**[0011]** In seabed where load bearing stratum level is not too deep to be reached by excavation, the invented foundation type is effective since it takes the advantages of having friction resistance and end bearing resistance of friction piles and caisson respectively .

## SUMMARY

**[0011a]** According to a first aspect of the present invention, there is provided a construction method for planting a bottom-closed hollow column into a seabed beneath water of a marine environment, the hollow column adapted to support a waterborne structure thereon, comprising: (a) driving a steel tube having an internal diameter with a margin tolerance greater than the external diameter of the hollow column into the seabed at an installation location thereof until it reaches a founding stratum of the seabed, (b) excavating any material of the seabed that is present inside the steel tube down to the founding stratum, (c) lifting a bottom-closed first segment of the hollow column into the steel tube vertically so that it floats on the water, and while the first segment is held in position, lifting a second segment onto the first segment in an end to end relation, the first and second segments aligned via match cast positioning blocks and shear keys, where opposed, joining faces of the first and second segments are coated with an epoxy resin or equivalent and joined by a compression set up by a plurality of stressing bars threaded through a plurality of preformed ducts extending across the joining faces, and where the lifting and joining steps are repeated until a final segment is joined such that it is exposed above the water surface, (d) filling up any gaps and cavities present between the steel tube and hollow column and between a base of the hollow column and founding stratum by applying a pressure grout of underwater concrete and cement, wherein after hardening the hollow column and steel tube form an integral unit adapted to take loads generated by a surface friction resistance between the outer surface steel tube surface and soil materials of the seabed, and by an end bearing resistance from the founding stratum, and (e) cutting the steel tube at a mud line level of the seabed, wherein step (e) is performed between steps (b) and (c) or alternatively after step (d).

**[0011b]** According to a second aspect of the present invention, there is provided a construction method for planting a bottom-closed hollow column into a seabed beneath water of a marine environment, the hollow column adapted to support a waterborne structure thereon, comprising: (a) driving a steel tube having an internal diameter with a

margin tolerance greater than the external diameter of the hollow column into the seabed at an installation location thereof until it reaches a founding stratum of the seabed, (b) excavating any material in the seabed that is present inside the steel tube down to the founding stratum, (c) placing the entire hollow column into the steel tube vertically and ballasting it with water until it sinks to a final depth at the founding stratum, (d) filling up any gaps and cavities between the steel tube and hollow column and between a base of the hollow column founding stratum by applying a pressure grout of underwater concrete and cement, where after hardening the hollow column and steel tube form an integral unit adapted to take loads generated by a surface friction resistance between the outer surface steel tube surface and soil materials of the seabed, and by an end bearing resistance from the founding stratum, and (e) cutting the steel tube at a mud line level of the seabed, wherein step (e) is performed between steps (b) and (c) or alternatively after step (d).

**[0012]** An example embodiment is directed to a construction method for fixing a foundation for supporting waterborne structures such as an offshore platform to a seabed, the foundation having one or more hollow columns that are to be fixed in the seabed, such as a seabed comprising a thick layer of soft marine deposits. The construction method comprises:

**[0013]** A) a steel tube with an internal clear diameter greater than the external diameter of the hollow column by a tolerance margin is driven into the seabed at the designated location until it reaches the design founding level,

**[0014]** B) excavate the materials inside the steel tube down to the founding level,

**[0015]** C) lift the first segment of the bottom closed hollow column into the steel tube which is able to float in the water. Whilst the first segment is held in position, the second segment is added to the column under a locking mechanism achieved by matched cast male and female positioning blocks and shear keys; the jointing procedures are to coat the two joining faces with epoxy resin or equivalent then lower the second segment onto the first segment and compress the joint with prestressing by stressing bars threaded through the two segments. The design length of each individual segment should be such that the assembled column is capable floating in the water. After all segments are assembled, the column is water ballasted to sink to the bottom of the steel tube.

**[0016]** D) the gap between the steel tube and the hollow column and the void underneath the hollow column base are filled by pressure grout with underwater concrete starting from

the low points at the base slab gradually pushing the front upward until the said concrete and cement emerging from the gap at the seafloor. After the said concrete and cement gained strength, the steel tube is now bonded to the hollow column and they become a single integral unit.

