

MECHANICAL JOINT FOR REINFORCED CONCRETE PILE AND METHOD THEREOF

TECHNICAL FIELD

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[001] The present disclosure generally relates to pre-cast Reinforced Concrete (RC) pile. The present disclosure also relates to a mechanical joint structure and method for interlocking end plate connector attached to the ends of a concrete pile by joining the end of one concrete pile to the end of another adjoining concrete pile to form a continuous pre-cast pile.

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BACKGROUND

[002] The most common pile used in many parts of the world, such as in Scandinavian countries, is the pre-cast Reinforced Concrete (RC) pile. Concrete piles, as conventionally known, are common structural foundation elements used to support structures such as buildings, bridges, oilrigs, and floating airports. A pile is basically a long section that is pushed into the ground to act as a steady support for structures built on top of it.

[003] Pile foundations are used in the following situations: When there is a layer of weak soil and cannot support the weight of the building, so the loads of the building must bypass this layer and be transferred to the layer of stronger soil or rock that is below the weak layer, and/or when a building has very heavy, concentrated loads, such as in a high-rise structure, bridge, or water tank. Pile foundations can take higher loads than spread footings. Further, the pre-cast RC piles are installed either via percussion hammers or jacked-in under reaction counterweights.

[004] In the conventional method of installation, pre-qualified welders are appointed for welding the pre-cast RC piles/sections thereof for joining. On completion of welding, any weld slag will be chipped off and wire brushed. The completed weld joint will be subjected to cooling followed by visual inspection, prior to resumption of installation.

[005] Welding equipment and accessories are required to be shifted in-between various piling locations. Equipment also needs to be regularly inspected and serviced-maintained, its

cables need to be elevated from ground for safety reason and welding electrodes need to be properly stored.

[006] These pre-cast concrete piles may be fabricated off-site and delivered into project sites. In its process of installation, these pre-cast sections are then spliced together via welding. This welding works emit high heat and toxic fumes and requires good workmanship to produce a quality splice. Welding process is also time-consuming.

[007] Because of manufacturing, structural, transportation, installation, and other limitations associated with concrete piles, the length of the piles is often limited to a pre-determined length. Depending on the situation, it is often necessary to join, or splice, two piles end-to-end at a construction site when an individual pile section is not long enough for a particular application. However, joining discrete concrete piles presents several difficult challenges, such as proper alignment of the pile sections, maintaining continuity of strength, mechanical performance, and other properties. Alignment is critical to prevent slippage, bending stresses, and other problems associated with pile splices.

[008] A concern that is often associated with the use of mechanical splices for piles is the ability of the splice to transmit stress waves of the impact hammer from the upper segment of the pile to the lower segment.

[009] Prior art concrete piles use concrete anchor bars to provide a means to attach and/or align joints. However, anchor bars of that type are not suitable for precision component purposes.

[0010] In view of the lack of suitable solutions to the aforementioned problems offered in the prior art, it should be apparent that there exists a need for an alternate concrete pile joint which does not require any conventional welding method (current weld joint method) to splice concrete pile sections and/or multiple concrete piles. The alternate concrete pile joint should be manufactured to sustain high stress tolerance at minimum cost that, when used to splice concrete pile sections, produces a highly reliable splice.

SUMMARY

[0011] The purpose of the present invention is to provide an alternate concrete pile joint which does not require any conventional welding method (current weld joint method) to splice concrete pile sections and/or multiple concrete piles. The alternate concrete pile joint is manufactured to sustain high stress tolerance at minimum cost that, when used to splice concrete pile sections, produces a highly reliable splice.

[0012] Accordingly, an aspect of the present invention provides a mechanical joint as an alternative for conventional welding process (current weld joint method) to splice concrete pile sections and/or multiple concrete piles by eliminating the drawbacks exhibited by known similar splices. More specifically, the invention seeks to provide a mechanical joint to increase productivity with more consistent quality.

[0013] The concrete pile to which the joint is attached preferably includes a square base. The connecting ends of driven reinforced concrete piles feature box-like or plate-like parts to which the locking structures are attached mechanically. This allows the splice to withstand forces acting on it from all directions. The tight dimensional tolerances are provided by precision machining and mechanical joining components together.

