 102 beyond the rubber ring gasket 310. The rubber ring gasket 310 protrudes slightly beyond the allowable gap 308 between the collar 102 and the spigot 104. Hence, as the collar 102 meshes with the spigot 104, the rubber ring gasket 310 is compressed and a tightened joint is created when the collar 102 is fully meshed with the spigot 104.

A chipboard packer 306 can be adhered to a plane 314 on the collar end of the pipe section 302. The plane 314 is on a surface of the collar end of pipe section 302 lying in between the meshed pipe sections and facing the spigot of the connecting pipe section 304. It is appreciated that the chipboard packer 306 may instead be adhered to a plane 316 on the spigot end of the pipe section 304 directly facing and parallel to the plane 314 or adhered to both planes 314 and 316 at the collar and spigot ends. The purpose of the chipboard packer 306 is to cushion the impact of the adjacent pipes during the jacking process, and to ensure an even jacking force is applied over the planes 314 and 316 of the pipe sections during jacking. This helps to protect the concrete body of the pipe sections from harm. The chipboard packer 306 may be made of plywood or other suitable materials.

abrasion resistant layer abrasion resistant layer abrasion resistant layer

Other features shown in Figure 3, such as the steel fishtail structure 202, the spiral and longitudinal steel reinforcements 204, the two recesses 210 and two corresponding protrusions 212, and the built-in collar seal 208 have already been discussed in Figure 2.

Figure 4 is a close-up cross-sectional view of the rubber ring gasket 310. With reference to both Figure 3 and Figure 4, the meshing contact point 402 of the rubber ring gasket 310 is sloped in a direction away from the edge of an incoming meshing collar. Figure 4 shows a clear picture of the slope formed at the meshing contact point 402. The base 404 of the rubber ring gasket 310 takes the shape of the groove (116 in Figure 1) formed on the spigot such that it can fit snugly into the groove 116. In this case, the base 404 is rectangular, but, it could also be hemispherical, triangular or the like. On the top surface of the rubber ring gasket 310, there are alternating parallel grooves 406 and ridges 408, all sloping in a direction away from the edge of an incoming meshing collar. The ridges 408, being sloped in this manner, help to prevent ingress of ground water into the pipe sections through the pipe joint and to ensure ease of installation. The grooves 406 provide room for the compression of the ridges 408 by an incoming meshing collar. The last ridge 410 to be contacted by the incoming meshing collar has a pointed edge and it is projected upwards to a height lower than the projections of the other ridges 408. The pointed edge 409 of the last ridge 410 will make contact with the incoming meshing collar when all the other ridges of the same height as ridges 408 are compressed in the direction of the adjacent grooves 406. The pointed edge 409 of the last ridge 410 acts as an anchor to prevent the backward movement of the meshing collar thereby creating a tight joint.

Figure 5 illustrates one example embodiment of a process, designated generally as reference numeral 500, used in manufacturing the pipe section (100 in Figure 1 and Figure 2) of the example embodiment.

- 25 Step 502 involves the assembly of the reinforcement cage 204 of the concrete body 110 of the pipe section 100. The reinforcement cage 204, which for this example is made of steel, is formed with an automatic welding and forming machine and the steel reinforcement 204 is bound in a spiral process to form the cage to a predetermined size.
- 30 Step 504 involves the fabrication of the abrasion resistant layer 106 of the collar, which for this example is made using a thin sheet of steel plate. At this step, pre-cut steel plate is fed through a roller to form the required circular sheet for the abrasion resistant layer 106.

Step 506 involves the fabrication of the corrosion resistant layer 108 of the collar, which for this example is made of HDPE. At this step, a preformed HDPE layer is welded to form the required shape and size.

- 5 Steps 504 and 506 may occur concurrently with step 502.

At step 508, the composite collar 102 comprising the steel abrasion resistant layer 106 and thick HDPE corrosion resistant layer 108 is assembled.

- 10 At step 510, a steel mould for forming the pipe section 100 is assembled. In this example, the mould is accomplished such that the two protrusions 212 can be formed when concrete is poured into the mould and one indentation 116 is formed on the spigot 104. The reinforcement cage 204 and the composite collar 102 are placed into the desired position in the steel mould. Steel fishtails 202 are welded to the steel abrasion
15 resistant layer 106 at this step.

At step 512, casting is done. Premixed concrete is poured or fed into the mould prepared at step 510.

- 20 At step 514, De-moulding is performed. The mould is stripped after the concrete has gained sufficient strength.

