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A. CASAGRANDE ET AL

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STABILIZATION OF SUBMARINE RAFT FOUNDATIONS

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2 Sheets-Sheet 2

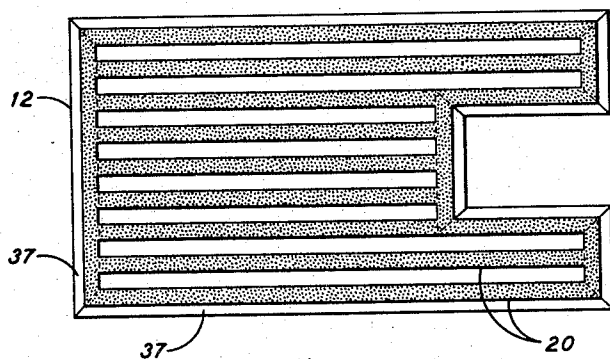


FIG. 4

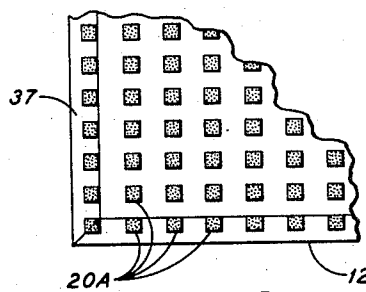


FIG. 5

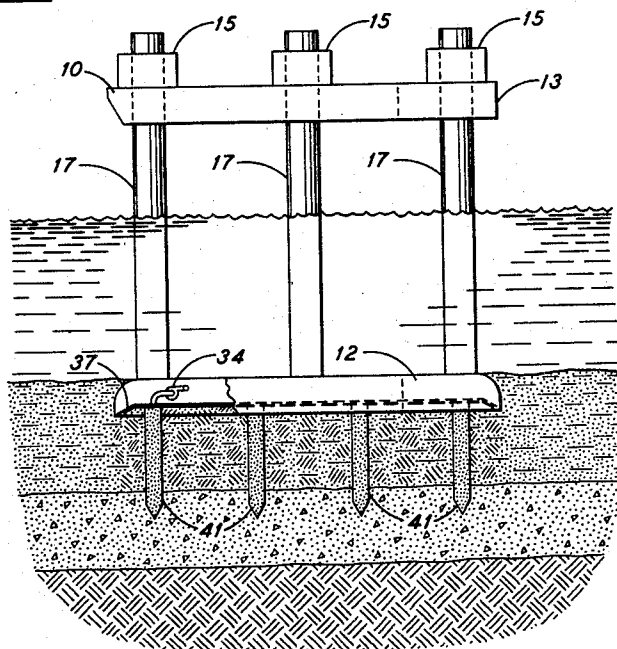


FIG. 7

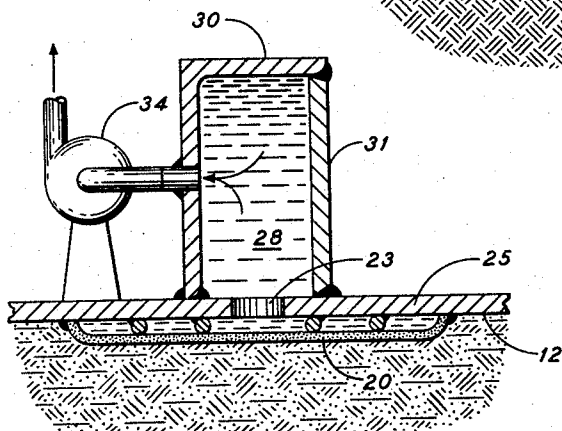


FIG. 6

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STABILIZATION OF SUBMARINE RAFT FOUNDATIONS

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2 Claims. (Cl. 61—46.5)

The present invention relates to the stabilization of submarine raft foundations for the support of working platforms above an underwater work site, more particularly, to a method of, and an apparatus for, stabilization of submarine raft foundations by the application thereto of a surcharge of at least a part of the hydrostatic head of water above the submerged foundation raft to increase the load on the raft foundation, and has for an object increasing the stabilization of submarine raft foundations in the underwater bottom by decreasing the pressure within the submarine raft foundation until a vacuum relative to the hydrostatic head is established throughout a substantial area of the bottom of said raft by evacuation of water from the soil beneath the bottom through ports covered by porous filter members.