[0014] In an aspect, the mechanical joint has consistent quality, higher productivity and eliminates hazards making it safe for use at any possible operational site and/or environment.

[0015] In an aspect, the mechanical joint provides on field joint splicing process thereby minimizing and/or eliminating the reliance on trained professionals (manpower and workmanship).

[0016] In an aspect, the mechanical joint is feasible for larger scale projects and in project environment where hot work splicing is not permitted, for example, Petro-chemical industries to thereby achieve consistency in quality, higher productivity, eliminate fire and health hazards, environmentally friendly.

[0017] In an aspect, the robustness and rigidity of the mechanical joint satisfies the requirements of a Eurocode, BS EN 12794 through rigorous testing followed by subsequent bending testing where applicable and as necessary as per general principles for execution of

displacement piles under Class D and/or Class C criteria for benefitting the industry by achieving consistency in quality, higher productivity, Greener environment (eliminate fire and health hazards, environmentally friendly), project time savings, and providing more commercial and technical options.

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[0018] The splice in accordance with the present invention offers several additional benefits. The present invention provides a simple construction, substantial savings are achieved in the cost of materials and labor. As a result, a threaded bolt method enables to achieve a non-loosening locked splice even after many impacts. At the same time, the present invention provides a locked splice that does not have to be anchored in the end plate using load-bearing welds.

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[0019] In one aspect, the present invention provides a mechanical joint for joining a first pre-cast pile with a second pre-cast pile to form a continuous pre-cast pile, the mechanical joint comprising: a first end plate comprising: four recesses extending substantially perpendicular to the plane of the first end plate; and a collar plate comprising four sockets extending substantially parallel to the plane of the first end plate, wherein each socket defines a first passage that intersects and passes through one of the four recesses; and a second end plate comprising four projections extending substantially perpendicular to the plane of the second end plate, each projection comprising a second passage therethrough which extends substantially parallel to the plane of the second end plate; wherein each recess is arranged to receive one complimentary projection, wherein each of first and second passages are configured to removably receive a bolt that interconnects each recess and projection pair, such that each bolt locks together the first and second end plate.

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[0020] In an embodiment, the first pre-cast pile is connected to the second pre-cast pile by locking and/or fastening of the first end plate with the second end plate without welding.

[0021] In an embodiment, the first pre-cast pile and the second pre-cast pile pre-cast pile is a reinforced concrete pile.

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[0022] In another embodiment, the first end plate and the second end plate comprise a square base.

[0023] In one embodiment, the first pre-cast pile is coupled to a side of the first end plate opposite to a side having the four recesses.

[0024] In one embodiment, the second pre-cast pile is coupled to a side of the second end plate opposite to a side having the projections.

[0025] In one embodiment, the mechanical joint satisfies the requirements of a Eurocode, BS EN 12794 as per general principles for execution of displacement piles under Class D and/or Class C criteria.

[0026] In one embodiment, the mechanical joint structure exhibits a non-loosening locked splice after impacts due to implementation of a threaded bolt method.

[0027] In another aspect, the present invention relates to a method of connecting a first pre-cast pile with a second pre-cast pile to form a continuous pre-cast pile using a mechanical joint, the method comprising the steps of: embedding a first end plate to an end portion of the first pre-cast pile, the first end plate comprising four recesses extending substantially perpendicular to the plane of the first end plate; and a collar plate comprising four sockets extending substantially parallel to the plane of the first end plate, wherein each socket defines a first passage that intersects and passes through one of the four recesses; embedding a second end plate to an end portion of the second pre-cast pile, the second end plate comprising four projections extending substantially perpendicular to the plane of the second end plate, each projection comprising a second passage therethrough which extends substantially parallel to the plane of the second end plate, inserting each of the projections of the second pre-cast pile into the complimentary recess of the first pre-cast pile, aligning the first passage and the second passage; and connecting the first pre-cast pile with the second pre-cast pile to form the continuous pre-cast pile by inserting a bolt through each first passage and second passage.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] The accompanying drawings are included to provide a further understanding of the present disclosure and are incorporated in and constitute a part of this specification. The drawings illustrate exemplary embodiments of the present disclosure and, together with the description, explain the principles of the present disclosure.

