

A COUPLING SYSTEM FOR CONNECTING FLOATING MODULES FOR NEARSHORE DEVELOPMENT

Field of the Invention

5 This invention relates to a system for coupling a first floating structure to a second floating structure. More particularly, this invention relates to a system that uses a combination of arms; and fastener and pivot hinge devices to couple a first floating structure to a second floating structure.

Summary of the Prior Art

10 Due to rising sea levels caused by climate change, there is a strong need for the use of floating cities. Such floating cities are beneficial as they would be able to withstand floods and while simultaneously addressing land scarce issues. Floating cities typically comprise of modular floating platforms that are connected together using coupling arms to prevent the platforms from colliding and damaging each other and/or to prevent the platforms from disconnecting and floating away.

15 Those skilled in the art have proposed that methods used to couple existing drilling platforms together may also be used to couple such modular floating platforms together.

Existing drilling platforms are typically held in place using mooring systems that utilize combinations of wire ropes, polyester ropes or chains during the drilling
20 and/ or oil production processes. Two floating structures are usually coupled together to restrict the relative movement between these two structures to facilitate the transfer of equipment or personnel. The nylon hawser rope system allows the relative distance between the two structures to be maintained within predetermined limits. However, the nylon hawser rope system does not prevent both floating structures
25 from colliding and only prevents the floating structures from drifting too far apart.

To address this, those skilled in the art have proposed solutions that involve the use of systems for coupling two floating structures together using a plurality of rigid arms with joints provided at the ends of the arms such that the arms will be able
30 to significantly pivot relative to each other to accommodate the movement of the floating structures as these structures heave, surge, sway and yaw under the wave motion. The rigid coupling arms thus ensure that the two floating structures maintain

a minimum stand-off distance and do not collide with one another even in rough sea conditions.

As most of the coupling systems disclosed by those skilled in the art are for use with floating structures that are deployed in rough sea conditions, the main objectives of these coupling systems are to ensure that the two structures do not drift too far apart from each other, and do not collide with each other under such conditions. In operation, the floating structures may be moving violently relative to each other as the coupling systems work hard to achieve the objectives mentioned above.

For those reasons, those skilled in the art are constantly striving to come up with ways to design a coupling system that is able to couple two floating structures together while ensuring that any relative movements between the two structure are absorbed by the coupling system as much as possible so that any movements will not be felt by those on board either floating structure.

Summary of Invention

The above and other problems are solved and an advance in the art is made by systems and methods provided by embodiments in accordance with the invention.

A first advantage of embodiments of a system and method in accordance with the invention is the resilient members in the fastener and pivot hinge device of the coupling system are able to absorb any motions and/or movements between the two floating structures thereby ensuring that the movement felt by occupants on either structure are minimized.

A second advantage of embodiments of a system and method in accordance with the invention is that the system is able to handle both lateral and rotational movements.

A third advantage of embodiments of a system and method in accordance with the invention is that the system is scalable and that any number of arms and/or fastener and pivot hinge devices may be used to increase the distance between the two floating structures as required.

The above advantages are provided by embodiments of a device or method in accordance with the invention operating in the following manner.

According to a first aspect of the invention, a system for coupling a first floating structure to a second floating structure is disclosed, the system comprising: a first arm having a first fastener and pivot hinge device provided at a first end of the first arm for attaching the first arm to the first floating structure and a coupling device
5 provided at a second end of the first arm for attaching the first arm to the second floating structure, whereby the fastener and pivot hinge device comprises: a clevis; a fastener plate configured to be secured to the clevis such that the clevis is movable along planes normal to a longitudinal axis of a fastener of the fastener plate and movable along the longitudinal axis of the fastener; and at least two resilient members
10 provided between the clevis and the fastener plate.