Portable marine structures, suitable for supporting a working platform above an underwater work location, such as a drilling site, are often subjected to large lateral forces due to waves and ocean currents, so that the stabilization against lateral movement and overturning is a serious problem. While the size of a submarine raft-type foundation may be increased to an area considerably greater than that required to support the working platform above water, frequently such increased area is not sufficient to withstand the lateral forces encountered during adverse weather or sea conditions. Accordingly, it has long been desired to be able to increase the holding power, or adhesion, of the submarine raft in its originally set position. While it has also been proposed to increase the weight on bottom by addition of ballast or other weighing materials to withstand lateral forces, such added weight must be removed before a foundation raft can be raised for moving to another location. Since, in general, it is desirable to be able to move the foundation raft and the working platform as rapidly as possible from one work site to another, this expedient of adding weight has not been widely adopted. Alternatively, it has likewise been proposed to increase the consolidation of the underwater bottom upon which the submarine raft is positioned prior to setting of the foundation. This requires underwater cutting of the bottom and filling thereof with clam shells, sand, rock, or the like. Obviously, such cutting and filling requires a large investment of time, material, and manpower to establish a base for the foundation. Additionally, in many locations, such as in the delta areas along the shore of the Gulf of Mexico, where it is desired to be able to drill at underwater locations, it has been found that the great depth of recent sediments, largely composed of unconsolidated clays, may entirely preclude excavating and filling of the site from an economic standpoint.

In accordance with the present invention, we have

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found it possible not only to increase the weight on bottom for a submergible raft foundation without addition of ballast material, but, at the same time, to consolidate, at least partially, the soil under the foundation. In accordance with the invention there is provided a method of increasing the bearing load on the underwater bottom which includes submerging the foundation raft into engagement with bottom, when equalizing the internal and external hydrostatic pressure upon the hull of the raft and then surcharging the upper surface of the raft hull with the weight of at least part of the hydrostatic head of water standing between the surface and the top of the hull by developing negative pressure along the bottom of the surface of the raft.

In a preferred form of apparatus for carrying out the method of the present invention, a **foundation raft** hull, of the pressure-resistant type, is provided with a plurality of port members formed in the bottom surface of the hull and filter plate means are arranged to cover each of said ports. Said port members are then desirably interconnected to a source of negative pressure for withdrawal of water from the area directly beneath the barge hull, thereby creating a pressure differential between the water adjacent the sides and top of the hull and that directly beneath the hull, thus increasing the effective weight of the hull on bottom. When the raft hull is resting on soft soil, the development of negative pressure along the bottom of the hull will cause the soil to consolidate under the effect of substantial seepage forces, thereby increasing the strength of the soil beneath the hull and further increasing the stability of the hull against horizontal forces.

Further objects and advantages of the present invention will become apparent from the following detailed description taken in conjunction with the accompanying drawings which form an integral part of the present specification.

In the drawings:

Figs. 1, 2 and 3 are schematic representations of a foundation raft being operated in accordance with the method of the invention, illustrating the sequential steps of floating to, and erection of, a working platform at an underwater work site.

Fig. 4 is a bottom plan view of one form of filter means for a submarine raft foundation, constructed in accordance with the present invention.

Fig. 5 is a partial bottom plan view similar to Fig. 4, illustrating an alternative arrangement for a filter means positioned on the bottom of a raft foundation.

Fig. 6 is a cross-sectional view through a portion of one of the filter plates on the bottom of the submarine raft foundation, taken in the direction of arrows 6—6 in Fig. 3.

Fig. 7 is a schematic representation of an alternative arrangement for increasing the stability of a raft foundation on bottom, which includes the provision of elongated well means interconnected with the filter ports, for withdrawal of water from a greater depth in the bottom beneath the hull.

Referring now to the drawings and, in particular, to Figs. 1 to 3 inclusive, there is illustrated a series of sequential operations for performing the method of the present invention to increase the bearing load of a submarine raft foundation on an underwater bottom. In the arrangement illustrated in Figs. 1 to 3 inclusive, the work structure assembly, identified generally as 10, is adapted

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to be floated to the desired location with a submergible raft foundation member 12 in direct engagement with a working platform 13. Platform 13 is desirably movable relative to foundation raft 12 by a plurality of jacking devices, indicated generally as 15, operating through spud members 17 which are shown as being connected to and extending upward from the raft foundation 12.

After arrival at the work site, foundation raft 12, as illustrated in Fig. 2, is submerged into engagement with the underwater bottom by suitable operation of the jacking members 15 to permit column 17 to pass downwardly therethrough. While the raft, or foundation hull, 12 may be submerged while buoyant through the operation jacks 15, the hull is preferably flooded to assist its lowering to bottom and, in either event, is flooded after being seated on bottom. The platform 13, of course, may be maintained buoyant until such time as the foundation raft 12 has attained a desired degree of stability and is capable of supporting the entire weight of working platform 13, including the working equipment, such as a drilling rig. The erected condition of work platform 13 relative to foundation hull 12 is particularly shown in Fig. 3.