[0029] FIG. 1 illustrates a perspective view of a mechanical joint structure used for splicing ends of two reinforced concrete piles, in accordance with an exemplary embodiment of the present disclosure.

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[0030] FIG. 2 illustrates a perspective view of the mechanical joint structure interlocked together, in accordance with an exemplary embodiment of the present disclosure.

[0031] FIG. 3A-C illustrates exemplary views of the first end plate and related components used in achieving mechanical joint, in accordance with an exemplary embodiment of the present disclosure.

[0032] FIG. 4A-C illustrates exemplary views of the second end plate and related components used in achieving mechanical joint, in accordance with an exemplary embodiment of the present disclosure.

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[0033] FIG. 5A-C illustrates exemplary views of the bolt and receiving passage through the projection used in achieving mechanical joint, in accordance with an exemplary embodiment of the present disclosure.

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[0034] FIG. 6 is a flowchart showing a method of connecting a first pre-cast pile with a second pre-cast pile to form a continuous pre-cast pile using a mechanical joint structure, in accordance with an exemplary embodiment of the present disclosure.

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DETAILED DESCRIPTION

[0035] The following detailed description is made with reference to the technology disclosed. Preferred implementations are described to illustrate the technology disclosed, not to limit its scope, which is defined by the claims. Those of ordinary skill in the art will recognize a variety of equivalent variations on the description.

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[0036] In the following detailed description, references are made to the accompanying drawings, which form a part of the description and in which are shown, by way of illustration, specific implementations. Although these disclosed implementations are described in sufficient

detail to enable one skilled in the art to practice the implementations, it is to be understood that these examples are not limiting, such that other implementations may be used and changes may be made to the disclosed implementations without departing from their spirit and scope. For example, the blocks of the methods shown and described herein are not necessarily performed
5 in the order indicated in some other implementations.

[0037] Several preferred embodiments of the invention are described for illustrative purposes, it being understood that the invention may be embodied in other forms not specifically shown in the drawings.

10 **[0038]** Embodiments of the present invention relates to a mechanical pile joint that provides an alternative to the current welding method which involves high heat, requires skilled labour, stringent site supervision and cannot be carried out in the rain. On the other hand, the mechanical pile joint as per the present invention is easy to assemble, leading to an increase in
15 productivity as well as time and overall cost savings. Furthermore, the method is less affected by the weather and does not pollute the environment or pose a fire hazard as compared to the welding method.

[0039] **FIG. 1** refers to a perspective view of a mechanical joint structure used before
20 splicing ends of two reinforced concrete piles, whereas **FIG. 2** illustrates an exemplary view of the interlocked mechanical joint structure, in accordance with an exemplary embodiment of the present disclosure.

[0040] The main aspect of the present invention is to provide to a mechanical joint structure
25 comprising interlocking end plates **101** and **102** attached to the ends of a concrete pile for joining the end of one concrete pile to the end of another adjoining concrete pile. In one embodiment, the end plates **101** and **102** can be a size of about 400mm x 400mm. It will be appreciated that end plates of varying other sizes can be used, for example the smaller sizes 200 x 200mm or larger sizes end plates 600x600mm or up to 800 x 800mm.

30 **[0041]** In an exemplary embodiment, it may be appreciated by a person skilled in the art that, the end plates may be made of a material selected steel or metal, however, any suitable material available now and in future used and suitable for mechanical joint can be used for manufacturing of the end plates.

[0042] FIG. 1 and FIG. 2 shows the first and second end plates **101**, **102** of the mechanical joint **100** or the mechanical joint structure **100** only, the RC pile sections are not shown. RC pile sections and the end plates are manufactured separately. At a construction site, pile sections
5 can be joined at end plates and then secured using bolts or locking pins.