At step 516, curing is performed on the formed pipe section 100. The pipe section 100 is placed in a controlled environment.

- 25 Optionally, at step 518, markings can be made on the concrete body 110 with paint, etc. for identification purposes.

- Figure 6 shows a pipe section 600 of a second example embodiment of the present invention. In the second example embodiment, the composite pipe collar is supplied as a
30 separate pipe component to be fitted onto adjoining pipe sections at the pipe installation site. The pipe section 600 is substantially the same as the pipe section 100 of the first example embodiment. However, the pipe section 600 of the second example embodiment has two spigots 620 and 602 at opposing ends. In this example embodiment, a collar 800 (Figure 8) is fitted over the spigot ends of two adjoining pipe

sections (802 and 804 in Figure 8) at the pipe joint as a separate component. This will be discussed in more detail below.

- The spigots 620 and 602 are part of the concrete body 604. They are shaped such that they can be fitted into the opening of the collar 800. There are grooves or indentations 606 and 616 on both spigots 602 and 620 respectively, for placing annular ring gaskets 608 and 618 respectively. Annular ring gaskets 608 and 618 can be made of a resilient flexible material, for example, rubber. It is appreciated that other resilient flexible materials may be used for the annular ring gaskets 608 and 618. The purpose of the ring gaskets 608 and 618 is to provide joint tightness at the connection of adjoining pipe sections to prevent leakage from within the pipeline. An example of a ring gasket that may be used for ring gaskets 608 and 618 in the second example embodiment is the ring gasket 310 described in Figure 4.
- Similar to the first example embodiment, the concrete body 604 contains four lifting anchors 622 that are strategically positioned on the concrete body 604 based on weight distribution. Two of the four lifting anchors are shown in Figure 6. The other two anchors (not shown) are located at the same distance from the top on the opposite side of the two illustrated anchors 622 on the pipe section 600. The purpose of the lifting anchors 622 is to ensure safe handling of the pipe section 600 and to eliminate the risk of handling damage to the pipe section 600. During, for example, a slurry pipe-jacking process, numerous pipe sections may be sequentially lowered into a jacking pit where the jacking machine resides. To lower a pipe section, four cables of equal length are hooked to a centralized point on a crane at one end and hooked onto the lifting anchors at the other end. Due to considerations made based on the weight distribution of the pipe section, the lifted pipe section remains horizontally stable and is safely positioned for pipe jacking when the pipe section is lowered into the pipe-jacking machinery for jacking at the installation site.
- In the second example embodiment, there can be an internal lining 610 on the internal wall 612 in the hollow centre of the pipe section 100. Lining 610 can have a high resistance to chemical/biological degradation. Lining 610 can be, by way of example and not limitation, HDPE, Polyvinylchloride (PVC), High Alumina cement,

or the like. Lining 610 is a useful addition, as highly corrosive material may be passed into the sewers. It can thus protect the concrete body 604.

5 In addition, in the second example embodiment, one or more grouting holes 624 penetrate the internal wall 612 and the external wall 614 of the pipe section 100 for injecting lubricant during the pipe jacking process.

Figure 7 shows a cross sectional view of the concrete pipe section 600 in Figure 6. In the second example embodiment, the concrete body 604 of the concrete pipe section 600 can be reinforced with spiral and longitudinal reinforcements 702. In the second example embodiment, the spiral and longitudinal reinforcements 702 can be steel. The reinforcements 702 are machine fabricated, uniformly spaced with strong welds and designed to withstand a large amount of crushing load. The external finish of the concrete body 604 can be smooth and dense so that there is less chance of ground water penetration, less abrasion damage and less jacking force required for pipe connection. The dimensional tolerance of the concrete body 604 can be consistently fine so that the concrete body 604 is suitable for a water joint. Additionally, a fine dimensional tolerance ensures an even transfer of jacking forces during pipe connection. The density of the concrete body 604 can be uniformly high throughout the pipe section length so that the concrete body 604 has high strength, corrosion resistance and very little segregation weakness.

Spigots 620 and 602 are located at both ends of the concrete pipe section 600 in Figure 7. In the second example embodiment, spigots 620 and 602 have protruding ends having a smaller outer diameter compared with the outer diameter of the concrete pipe section 600 for the major length of the concrete pipe section 600. Each protruding end of the spigots 620 and 602 terminates at sloped portions 706 and 704 respectively, and are shaped to match the edge of an adjoining collar 800. As such, seats 708 and 710 are formed on each respective spigot 620 and 602 so that collars, such as collar 800 or the collar end 102 of the first example embodiment, will mesh with the spigots 620 and 602 during pipe connection. Grooves 616 and 608 for placing the ring gaskets 618 and 606 in Figure 6 respectively are located on the seats 708 and 710 respectively.