**[0017]** E) cut the steel tube at the mud line of the seafloor;

**[0018]** Alternatively, the cutting of the steel tube can be carried out before the installation of the first segment.

**CLAIMS:**

1. A construction method for planting a bottom-closed hollow column into a seabed beneath water of a marine environment, the hollow column adapted to support a waterborne structure thereon, comprising:

(a) driving a steel tube having an internal diameter with a margin tolerance greater than the external diameter of the hollow column into the seabed at an installation location thereof until it reaches a founding stratum of the seabed,

(b) excavating any material of the seabed that is present inside the steel tube down to the founding stratum,

(c) lifting a bottom-closed first segment of the hollow column into the steel tube vertically so that it floats on the water, and while the first segment is held in position, lifting a second segment onto the first segment in an end to end relation, the first and second segments aligned via match cast positioning blocks and shear keys, where opposed, joining faces of the first and second segments are coated with an epoxy resin or equivalent and joined by a compression set up by a plurality of stressing bars threaded through a plurality of preformed ducts extending across the joining faces, and where the lifting and joining steps are repeated until a final segment is joined such that it is exposed above the water surface,

(d) filling up any gaps and cavities present between the steel tube and hollow column and between a base of the hollow column and founding stratum by applying a pressure grout of underwater concrete and cement, wherein after hardening the hollow column and steel tube form an integral unit adapted to take loads generated by a surface friction resistance between the outer surface steel tube surface and soil materials of the seabed, and by an end bearing resistance from the founding stratum, and

(e) cutting the steel tube at a mud line level of the seabed, wherein step (e) is performed between steps (b) and (c) or alternatively after step (d).

2. A construction method for planting a bottom-closed hollow column into a seabed beneath water of a marine environment, the hollow column adapted to support a waterborne structure thereon, comprising:

(a) driving a steel tube having an internal diameter with a margin tolerance greater than

the external diameter of the hollow column into the seabed at an installation location thereof until it reaches a founding stratum of the seabed,

(b) excavating any material in the seabed that is present inside the steel tube down to the founding stratum,

(c) placing the entire hollow column into the steel tube vertically and ballasting it with water until it sinks to a final depth at the founding stratum,

(d) filling up any gaps and cavities between the steel tube and hollow column and between a base of the hollow column founding stratum by applying a pressure grout of underwater concrete and cement, where after hardening the hollow column and steel tube form an integral unit adapted to take loads generated by a surface friction resistance between the outer surface steel tube surface and soil materials of the seabed, and by an end bearing resistance from the founding stratum, and

(e) cutting the steel tube at a mud line level of the seabed, wherein step (e) is performed between steps (b) and (c) or alternatively after step (d).

3. The method of claims 1 or 2, wherein the base is embodied as a bottom slab that is tapered with its apex pointing downward to serve as a lowest point of the slab, thereby allowing grout egressed from the lowest point to flow and rise so as to facilitate filling the gaps and cavities around the hollow column.

4. The method of claims 1 or 2, further comprising backfilling a layer of sand or stone in the bottom interior of the steel tube.

5. The method of claims 1 or 2, wherein

the hollow column is assembled from a plurality of match cast segments, and

a reverse profile of shear keys are formed in a given match cast segment by casting against the face of the segment with shear keys of a completed match cast segment.

6. The method of claims 1 or 2, wherein

the hollow column is assembled from a plurality of match cast segments, and

a reverse profile of positioning blocks are formed in a given match cast segment by

casting against the face with positioning blocks of a completed match cast segment.

7. The method of claims 1 or 2, wherein uniformly distributed shear keys, such as triangle-shaped shear keys with sharp tips pointing downward, are welded to the inner face of the steel tube to increase bonding between the steel tube and the hollow column.

8. The method of claims 1 or 2, wherein a platform of the waterborne structure includes a plurality of openings, each for insertion of a corresponding hollow column therethrough as the platform is supported on a temporary floater.

9. The method of claims 1 or 2, wherein the waterborne structure includes a platform, with the hollow columns serving to support the platform thereon as the hollow columns are casted to corresponding platform joints.

10. The method of claims 1 or 2, wherein space within the hollow columns are adapted for storage.

**I claim:**

1. A construction method for fixing a bottom closed hollow column into seabed and adapted to support a waterborne structure thereon to a seabed, comprising:

a) drive a steel tube, with an internal clear diameter greater than the external diameter of the hollow column by a tolerance margin, into the seabed at an installation location until it reaches the designated founding stratum,

b) excavate and remove the material inside the steel tube down to the designated founding stratum,

c) lift the bottom closed first segment of the hollow column into the steel tube vertically and float in the water; while the first segment is held in position, the second segment is lifted onto the first segment end to end aligned by the matched cast positioning blocks and shear keys; the joining faces of the two segments are coated with epoxy resin or equivalent and the two faces are joined tightly by compression set up by the stressing bars threaded through the preformed ducts across the joining faces; repeat the above steps until the final segment which should expose above the water surface,

d) fill up the gap and cavity between the steel tube and the hollow column and between the hollow column base and the founding stratum by pressure grout of underwater concrete and cement; after hardening, the hollow column and the steel tube become an integral unit that takes the loads by surface friction resistance between the steel tube surface and the soil, and by end bearing resistance from the designated founding stratum in the seabed,

e) cut the steel tube at the mud line level of the seabed; wherein the step e) may be performed before the step c) and after step b), or may be performed after step d).