In accordance with the first aspect of the invention, the system further comprises: a piston device, coupled to coupling device, for attaching the first arm to the second floating structure, the piston device being configured to move the first arm along a longitudinal axis of the piston device. In embodiments of the invention, the
15 piston device could comprise a hydro-pneumatic or pneumatic type piston.

In accordance with the first aspect of the invention, the coupling device comprises a second fastener and pivot hinge device.

In accordance with the first aspect of the invention, the system further comprises: a second arm having a first end coupled to the coupling device and a
20 second end for attaching the second arm to the second floating structure.

In accordance with the first aspect of the invention, the system further comprises: a piston device, coupled to the second end of the second arm, for attaching the second arm to the second floating structure, the piston device being configured to move the second arm along a longitudinal axis of the piston device.

25 In accordance with the first aspect of the invention, the system further comprises a third fastener and pivot hinge device coupled to the second end of the second arm and to the piston device, the piston device being configured to move the third fastener and pivot hinge device along a longitudinal axis of the piston device.

In accordance with the first aspect of the invention, each resilient member
30 comprises a metal spring.

In accordance with the first aspect of the invention, each of the arms comprise a hollow tubular member.

According to a second aspect of the invention, a method for coupling a first floating structure to a second floating structure is disclosed, the method comprising
5 the step of attaching a first end of a first arm to the first floating structure using a first fastener and pivot hinge device provided at the first end of the first arm; attaching a second end of the first arm to the second floating structure using a coupling device provided at the second end of the first arm; whereby the fastener and pivot hinge device comprises: a clevis; a fastener plate configured to be secured to the clevis
10 using a pin such that the clevis is movable along planes normal to a longitudinal axis of a fastener of the fastener plate by pivoting about the pin; and at least two resilient members provided between the clevis and the fastener plate.

In accordance with the second aspect of the invention, the fastener plate further comprises a pin hole that is elongated along the longitudinal axis of the
15 fastener for receiving the pin such that the clevis is further movable along the longitudinal axis of the fastener.

In accordance with the second aspect of the invention, the fastener plate further comprises at least two protrusions extending towards the clevis.

In accordance with the second aspect of the invention, the method further
20 comprises providing a piston device that is coupled to coupling device, for attaching the first arm to the second floating structure, the piston device being configured to move the first arm along a longitudinal axis of the piston device.

In accordance with the second aspect of the invention, the coupling device comprises a second fastener and pivot hinge device.

25 In accordance with the second aspect of the invention, the method further comprises providing a second arm having a first end that is coupled to the coupling device and a second end for attaching the second arm to the second floating structure.

In accordance with the second aspect of the invention, the method further comprises providing a piston device that is coupled to the second end of the second
30 arm, for attaching the second arm to the second floating structure, the piston device

being configured to move the second arm along a longitudinal axis of the piston device.

5 In accordance with the second aspect of the invention, the method further comprises providing a third fastener and pivot hinge device that is coupled to the second end of the second arm and to the piston device, the piston device being configured to move the third fastener and pivot hinge device along a longitudinal axis of the piston device.

In accordance with the second aspect of the invention, each resilient member comprises a metal spring.

10 **Brief Description of the Drawings**

The above advantages and features of a system in accordance with this invention are described in the following detailed description and are shown in the drawings:

15 Figure 1 illustrating two moored floating structures that are coupled together using the coupling system in accordance with embodiments of this invention;

Figure 2 illustrating floating structures of different shapes and configurations being coupled together in accordance with embodiments of the invention;

20 Figure 3 illustrating a perspective view of the fastener and pivot hinge device along with the expanded view of the device in accordance with embodiments of the invention;

Figure 4 illustrating a side view of the fastener and pivot hinge device in accordance with embodiments of the invention;

25 Figure 5A illustrating a side view of a fastener and pivot hinge device as provided at an end of an arm to couple two floating structures together in accordance with an embodiment of this invention;

Figure 5B illustrating a top view of a fastener and pivot hinge device as provided at an end of an arm to couple two floating structures together in accordance with an embodiment of this invention;