[0043] The first end plates **101** can also be termed as the lower end plate and the second end plate **102** also being termed as the upper end plate. During installation for each mechanical joint end plate pairing, the lower end plate **101** will be placed and orientated first closer to the
10 ground with the upper end plate **102** being subsequently placed and orientated on top of said lower end plate **101**. Thus, the “lower” and “upper” is relative to the proximity of the end plate to the ground for each joint pairing.

[0044] In an embodiment of the present invention, a mechanical joint structure is disclosed
15 to connect a first pre-cast pile with a second pre-cast pile to form a continuous pre-cast pile.

[0045] The first end plate **101** comprises at least one recess **104** and a collar plate **107**. In FIG. 1, four recesses **104** are shown extending substantially perpendicular to the plane of the first end plate **101**, and the collar plate **107** comprising four sockets **106** extending substantially
20 parallel to the plane of the first end plate **101**, wherein each socket **106** defines a first passage **105** that intersects and passes through one of the four recesses **104**. In this regard, the first passage **105** is a horizontally orientated passage formed through the recess **104** from one side to the opposite side. Each socket **106** has an opening **110** at the surface of the collar plate **107**. The collar plate **107** extends vertically down from the edges of the first end plate **101**.

[0046] The socket **106** comprises three sections from the socket opening **110** to a socket end after it has passed through the recess. The first section can comprise socket surrounding walls that extend from the socket opening to the point where the socket intersects and joins with the recess **104**. The second section passes through the recess **104** via two recess openings on
30 opposite sides, however this second section does not include surrounding walls and is open within the recess **104** so as to not impede the insertion of the projection to the bottom of the recess **104**. The third section can comprise surrounding walls that exit the recess **104** in alignment with the first and second sections and can comprise a bottom to close or end the first

passage **105**. Accordingly, the three sections are all in alignment in the same plane with each other to allow a bolt or other locking mechanism to be inserted therethrough.

[0047] In one embodiment, the first section of the socket can comprise a first portion at the socket opening to receive a bolt head of an inserted bolt such that the bolt head is flush with the surface of the collar plate. The first portion can be of a different size to the remaining second portion of the first section in order for a receiving bolt head to be flush against the collar plate surface.

[0048] The second end plate **102** comprises at least one projection **103**. In **FIG. 1**, four projections **103** are shown. Each projection **103** has a second passage **109**. The second passage **109** is a horizontal passage formed through the projection **103** from one side to the opposite side. The second end plate can also include a collar plate with no openings on the surface.

[0049] It should be noted that in the mechanical joint structure, the first pre-cast pile is coupled to a side of the first end plate opposite to a side having the recesses **104**, more specifically the recess openings, and the second pre-cast pile is coupled to a side of the second end plate opposite to a side having the projections **103** extending therefrom. In addition, the end plates can be supported by mean of anchorage bars attached to each end plate on the side of the first and second end plate opposite to a side having the projections and recesses. The anchorage bars enable the end plates to be oriented in an intended fashion.

[0050] In one embodiment, the at least one projection **103** of the second end plate **102** is inserted into a complimentary recess **104** of the first end plate **101**. After insertion, the first and second passages **105** and **109** are aligned and in registration with one another for each complimentary projection and recess pairing. Accordingly, the first and second passages can be shaped and sized the same.

[0051] In one embodiment, the first end plate **101** comprises four recesses **104** and the second end plate **102** comprises four projections **103**, whereby each of the four projections **103** can be inserted into one of the corresponding four recesses **104** they are in alignment with.

[0052] In one embodiment, the first and second end plates **101** and **102** are in a square form shape, wherein the projections **103** are positioned equidistance from one another adjacent to

each corner of the second end plate **102**, with one recess **104** being positioned on the first end plate **101** to be in alignment and in registration with said projections. In one embodiment, the end plates **101** and **102** can be a size of about 400mm x 400mm, whereby each of the projections **103** can be positioned about 75 - 100 mm from adjacent sides of the second end plate **102** with each projection **103** being positioned about 215 - 230 mm from each other. Similarly, each of the recesses **104** can be positioned about 75 - 100 mm from adjacent sides of the first end plate **101** with each recess **104** being positioned about 215 - 230 mm from each other. It will be appreciated that such distances of the projections and recesses may vary and be scaled accordingly dependent on the size of the joint plates.