With reference to Figure 8, the collar 800 of the second example embodiment comprises an corrosion resistant layer 806 and an abrasion resistant layer 808. The collar 800 is tubular in shape and has two open ends 814 and 816 for receiving two spigots 802 and 804 during pipeline connection. The abrasion resistant layer 808 can fully cover the top outer surface of the corrosion resistant layer 806. The abrasion resistant layer 808 can be made, by way of example and not limitation, from a thin sheet of mild steel, stainless steel or the like that is abrasion resistant. The corrosion resistant layer 806 can be made of a thick layer of High Density Polyethylene (HDPE), Polyvinylchloride (PVC), High Alumina cement, or the like, that is corrosion resistant. The surfaces of the corrosion resistant layer 806 of the collar 800 at the open ends 814 and 816 are bevelled towards the centre of the collar 800. It is appreciated that can be used for the abrasion resistant layer 808 and other polymer materials, e.g. can be used for the corrosion resistant layer 806. It is further appreciated that the thickness of the abrasion resistant layer 808 and the corrosion resistant layer 806 may vary according to the environmental demands at the site of the pipe installation. Advantageously, the abrasion resistant layer 808 can resist abrasion and stress, for example, during the slurry pipe-jacking process. As the abrasion resistant layer 808 can fully cover the top outer surface of the corrosion resistant layer 806, it protects the corrosion resistant layer 806 against abrasion and stress during the pipe jacking process. The corrosion resistant layer 806 provides an extended life to the pipeline.

During pipeline connection in, for example, a slurry pipe-jacking process, a first pipe section is jacked into position. Then, the collar 800 is meshed with the spigot end 804 in direction 812 using the pipe-jacking machine. After the collar 800 is fitted over spigot 804, a second pipe section is jacked into position such that a spigot 802 belonging to the second pipe section is jacked into the collar 800. Alternately, a collar 800 can be fitted onto the spigot 804 prior to lowering into the jacking machine. Subsequent pipe sections with the collar already attached can then be lowered and jacked into position.

Figure 9 is a cross-sectional view of one portion of the spigot ends of the two pipe sections 802 and 804 when they are fully meshed with the collar 800 during pipeline connection. The bevelled portions 904 and 906 of the two ends of the corrosion resistant layer 806 of the collar 800 and the first meshing contact point 704 and 706 respectively of the respective rubber ring gasket 608 and 618 are shaped to slope

away from and be substantially parallel to one another, so as to facilitate the meshing of the collar 800 beyond the rubber ring gaskets 608 and 618 respectively. The rubber ring gaskets 608 and 618 protrude slightly beyond the allowable gap 908 between the collar 800 and the spigot ends 802 and 804. As the collar 800 meshes with the spigots 802 and 804, the rubber ring gaskets 608 and 618 are compressed. A tightened joint is created when the collar 800 is fully meshed with the spigots 802 and 804.

In the second example embodiment, a chipboard packer 902 can be adhered to a plane 910 on the spigot end 804. The plane 910 is a surface on the spigot end 804 that is in between the adjacent pipe sections and directly facing the spigot end 802 of the connecting pipe section. It is appreciated that the chipboard packer 902 may instead be adhered to a plane 912 on the spigot end 802 that is parallel and directly facing the plane 910 or adhered to both planes 912 and 910 at both spigot ends 802 and 804 respectively. The purpose of the chipboard packer 902 is to cushion the impact of the adjacent pipes during the jacking process, and to ensure that an even jacking force is applied over the planes 912 and 910 of the pipe sections during jacking. This helps to protect the concrete body of the pipe sections from harm. The chipboard packer 902 may be made of plywood or other suitable materials.

Figure 10 shows a cross sectional view of one portion of collar 800. In the second example embodiment, there are two steel bars 1006 and 1008 extending from the abrasion resistant layer 808 into two respective gaps 1004 and 1012 located on the corrosion resistant layer 806 of the collar 800. The two respective gaps 1004 and 1012 can be filled in with HDPE during manufacturing so as to hold the corrosion resistant layer 806 tightly to the two steel bars 1006 and 1008. The two steel bars 1006 and 1008 are secured to the corrosion resistant layer 806, for example by welding, etc. at locations 1002 and 1010 respectively. The two steel bars 1006 and 1008 serve as blockages to prevent movement of the abrasion resistant layer 808 and the corrosion resistant layer 806 with respect to each other.