Figure 6 illustrating a side view of a fastener and pivot hinge device as provided at an end of an arm to couple two floating structures together in accordance with an embodiment of this invention whereby a piston device is provided at the other end of the arm;

5 Figure 7 illustrating a side view of coupling system to couple two floating structures together in accordance with an embodiment of this invention whereby the system comprises two arms coupled together using a coupling device, a fastener and pivot hinge device that is provided at an end of an arm to attach the arm to a floating structure, and another end of the other arm that is in turn attached to the other floating
10 structure;

 Figure 8 illustrating a side view of coupling system to couple two floating structures together in accordance with an embodiment of this invention whereby the system comprises two arms coupled together using a coupling device, a fastener and pivot hinge device that is provided at an end of an arm to attach the arm to a floating
15 structure, and another end of the other arm that is attached to a piston device which is in turn coupled to the other floating structure; and

 Figure 9 illustrating a side view of coupling system to couple two floating structures together in accordance with an embodiment of this invention whereby the system comprises two arms coupled together using a coupling device, a fastener and
20 pivot hinge device that is provided at an end of an arm to attach the arm to a floating structure, and another end of the other arm that is attached to a coupling device that is attached to a piston device which is in turn coupled to the other floating structure.

Detailed Description

 This invention relates to a system for coupling a first floating structure to a
25 second floating structure. More particularly, this invention relates to a system that uses a combination of arms; and fastener and pivot hinge devices to couple a first floating structure to a second floating structure. The fastener and pivot hinge device used in this system comprises a clevis and a fastener plate that is configured to be secured to the clevis in such a manner that the clevis is movable along planes normal
30 to a longitudinal axis of a fastener of the fastener plate and along the longitudinal axis of the fastener as well. Additionally, at least two resilient members are provided between the fastener plate and the clevis to absorb rotational and lateral stresses at

the fastener and pivot hinge device ensuring that both floating structures remain stable relative to one another.

Figure 1 illustrates floating structure 105 that is moored to seabed 125 using mooring lines 120 and floating structure 110 that is moored to seabed 125 using mooring lines 121. As illustrated in Figure 1, these two structures are floating on water body 115 and these two floating structures are coupled together using a coupling system that comprises fastener and pivot hinge device 102 and arm 103.

Figure 2 illustrates floating structures of different shapes and configurations being coupled together using a plurality of coupling systems 103 in accordance with embodiments of the invention. In particular, the floating structures may comprise, but are not limited to, floating structures in the shape of hexagonal modules 202, circular modules 204, triangular modules 206, and square modules 202 that are all coupled to their respective modules using a plurality of coupling systems 103. Although not shown, one skilled in the art will recognize that coupling systems 103 may be used to couple modules of different shapes and sizes together without departing from this invention, e.g. module 202 may be coupled to module 206 and etc.

Figure 3 illustrates a perspective view of the fastener and pivot hinge device whereby device 102 is illustrated as the assembled device while the other parts are shown as an exploded view of device 102 in accordance with embodiments of the invention. In particular, fastener and pivot hinge device 102 comprises fastener plate 302, fastener 303, clevis 304, pin 308 and resilient members 306. Fastener 303 is secured to clevis 304 using pin 308 which passes through both pin-holes 307 and 305, thereby securing fastener 303 to clevis 304. Resilient members 306 are then provided between clevis 304 and fastener plate 302 to absorb movements that occur at device 102. One skilled in the art will recognize that although four resilient members 306 are shown in Figure 3, any number of resilient members may be used without departing from the invention, as long as at least two resilient members are utilized to spread the twisting forces evenly across device 102. In embodiments of the invention, resilient member 306 may comprise, but are not limited to, metal springs or elastic springs made from various materials having high stiffness values.