[0053] In one embodiment, at least one bolt **108** is used to connect two end plates **101** and **102** by inserting the bolt **108** through the first passage **105** of the socket **106**, and through the second passages **109** of the projection **103** to attach and retain the projection within the recess **104**. In this regard, the socket **106** in the first end plate **101** can connect or guide the bolt **108** through the recess **104** and projection **103**, when inserted in to the first passage **105** and through the second passage **109**. Thus, locking or fastening the two end plates **101** and **102** of RC pile sections are performed without welding.

[0054] Accordingly, in one embodiment the mechanical joint can comprise four fastening or locking mechanisms, whereby each fastening or locking mechanism comprises the recess **104**, the socket **106**, the projection **103** and the bolt **108** for interlocking and retaining the projection **103** in said recess **104** via the first passage **105** of the socket **106** that is in registration and alignment with the second passage **109** in the projection **103**. In one embodiment, all four recesses **104** are positioned on the first end plate **101** and all four projections **103** are positioned on the second end plate **102**.

[0055] In an exemplary embodiment, the first pre-cast pile is connected to the second pre-cast pile by locking and/or fastening of the first end plate **101** with the second end plate **102** without welding.

[0056] In an exemplary embodiment, at least one of the first pre-cast pile and the second pre-cast pile is a Reinforced Concrete (RC) pile.

[0057] In an exemplary embodiment, the first end plate **101** and the second end plate **102**, preferably formed in a square shape.

[0058] **FIGs. 3-5** illustrates exemplary plan views of the components used in achieving mechanical joint, in accordance with an exemplary embodiment of the present disclosure.

[0059] **FIGs. 3A-C** illustrate the female joint plate described as the first end plate **101** according to the present invention with associated components. As shown in **FIG. 3A**, the first end plate **101** can include sockets **106** with the opening **110** at the periphery and on the collar plate for receiving the bolt **108**. Each socket **106** defines a first passage **105** that intersects and passes through the recess **104**, whereby the bolt can be inserted through the first passage. The first end plate **101** comprises recesses **104**, each recess is connected to one socket **106** and a corresponding first passage **105** with an opening at the periphery of the first end plate **101**. In particular, the first end plate **101** comprises four recesses **104** equidistance from each other and arranged in consideration of the anchorage bars.

[0060] **FIG. 3B** shows an illustration of the cross-section A-A shown in **FIG 3A** of the first end plate in **FIG. 3A**. **FIG. 3C** shows an exploded view of **FIG 3B** and the first passage and socket that intersects and passes through each recess **104**.

[0061] **FIGs. 4A-C** illustrate the male joint plate described as a second end plate **102** according to the present invention with associated components. As shown in **FIG. 4A**, the second end plate **102** includes projections **103** with a second passage **109** formed therethrough. In particular, the second end plate **102** comprises four projections **103** equidistance from each other and arranged in consideration of anchorage bars.

[0062] **FIG. 4B** shows an illustration of the cross-section B-B of the second end plate **102** in **FIG. 4A**. **FIG. 4C** shows an exploded view of **FIG 4B** and the second passage **109** that runs through each projection **103**.

[0063] The projections **103** of the second end plate **102** are inserted into the recesses **104** of the first end plate **101**. After insertion, the first and second passages **105** and **109** are in alignment and registration with one another to effectively create a single unified passage for receiving a locking device, such as a bolt, inserted into the socket **106**.

[0064] FIG. 5A shows an exemplary overview of the bolt **108** used to connect and hold the joint and end plates **101** and **102** in place after insertion of the bolt **108** into the socket **106** and through the first and second passages **105** and **109**. The bolt **108** can be a threaded screw bolt or a socket cap screw (metric hex bolt), for example, Hexagon 8.8 High Tensile Bolts, M12 X 30mm 8.8 High Tensile Bolt, 8 mm High Tensile Bolts, Metric Class 8.8 Hexagon Head Bolts. FIG. 5B and C, show the second passage **109** through the projection **103** as including a threaded socket to compliment and receive the threaded screw bolt **108**.