2. A construction method for fixing a bottom closed hollow column into seabed and adapted to support a waterborne structure thereon to a seabed, comprising:

a) drive a steel tube, with an internal clear diameter greater than the external diameter of the hollow column by a tolerance margin, into the seabed at an installation location until it reaches the designated load bearing stratum,

b) excavate the material inside the steel tube down to the designated founding stratum,

c) lift the bottom closed whole unit of the hollow column into the steel tube vertically and ballast it with water until it sinks to its final depth at the designated founding stratum.

d) fill up the gap and cavity between the steel tube and the hollow column and between the hollow column base and the founding stratum by pressure grout of underwater concrete and cement; after hardening, the hollow column and the steel tube become an integral unit that takes the loads by surface friction resistance between the steel tube surface and the soil, and by end bearing resistance from the designated founding stratum in the seabed,

e) cut the steel tube at the mud line level of the seabed; wherein the step e) may be performed before the step c) and after step b), or may be performed after step d).

3. According to the claims 1 and 2, the hollow column bottom is a conic shape.

4. According to any claim, prior to step c) backfill sad/stone in the bottom of the steel tube.

5. According to claim 1 or 3 or 4, the characteristic of the method in the joining of any two segments is to achieve by complementary male and female shear keys and ducts for prestressing and anchorage from the matched casting of one segment against the end of the completed segment.

6. According to claim 1 or 3 or 4 or 5, the characteristic of the method in the joining of any two segments is achieved by complementary male and female positioning and ducts for prestressing and anchorage from the matched casting of one segment against the end of the completed segment.

7. According to any claim 1, 3, 4, 5 or 6, the characteristic of the method in the joining of any two segments is achieved by complementary male and female shear keys and ducts for prestressing and anchorage from the matched casting of one segment against the end of the completed segment.

8. According to any claim 1, 3, 4, 5, 6 or 7, the characteristic of the method is the segment axial length of the first segment greater than the length of any segment.

9. According to any claim 8, the characteristic of the method in the joining of a series of segments the buoyancy of the series of segments is greater than the sum of dead weight of the series of segments

10. According to claim 2, the characteristic of the method is to backfill the bottom of the steel tube a layer of sand/stone before step c).

11. According to any claim of the above method, steel shear keys in the form of triangle with its sharp angle point downward are welded uniformly in the inner of the face of the steel tube.

12. An offshore waterborne structure especially offshore platform comprising at least one hollow column supporting a beam-and-slab type platform wherein the method includes:

transport the on land prefabricated platform by floater in sea to the installation location,

according to the method of any of the above claims, the platform is joined to the last installed segment of the hollow column or the above water portion of the hollow column by insitu concrete.

13. According to any of the above claims, the last segment of the hollow column or the top end of the single piece hollow column is embedded with starter reinforcement bars for lapping.

14. According to claims 12 or 13, disassembled steel props are erected on the steel brackets welded to the outer face of the steel tube to support the platform with mechanism to level the platform before it is fixed.

15. According to any claim of the above method, pipes are embedded in the wall of hollow column for pumping underwater concrete outside the wall.

16. According to claims 12 to 15, steel shear keys are welded uniformly to the inner face of the steel tube with the sharp angle pointing downward.

17. A waterborne platform especially offshore platform according to the method of claims 1-11, the fixing of hollow column includes the steps:

penetrate to the founding level of a steel tube,

locate a bottom closed hollow column with a portion of it exposed above the water surface, and

underwater concrete is grouted between the inner face of the steel tube and outer face of the hollow column.

18. According to claim 17, the hollow column is formed with a number of segments and the segments are joined by shear keys.

19. According to claim 17 or 18, steel shear keys in triangle shape are welded uniformly to the inner face of the steel tube with the sharp angle pointing downward.

20. According to claim 18, starter reinforcement bars are installed in the last segment of the hollow column or installed in the top end of the hollow column for lapping.

21. According to claims 17-20, the said platform is installed with pipes in its wall and have egress outlet outside to pump the underwater concrete out.

22. A waterborne structure especially offshore platform wherein the installation method according to claims 12-16 includes:

at least one hollow column and one beam-and-slab type platform formed according to any claims 17-21.

23. According to claim 22, the last hollow column segment or the top end of the one piece column, reinforcement lapping bars are pre-installed.

24. According to claim 22 or 23 the said platform is leveled whilst the platform is supported from underneath props which sit on the bracket welded to the steel tube outside face.

25. According to any of the claims 22-24, pipes for pumping underwater concrete out of the hollow column are pre-installed in the wall and the slab of the hollow column.