When secured as such, clevis 304 is movable along planes that are normal to longitudinal axis 350 of fastener 303. In other words, clevis 304 is able to rotate/pivot around pin 308, along a plane that is normal to longitudinal axis 350 of fastener 303, while being restrained by resilient members 306.

In other embodiments of the invention, pin-hole 307 may be elongated (not shown) along the longitudinal axis 350 of fastener 303, thereby allowing clevis 304 to move along the longitudinal axis 350 of fastener 303. In this embodiment, not only is clevis 304 movable along planes that are normal to longitudinal axis 350, clevis
5 304 is also movable along the longitudinal axis 350 – subject to the restraining force of resilient members 306.

Figure 4 illustrates a side view of the fastener and pivot hinge device. As illustrated, it can be seen that fastener and pivot hinge device 102 comprises fastener plate 302 which is secured in a rotatable manner to clevis 304 using pin 308.
10 Resilient members 306 are then provided on protrusions at fastener 302 and clevis 304 accordingly whereby these protrusions hold resilient members 306 securely in place such that any twisting or compressing forces may be transferred from device 102 to resilient members 306.

As shown in Figure 4, clevis 304 may move along planes that are normal to
15 longitudinal axis 350 of fastener 303, along axis-A. In embodiments of the invention, when pin-hole 307 is elongated (not shown) along the longitudinal axis 350 of fastener 303, clevis 304 may move along longitudinal axis 350 of fastener 303, along axis-B. It should be noted that either one or both of these motions will be restricted by the stiffness of resilient members 306, which will constantly apply opposing forces
20 to the applied twisting/compressing pressures to return device 102 to its original configuration. Protrusions 410 provided at fastener plate 302 extend towards clevis 304 thereby preventing clevis 304 from excessive movements either along axis-A or axis-B. Although only two protrusions 410 are illustrated in Figure 4, one skilled in the art will recognize that any number of such protrusions may be used without departing
25 from the invention.

Figure 5A illustrates a side view of an embodiment of the invention whereby floating structures 501 and 502 are coupled together using a coupling system in accordance with an embodiment of the invention. The coupling system used in this embodiment comprises arm 510 that uses fastener and pivot hinge device 511 to
30 attach an end of arm 510 to floating structure 501 and uses coupling device 512 to attach another end of arm 510 to floating structure 502. One skilled in the art will recognize that either the fastener or the clevis may be attached to floating structure 501 without departing from the invention. Through the use of fastener and pivot hinge device 511, floating structure 501 is able to move along the direction of axis-A, and

in further embodiments of the invention, floating structure 501 is also able to move along the direction of axis-B. One skilled in the art will recognize that coupling device 512 may comprise of any type of attachment that allows arm 510 to be attached to floating structure 502. One skilled in the art will also recognize that as mentioned
5 above, the clevis of device 511 is movable along planes normal to a longitudinal axis of the fastener of the fastener plate of device 511. As such, subject to the manner and alignment in which fastener and pivot hinge device 511 is attached to floating structure 501 and to arm 510, arm 510 may pivot along other axes such as axis A' or A'' as long as the arrangement ensures that the clevis of device 511 is movable along
10 planes normal to a longitudinal axis of the fastener of the fastener plate of device 511. The exact alignment of device 511 at floating platform 501 is left as a design choice to one skilled in the art.

In embodiments of the invention, coupling device 512 may also comprise a fastener and pivot hinge device whereby either the fastener or the clevis may be
15 attached to floating structure 502 without departing from the invention. In this embodiment, through the use of the fastener and pivot hinge device to attach arm 510 to floating structure 502, floating structure 502 is now able to move along the direction of axis-A, and in further embodiments of the invention, floating structure 502 is also able to move along the direction of axis-B. This means that floating structure
20 501 is now able to move independently of floating structure 502 and once the forces applied to either floating structures 501 and 502 have stopped, the resilient members in each fastener and pivot hinge device would return the floating structures back to their original configurations.