[0065] Table 1 depicts deliverables and performance targets achieved by the implementation of mechanical joint as per the present invention (indicated as proposed results) and by the implementation of mechanical joint as per the conventional welding approach (indicated as current method), in accordance with an exemplary embodiment of the present disclosure.

Table 1:

Productivity (Piles)/man-hours	Current Method	Proposed Results	Improvement Expected	Actual Results	Actual Improvement
No. of manpower required	2	1	50%	1	50%
No. of Pile Joints per Day	5	7	40%	7	40%
Time required to join 1 pile joint	15 mins	5 mins	67%	3 mins	80%
Total man-hours required per pile joint	0.5	0.08	84%	0.05	90%
Productivity (Pile Joints)/man-hours	10	88	780%	140	1300%
Productivity Gain		780%			1300%

[0066] As shown in Table 1, the productivity of the mechanical joint implemented as per the present invention (indicated as proposed results) and by the implementation of mechanical joint as per the conventional welding approach (indicated as current method) was determined and it was noted that the mechanical joint implemented as per the present invention (indicated as proposed results) clearly shows advantageous effects as compared to the joint formed by the convention methods. For example, the number of manpower required is less as compared to the conventional methods, number of pile joints that can be installed per day is more as

compared to the conventional methods, time required for installation for each join is less as compared to the conventional methods, total man hours required for installation is also less as compared to the conventional methods, and there by the total productivity achieved by the implementation of the of the mechanical joint implemented as per the present invention (indicated as proposed results) is much higher as compared to the conventional methods.

[0067] **Table 2** shows an exemplary time taken for joint installation in accordance with an exemplary embodiment of the present disclosure. In an exemplary embodiment, the time was measured during the installation of mechanical joint. A total of six joints from more than one specimen were recorded. From **Table 2**, it is evident that the average time taken to install the joints is around 2 minutes and 53 seconds.

Table 2:

Date	Specimen	Timing For 1st Joint	Timing For 2nd Joint	Average Timing
16 Oct 2020	1	5mins 16secs	2mins 43secs	4mins
14 Dec 2020	2	2mins 10secs	2mins 22secs	2mins 16secs
14 Dec 2020	3	2mins 33secs	2mins 15secs	2mins 24secs
Average				2mins 53secs

[0068] As shown in **Table 2**, the current method of welding of 15mins does not include cooling time. It needs to be noted that specimens 1-3 refer to a same joint structure however the test is repeated at different time and/or dates. Typically, after the completion of welding, an additional cooling time of 10-15 mins is required. This will total up to 30 mins required for current welding method. As opposed to the mechanical joint method, the installation is faster and there is no need for any cooling time.

[0069] **FIG. 6** is a flowchart showing a method **200** of connecting a first pre-cast pile with a second pre-cast pile to form a continuous pre-cast pile using a mechanical joint structure, in accordance with an exemplary embodiment of the present disclosure. The mechanical joint structure used to connect a first part of a pre-cast pile with a second part of the pre-cast pile to form a continuous pre-cast pile, comprises a first end plate and a second end plate. As at step **202**, a first end plate is coupled to an end portion of the first pre-cast pile. The first end plate has at least one recess extending in a longitudinal direction of the first pre-cast pile. As at step

204, the second end plate is coupled to an end portion of the second pre-cast pile. The second end plate has at least one projection extending in a longitudinal direction of the second pre-cast pile. At least one second passage in the projection, and at least one first passage in the first end plate, facilitate the connection of the first part of the pre-cast pile with the second part of the pre-cast pile.

[0070] As at step 206, the at least one projection is inserted in to one recess. Then, as at step 208, the at least one first passage and the at least one second passage are aligned. Finally, as at step 210, the first pre-cast pile is connected with the second pre-cast pile to form the continuous pre-cast pile by inserting at least one bolt through the at least one first passage. It should be noted that, the at least one bolt is adapted to pass through the at least one first passage and the at least one second passage. The first end plate includes a socket that defines the first passage and enables the at least one bolt to pass through the at least one second passage when inserted in the at least one first passage.