In the second example embodiment, the composite collar 800 and the concrete pipe section 600 are manufactured as separate components. Figure 11 illustrates one example embodiment of a process, designated generally as reference numeral 1100,

used in manufacturing the composite collar (800 in Figures 8, 9 and 10) of the second example embodiment.

- 5 Step 1102 involves the fabrication of the abrasion resistant layer 808 of the composite collar 800, which, for this example, is made using a thin sheet of steel plate. At this step, pre-cut steel plate is fed through a roller to form the required circular sheet for the abrasion resistant layer 808. The two steel bars 1006 and 1008 can be secured to the abrasion resistant layer 808 by welding at this step.
- 10 Step 1104 involves the fabrication of the corrosion resistant layer 806 of the composite collar, which for this example is made of HDPE. At this step, a preformed HDPE layer is welded to form the required shape and size. The two gaps 1004 and 1012 are formed at this step.
- 15 At step 1106, the composite collar 800 comprising the thin steel abrasion resistant layer 808 and thick HDPE corrosion resistant layer 806 is assembled. The two gaps 1004 and 1012 are filled with HDPE at this step to hold the corrosion resistant layer 806 tightly to the two steel bars 1006 and 1008.
- 20 Figure 12 illustrates one example of a process, designated generally as reference numeral 1200, used in manufacturing the pipe section (600 in Figure 6 and Figure 7) of the second example embodiment.

- 25 Step 1202 involves the assembly of the reinforcement cage 702 of the concrete body 604 of the pipe section 600. The reinforcement cage 702, which for this example is made of steel, is formed with an automatic welding and forming machine, and the steel reinforcement 702 is bound in a spiral process to form the cage to a predetermined size.

- 30 At step 1204, a steel mould for forming the pipe section 600 is assembled. In this example, the mould is created such that the two spigot ends 602 and 620 can be formed when the concrete is poured into the mould. The reinforcement cage 702 is placed into the desired position in the steel mould.

At step 1206, casting is done. Premixed concrete is poured or fed into the mould prepared at step 1204.

- 5 At step 1208, De-moulding is performed. The mould is stripped after the concrete has gained sufficient strength.

At step 1210, curing is performed on the formed pipe section 600. The pipe section 600 is placed in a controlled environment for a period of time to effect curing.

- 10 At step 1212, markings can be made on the concrete body 604 with paint for identification purposes.

One possible technical specification for a collar and concrete pipe section according to the first and second example embodiments is shown below.

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Parameter	Unit
Internal diameter of the pipe section, D1	2100 mm
External diameter of the pipe section, D2	2470 mm
Thickness of the walls of the pipe section, T	185 mm
Length of the pipe section from one edge of the concrete body (excluding the collar) to the other edge of the concrete body, L	2900 mm
Spigot length, λ	155 mm
Allowable pipe jacking force for the slurry pipe-jacking system	1600 Tonnes
Weight of the pipe section	9.2 Tonnes
Width of the rubber ring gasket, B	30 mm
Thickness of the rubber ring gasket below the grooves, g	15 mm
Thickness of the rubber ring gasket with grooves, e	19 mm
Thickness of the HDPE inner layer of the collar, TC_{HDPE}	25 mm
Thickness of the mild steel outer layer of the collar, $TC_{M.S.}$	2 mm
Internal diameter of the HDPE inner layer of the collar, DC	2414 mm
Width of the HDPE inner layer of the collar, BC_{HDPE}	300 mm
Width of the mild steel outer layer of the collar, $BC_{M.S.}$	375 mm

It is appreciated that the exposed surfaces of the composite collar may be externally coated with epoxy paint, HDPE, steel plating, or other plastic or protective material. This can further protect against harsh environmental factors or pipe jacking stresses and enable the collar to resist degradation caused by ultra violet radiation or handling contacts incidental to transportation or installation. The composite collar may have an additional layer or layers made of epoxy paint, HDPE, steel, or other plastic or protective material laid on top of the abrasion resistant layer, below the HDPE corrosion resistant layer, or in between the abrasion resistant layer and the corrosion resistant layer of the composite collar of the example embodiment. Such additional layers can further protect against harsh environmental factors or pipe jacking stresses. They can also enable the collar to resist degradation caused by ultra violet radiation or handling contacts incidental to transportation or installation.