Figure 5B illustrates a top view of the embodiment of the invention illustrated
25 in Figure 5A whereby floating structures 501 and 502 are coupled together using a coupling system in accordance with an embodiment of the invention. Figure 5B shows that subject to the manner and alignment in which fastener and pivot hinge device 511 is attached to floating structure 501 and to arm 510, arm 510 may pivot along other axes such as axis A' or A'' as long as the arrangement ensures that the
30 clevis of device 511 is movable along planes normal to a longitudinal axis of the fastener of the fastener plate of device 511.

Figure 6 illustrates a side view of another embodiment of the invention whereby floating structures 501 and 502 are coupled together using a coupling system in accordance with an embodiment of the invention. Similar to the

embodiment illustrated in Figure 5, arm 510 uses fastener and pivot hinge device 511 to attach an end of arm 510 to floating structure 501. However, instead of attaching coupling device 512 directly to floating structure 502, coupling device 512 is now attached to piston device 602 which is in turn attached to floating structure 502.

5 Piston device 602 may comprise, but is not limited to, a hydraulic piston powered by pressurized hydraulic fluid, such as oil. Typically, the hydraulic piston will have a barrel, in which a piston connected to a rod moves in and out from. When the distance between the two floating structures are to be increased, the rod will extend out of the hydraulic piston thereby moving the floating structures 501 and 502 apart
10 from one another. When the floating structures 501 and 502 are to be brought closer, the rod retracts back into the hydraulic piston drawing the two structures closer together. In embodiments of this invention, coupling device 512 may also comprise a fastener and pivot hinge device whereby either the fastener or the clevis may be attached to piston device 602 without departing from the invention. In further
15 embodiments of the invention, the piston device could comprise a hydro-pneumatic or pneumatic type piston.

Figure 7 illustrates a side view of yet another embodiment of the invention whereby floating structures 501 and 502 are coupled together using a coupling system in accordance with an embodiment of the invention. Similar to the
20 embodiment illustrated in Figure 5, arm 510 uses fastener and pivot hinge device 511 to attach an end of arm 510 to floating structure 501. However, instead of attaching coupling device 512 directly to floating structure 502, coupling device 512 is now attached to an end of arm 710 which in turn has another end that is attached to floating structure 502. By doing so, the distance between floating structure 501 and
25 502 may be easily adjusted, and increased or decreased as required. In embodiments of this invention, coupling device 512 may also comprise a fastener and pivot hinge device whereby either the fastener or the clevis may be attached to arm 710 without departing from the invention.

Figure 8 illustrates a side view of still yet another embodiment of the invention whereby floating structures 501 and 502 are coupled together using a coupling
30 system in accordance with an embodiment of the invention. Similar to the embodiment illustrated in Figure 7, arm 510 uses fastener and pivot hinge device 511 to attach an end of arm 510 to floating structure 501. Coupling device 512 is provided at an end of arm 710 which in turn has another end attached to piston device 802

which is in turn attached to floating structure 502. The operation of piston device 802 is similar as that of piston device 602.

Figure 9 illustrates a side view of yet another embodiment of the invention whereby floating structures 501 and 502 are coupled together using a coupling system in accordance with an embodiment of the invention. Similar to the
5 embodiment illustrated in Figure 8, arm 510 uses fastener and pivot hinge device 511 to attach an end of arm 510 to floating structure 501. Coupling device 512 is shown to be attached to an end of arm 710 which in turn has another end attached to coupling device 911. As for the other end of arm 710, this end is now attached to
10 piston device 802 which is in turn attached to floating structure 502. The operation of piston device 802 is similar as that of piston device 602. In embodiments of this invention, coupling devices 512 and/or 911 may comprise fastener and pivot hinge devices.

The above is a description of embodiments of a system and method in
15 accordance with the present invention as set forth in the following claims. It is envisioned that others may and will design alternatives that fall within the scope of the following claims.