[0071] To summarize, the present invention provides a mechanical pile joint as an alternative to the current welding method which involves high heat, requires skilled labour, stringent site supervision and cannot be carried out in the rain. On the other hand, the mechanical pile joint of present invention is easy to assemble, leading to an increase in productivity as well as time and cost savings. Furthermore, the method is less affected by the weather and does not pollute the environment or pose a fire hazard as compared to the welding method.

[0072] The performance of the mechanical joints of the present invention were tested under Eurocode (BS EN 12794) guidelines for the classification of pile joints. Tests comprises of site Impact testing. The approach was to satisfy the minimum criteria set out in verifying the robustness and rigidity of Class D (Compression joint), where test specimens will be subjected to 500 impact blows of 17N/mm². Upon satisfactory result, the pile joint satisfies certification.

[0073] In particular, the mechanical joints of the present invention were further subjected to Four-point bending tests. Based on the test results, the mechanical pile joint disclosed herein is shown to have sufficient bending capacity as compared to the calculated bending moment. As an integral test programme, the results from the impact testing and Four-point bending tests indicate

that the mechanical pile joint disclosed herein meets the Class C criteria with adequate robustness and rigidity.

[0074] Table 3 below summarizes the performance results of tests performed on the mechanical joint disclosed herein.

Table 3:

Description	Criteria	Assessment
Impact Testing (Class D)	500 blows of 17N/mm ²	Pile joint achieved the criteria for Class D Compression Pile
Impact Testing (Class C)	1000 blows of 17N/mm ²	Pile joint achieved the criteria for Class C Compression & Bending Tests
Bending Test (Class C)	Moment Capacity	3 Specimens had achieved the design pile joint capacity
Productivity Gain	780%	1300%

ADVANTAGES OF THE PRESENT INVENTION:

[0075] The present invention provides a mechanical joint as an alternative for conventional welding process (current weld joint method) to splice concrete pile sections and/or multiple concrete piles by eliminating the drawbacks exhibited by known similar splices.

[0076] The present invention provides a mechanical joint with low cost of materials and labor in production.

[0077] The concrete pile to which the joint of the present invention is attached preferably includes a square base. The connecting ends of driven reinforced concrete piles feature box-like or plate-like parts to which the locking structures are attached mechanically. This allows the splice to withstand forces acting on it from all directions. The tight dimensional tolerances are provided by precision machining and mechanical joining components together.

[0078] The mechanical joint of the present invention has consistent quality, higher productivity and eliminates hazards making it safe for use at any possible operational site and/or environment.

5 **[0079]** The mechanical joint of the present invention provides on field joint splicing process thereby minimizing and/or eliminating the reliance on trained professionals (manpower and workmanship).

[0080] The mechanical joint of the present invention resulted in improved productivity.

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[0081] The mechanical joint of the present invention is feasible for larger scale projects and in project environment where hot work splicing is not permitted, for example, Petro-chemical industries to thereby achieve consistency in quality, higher productivity, eliminate fire and health hazards, environmentally friendly.

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[0082] The mechanical joint of the present invention satisfies the robustness and rigidity requirements of a Eurocode, BS EN 12794 as per general principles for execution of displacement piles under Class D and/or Class C criteria for benefitting the industry by achieving consistency in quality, higher productivity, Greener environment (eliminate fire and health hazards, environmentally friendly), project time savings, and providing more commercial and technical options.

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[0083] As used herein, and unless the context dictates otherwise, the term “coupled to” is intended to include both direct coupling (in which two elements that are coupled to each other or in contact each other) and indirect coupling (in which at least one additional element is located between the two elements). Therefore, the terms “coupled to” and “coupled with” are used synonymously. Within the context of this document terms “coupled to” and “coupled with” are also used euphemistically to mean “communicatively coupled with” over a network, where two or more devices can exchange data with each other over the network, possibly via one or more intermediary device.