Example embodiments of the illustrated pipe section provide several advantages over prior art pipe sections. For example, the composite collar is lighter in weight than a collar made entirely out of steel and is easier to handle. Furthermore, the corrosion resistant layer of the collar provides increased corrosion resistance and hence a longer service life for the pipe section. The composite collar also has increased flexibility without compromising seal tightness. Furthermore, the raw materials for the composite collar are more readily available and sourced, and the material cost of the composite collar is less than a collar made entirely of steel.

It will be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

CLAIMS

1. A collar for attaching to a concrete pipe section, the concrete pipe section comprising a spigot formed on a tubular concrete body, the collar
5 comprising:

an abrasion resistant layer; and
a corrosion resistant layer,

wherein the collar is configured to mesh with the spigot of the concrete pipe section.

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2. The collar as claimed in claim 1, wherein the abrasion resistant layer is on an outside surface of the collar and the corrosion resistant layer is on an inside surface of the collar.

- 15 3. The collar as claimed in claims 1 or 2, wherein the abrasion resistant layer completely covers the corrosion resistant layer.

4. The collar as claimed in any one of the preceding claims, wherein the abrasion resistant layer of the collar comprises mild steel or stainless steel.

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5. The collar as claimed in any one of the preceding claims, wherein the corrosion resistant layer of the collar comprises one of High Density Polyethylene (HDPE), Polyvinylchloride (PVC) and High Alumina cement.

- 25 6. The collar as claimed in any one of the preceding claims, wherein the collar further comprises one or more protective layers.

7. The collar as claimed in any one of the preceding claims, wherein exposed surfaces of the collar are externally coated with one or more protective
30 materials.

8. The collar as claimed in any one of the preceding claims, wherein the collar further comprises recesses on the corrosion resistant layer for engaging

protrusions on the tubular concrete body for preventing movement of the corrosion resistant layer and the tubular concrete body with respect to each other.

- 5 9. The collar as claimed in any one of the preceding claims, wherein the collar further comprises one or more bars extending from the abrasion resistant layer into the corrosion resistant layer for preventing movement of the abrasion resistant layer and the corrosion resistant layer with respect to each other.

- 10 10. A concrete pipe section comprising:
 a tubular concrete body having a first end and a second end, said second end disposed opposite to the first end;
 a collar disposed on the first end of the tubular concrete body, the collar comprising:
 an abrasion resistant layer; and
15 a corrosion resistant layer; and
 a spigot formed on the tubular concrete body at the second end, wherein the collar is configured to mesh with a spigot of an adjoining concrete pipe section.

- 20 11. The concrete pipe section as claimed in claim 10, wherein the abrasion resistant layer is on an outside surface of the collar and the corrosion resistant layer is on an inside surface of the collar.

- 25 12. The concrete pipe section as claimed in claims 10 or 11, wherein the abrasion resistant layer of the collar comprises mild steel or stainless steel.

- 30 13. The concrete pipe section as claimed in claims 10, 11 or 12, wherein the abrasion resistant layer of the collar comprises a steel fishtail structure to firmly secure the abrasion resistant layer to the tubular concrete body.

14. The concrete pipe section as claimed in any one of claims 10 to 13, wherein the corrosion resistant layer of the collar comprises one of High Density Polyethylene (HDPE), Polyvinylchloride (PVC) or High Alumina cement.

15. The concrete pipe section as claimed in any one of claims 10 to 14, wherein the collar further comprises one or more protective layers.

5 16. The concrete pipe section as claimed in any one of claims 10 to 15, wherein exposed surfaces of the collar are externally coated with one or more protective materials.

10 17. The concrete pipe section as claimed in any one of claims 10 to 16, wherein the collar further comprises recesses on the corrosion resistant layer for engaging protrusions on the tubular concrete body for preventing movement of the corrosion resistant layer and the tubular concrete body with respect to each other.

15 18. The concrete pipe section as claimed in any one of claims 10 to 17, wherein the collar further comprises one or more bars extending from the abrasion resistant layer into the corrosion resistant layer for preventing movement of the abrasion resistant layer and the corrosion resistant with respect to each other.

20 19. The concrete pipe section as claimed in any one of claims 10 to 18, wherein the collar is formed integrally with the pipe section.