CLAIMS

1. A system for coupling a first floating structure to a second floating structure, the system comprising:
 - 5 a first arm having a first fastener and pivot hinge device provided at a first end of the first arm for attaching the first arm to the first floating structure and a coupling device provided at a second end of the first arm for attaching the first arm to the second floating structure,
whereby the fastener and pivot hinge device comprises:
 - 10 a clevis;
a fastener plate configured to be secured to the clevis using a pin such that the clevis is movable along planes normal to a longitudinal axis of a fastener of the fastener plate by pivoting about the pin; and
at least two resilient members provided between the clevis and the
15 fastener plate.
2. The system according to claim 1 whereby the fastener plate further comprises a pin hole that is elongated along the longitudinal axis of the fastener for receiving the pin such that the clevis is further movable along the longitudinal axis of the
20 fastener.
3. The system according to claim 1 whereby the fastener plate further comprises at least two protrusions extending towards the clevis.
- 25 4. The system according to claim 1 further comprising:
a piston device, coupled to coupling device, for attaching the first arm to the second floating structure, the piston device being configured to move the first arm along a longitudinal axis of the piston device.
- 30 5. The system according to claims 1 or 2 wherein, the coupling device comprises a second fastener and pivot hinge device.
6. The system according to claim 1 further comprising:
a second arm having a first end coupled to the coupling device and a
35 second end for attaching the second arm to the second floating structure.
7. The system according to claim 6 further comprising:

a piston device, coupled to the second end of the second arm, for attaching the second arm to the second floating structure, the piston device being configured to move the second arm along a longitudinal axis of the piston device.

5 8. The system according to claim 7 further comprising:

a third fastener and pivot hinge device coupled to the second end of the second arm and to the piston device, the piston device being configured to move the third fastener and pivot hinge device along a longitudinal axis of the piston device.

10

9. The system according to claim 1 wherein each resilient member comprises a metal spring.

15

10. The system according to any one of claims 1 – 9 wherein each of the arms comprise a hollow tubular member.

11. A method for coupling a first floating structure to a second floating structure, the method comprising:

20

attaching a first end of a first arm to the first floating structure using a first fastener and pivot hinge device provided at the first end of the first arm;

attaching a second end of the first arm to the second floating structure using a coupling device provided at the second end of the first arm;

whereby the fastener and pivot hinge device comprises:

25

a clevis;

a fastener plate configured to be secured to the clevis using a pin such that the clevis is movable along planes normal to a longitudinal axis of a fastener of the fastener plate by pivoting about the pin; and

at least two resilient members provided between the clevis and the fastener plate.

30

12. The method according to claim 11 whereby the fastener plate further comprises a pin hole that is elongated along the longitudinal axis of the fastener for receiving the pin such that the clevis is further movable along the longitudinal axis of the fastener.

35

13. The method according to claim 11 whereby the fastener plate further comprises at least two protrusions extending towards the clevis.

14. The method according to claim 11 further comprising:
providing a piston device that is coupled to coupling device, for attaching
the first arm to the second floating structure, the piston device being configured
5 to move the first arm along a longitudinal axis of the piston device.
15. The method according to claims 11 or 12 wherein, the coupling device comprises
a second fastener and pivot hinge device.
- 10 16. The method according to claim 11 further comprising:
providing a second arm having a first end that is coupled to the coupling
device and a second end for attaching the second arm to the second floating
structure.
- 15 17. The method according to claim 16 further comprising:
providing a piston device that is coupled to the second end of the second
arm, for attaching the second arm to the second floating structure, the piston
device being configured to move the second arm along a longitudinal axis of the
piston device.
- 20 18. The method according to claim 17 further comprising:
providing a third fastener and pivot hinge device that is coupled to the
second end of the second arm and to the piston device, the piston device being
configured to move the third fastener and pivot hinge device along a longitudinal
25 axis of the piston device.
19. The method according to claim 11 wherein each resilient member comprises a
metal spring.