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[0084] Moreover, in interpreting both the specification and the claims, all terms should be interpreted in the broadest possible manner consistent with the context. In particular, the terms “comprises” and “comprising” should be interpreted as referring to elements, components, or

steps in a non-exclusive manner, indicating that the referenced elements, components, or steps may be present, or utilized, or combined with other elements, components, or steps that are not expressly referenced.

5 **[0085]** While some embodiments of the present disclosure have been illustrated and described, those are completely exemplary in nature. The disclosure is not limited to the embodiments as elaborated herein only and it would be apparent to those skilled in the art that numerous modifications besides those already described are possible without departing from the inventive concepts herein. All such modifications, changes, variations, substitutions, and
10 equivalents are completely within the scope of the present disclosure. The inventive subject matter, therefore, is not to be restricted except in the protection scope of the appended claims.

[0086] Although certain presently preferred embodiments of the disclosed invention have been specifically described herein, it will be apparent to those skilled in the art to which the
15 invention pertains those variations and modifications of the various embodiments shown and described herein may be made without departing from the spirit and scope of the invention. Accordingly, it is intended that the invention be limited only to the extent required by the appended claims and the applicable rules of law.

WHAT IS CLAIMED IS:

1. A mechanical joint for joining a first pre-cast pile with a second pre-cast pile to form a continuous pre-cast pile, the mechanical joint comprising:

5 a first end plate comprising: four recesses extending substantially perpendicular to a plane of the first end plate; and

a collar plate comprising four sockets extending substantially parallel to a plane of the first end plate, wherein each socket defines a corresponding first passage that intersects and passes through a corresponding one of the four recesses, and each socket comprises a first section having socket surrounding walls extending from an opening in the collar plate to where the socket intersects with the recess, and a second section that passes through the recess via two recess openings on opposite sides; and

10 a second end plate comprising four projections extending substantially perpendicular to the plane of the second end plate, each projection comprising a second passage therethrough which extends substantially parallel to the plane of the second end plate;

wherein each recess is arranged to receive one complimentary projection,

wherein each pair of first and second passages are configured to removably receive a bolt that interconnects each recess and projection pair, such that each bolt locks each projection within the complimentary recess.

2. The mechanical joint of claim 1, wherein the first pre-cast pile is connected to the second pre-cast pile by locking and/or fastening of the first end plate with the second end plate without welding.

3. The mechanical joint of any of the preceding claims 1-2, wherein each of the first pre-cast pile and the second pre-cast pile pre-cast pile is a reinforced concrete pile.

4. The mechanical joint of any of the preceding claims 1-3, wherein the first end plate and the second end plate comprise a square base.

5. The mechanical joint of any of the preceding claims 1-4, wherein the first pre-cast pile is coupled to a side of the first end plate opposite to a side having openings of the recesses.

6. The mechanical joint of any of the preceding claims 1-5, wherein the second pre-cast pile is coupled to a side of the second end plate opposite to a side having the projections.

5 7. The mechanical joint of any of the preceding claims 1-6, wherein the bolt is threaded and the first passage of the socket is correspondingly threaded so as to complementarily receive the bolt.

10 8. A method of connecting a first pre-cast pile with a second pre-cast pile to form a continuous pre-cast pile using a mechanical joint, the method comprising the steps of:

15 embedding a first end plate to an end portion of the first pre-cast pile, the first end plate comprising four recesses extending substantially perpendicular to the plane of the first end plate; and a collar plate comprising four sockets extending substantially parallel to the plane of the first end plate, wherein each socket defines a corresponding first passage that intersects and passes through a corresponding one of the four recesses, and each socket comprises a first section having socket surrounding walls extending from an opening in the collar plate to where the socket intersects with the recess and a second section that passes through the recess via two recess openings on opposite sides;

20 embedding a second end plate to an end portion of the second pre-cast pile, the second end plate comprising four projections extending substantially perpendicular to the plane of the second end plate, each projection comprising a second passage therethrough which extends substantially parallel to the plane of the second end plate,

inserting each of the projections into the respective recesses;

25 aligning the first passage and the second passage; and

connecting the first pre-cast pile with the second pre-cast pile to form the continuous pre-cast pile by inserting a bolt through each pair of the first passages and the second passages.