20. The concrete pipe section as claimed in any one of claims 10 to 18, wherein the concrete pipe section further comprises a spigot formed at the first end, and wherein the collar is attached to the spigot at the first end.

25 21. A method of manufacturing a collar for a concrete pipe section having a spigot formed on a tubular concrete body, the method comprising the steps of:

30 fabricating an abrasion resistant layer;
 fabricating a corrosion resistant layer; and
 assembling the collar by joining the abrasion resistant layer to the corrosion resistant layer.

22. The method as claimed in claim 21, wherein the abrasion resistant layer is on an outside surface of the collar and the corrosion resistant layer is on an inside surface of the collar.

5 23. The method as claimed in claims 21 and 22, further comprising the step of fabricating one or more protective layers for the collar and assembling the collar by joining the one or more protective layers together with the abrasion resistant layer and the corrosion resistant layer.

10 24. The method as claimed in any one of claims 21 to 23, wherein the step of fabricating the corrosion resistant layer comprises forming at least one recess on the corrosion resistant layer.

15 25. The method as claimed in any one of claims 21 to 24, wherein the step of fabricating the collar further comprises welding one or more bars extending from the abrasion resistant layer into the corrosion resistant layer for preventing movement of the abrasion resistant layer and the corrosion resistant layer with respect to each other.

20 26. The method as claimed in any one of claims 21 to 25, wherein the abrasion resistant layer of the collar comprises mild steel or stainless steel.

25 27. The method as claimed in any one of claims 21 to 26, wherein the corrosion resistant layer of the collar comprises one of High Density Polyethylene (HDPE), Polyvinylchloride (PVC) and High Alumina cement.

30 28. A method of manufacturing a concrete pipe section, the concrete pipe section comprising a tubular concrete body having a first end and a second end opposite to the first end, a collar attached to the first end and a spigot formed on the second end such that the collar is configured to mesh with a spigot of an adjoining concrete pipe section, the method comprising the steps of:

fabricating the collar, the collar comprising at least an abrasion resistant layer and a corrosion resistant layer;

assembling a reinforcement cage for the concrete pipe section;

assembling a mould for the concrete pipe section;
positioning said collar and said reinforcement cage into said mould;
pouring concrete into said mould;
allowing the concrete to harden within said mould to produce said
5 concrete pipe section; and
removing the concrete pipe section from said mould.

29. The method as claimed in claim 28, wherein the step of fabricating the collar
further comprises:
10 fabricating an abrasion resistant outer layer;
fabricating a corrosion resistant inner layer; and
assembling the collar by joining the abrasion resistant layer to the
corrosion resistant layer.

15 30. The method as claimed in claim 29, further comprising the step of
fabricating one or more protective layers for the collar and assembling the collar by
joining the one or more protective layers together with the abrasion resistant layer and
the corrosion resistant layer.

20 31. The method as claimed in claim 30, wherein the step of fabricating the
corrosion resistant layer comprises forming at least one recess on the corrosion
resistant layer, and the step of assembling said mould is accomplished such that at
least one protrusion is formed on the first end.

25 32. The method as claimed in claim 31, wherein the at least one protrusion is
positioned to engage said at least one recess.

30 33. The method as claimed in any one of claims 28 to 32, wherein the
abrasion resistant layer of the collar comprises mild steel or stainless steel.

34. The method as claimed in any one of claims 28 to 33, wherein the
corrosion resistant layer of the collar comprises one of High Density Polyethylene
(HDPE), Polyvinylchloride (PVC) or High Alumina cement.

35. The method as claimed in any one of claims 28 to 33, wherein the concrete pipe section further comprises a spigot on the first end and wherein the step of positioning the collar is eliminated, the method further comprising a step of:

5 attaching the collar to the spigot on the first end to form the concrete pipe section.

36. A concrete pipe formed by connecting a plurality of concrete pipe sections, each concrete pipe section comprising:

10 a tubular concrete body having a first end and a second end, said second end disposed opposite to the first end;

a collar disposed on the first end of the tubular concrete body, the collar comprising:

an abrasion resistant layer; and

a corrosion resistant layer; and

15 a spigot formed on the tubular concrete body at the second end, wherein the collar is configured to mesh with a spigot of an adjoining concrete pipe section.

37. The concrete pipe section as claimed claim 36, wherein the collar is formed integrally with the pipe section.

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38. The concrete pipe section as claimed in claim 36, wherein the concrete pipe section further comprises a spigot formed at the first end, and wherein the collar is attached to the spigot at the first end.

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