As particularly contemplated by the present invention, the effective weight of foundation raft 12 on bottom is increased by forming in its bottom surface a plurality of filter ports with interconnecting filter plate means covering each of these openings in the bottom of the raft. In this way, there is made possible the application of a negative pressure between the bottom of hull 12 and the soil directly therebeneath. The manner in which the filter ports are formed in the bottom of foundation hull 12 is particularly illustrated in Figs. 4 and 6. As shown, particularly in Fig. 4, a plurality of elongated strips 20 formed of porous filter material and having substantial structural rigidity cover to a substantial degree the bottom area of raft 12. Strips 20 are desirably formed of porous stainless steel, but may be made of porous copper, or a porous ceramic. Strips 20 are suitably affixed, for example by welding to bottom wall 25 of hull 12, to cover the port members, such as port 23, shown in Fig. 6. As further illustrated in Fig. 6, ports 23 through bottom wall 25 are interconnected through suitable pumping conduits 28, and as shown these may be formed by an angle iron 30 and plate 31 welded together. Desirably all of the filter ports 23 and conduits 28 are interconnected to a single pump 34 capable of pumping both water and air, or combinations thereof.

In applying the increased load on the underwater bottom, the surcharge, or additional weight, of at least a portion of the hydrostatic head of water lying between the top of the barge hull and the surface of the water, is developed by pump 34 acting to withdraw water through filter plate 20, by way of interconnected ports 23 and conduit 28.

The output of pump 34 may be exhausted to the exterior of the hull. In this manner, there is developed a pressure differential between the volume of earth immediately beneath the barge hull and that of the water immediately surrounding and above the hull. For the purpose of insuring the maintenance of this pressure differential, which represents at least a portion of the hydrostatic head of water standing above the barge hull, the outer edges of the hull 12 are provided with downwardly flared portions 37, as illustrated in Figs. 1 to 3, and more fully shown in Fig. 4; said skirts permit maintenance of the desired pressure differential, even under erosion or scouring conditions of the underwater bottom, caused by storm or turbidity current conditions.

Where it is found desirable to increase the load on bottom, even more than that available by imposition of a surcharge of the weight of the hydrostatic column of water above the hull, a portion of the weight of the atmosphere may be applied by further operation of pump 34 to evacuate air from conduits 28 and filter ports 23. By this reduction in pressure along the bottom of hull

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12 to less than atmospheric pressure, there may be added to the weight on hull 12, an additional surcharge equivalent to at least a portion of the atmospheric pressure existing at the water's surface and thereby increasing, to a substantial degree, the total downward weight on the barge hull and the resistance of said foundation to lateral loads.

There is illustrated in Fig. 7 an alternative arrangement for increasing the stability of the bearing soil below barge hull 12. In that arrangement, withdrawal of interstitial water from the soil located at a considerable distance below the hull is made possible by a plurality of wells, or well points, indicated generally as 41, extending below the barge hull into bottom. Well points 41 may be independently pumped, but desirably are interconnected with the porous plates covering the bottom of the barge hull. In this present example, points 41 are also constructed of a porous filter-type material, such as porous stainless steel. The arrangement of Fig. 7 is particularly useful in those areas where little quartz, or other sand-like materials, are found in the bearing soil. These soils are frequently encountered in the very recent delta sediments found at the outlets of major rivers, such as the Mississippi.

While the arrangement of the porous filter plates desirably extends around the entire area of the bottom of the hull 12 as shown in Fig. 4, under some circumstances a plurality of individual port members may be provided in a checkerboard pattern, as illustrated in the segment of the hull shown in Fig. 5. As there shown, each of the filter ports in the bottom is covered by an individual filter plate 20A, each of which may be interconnected by conduits, such as 28, within structurally-reinforced barge hull 12, in the same manner as illustrated in Fig. 6.

The watering or dewatering of hull 12 is preferably accomplished by pumping means independent of negative pressure applying pump 34. However, pump 34 may be used for this purpose by providing suitable valves to separate the hull filling or emptying operation from the pressure developing system, including conduits 28, and filter means 20.

While various modifications and changes in the method of the present invention, as well as in the specific forms of apparatus described hereinabove, will occur to those skilled in the art, all such modifications and changes falling within the scope of the appended claims are intended to be included therein.

We claim:

1. Apparatus for increasing the stability of a submergible foundation raft against lateral or overturning forces acting on said raft when seated on the underwater bottom comprising a submergible foundation raft, a plurality of ports formed in the bottom surface of the hull of said raft, filter means permeable to water and substantially impermeable to clayey underwater bottom sediments covering each of said ports, conduit means for interconnecting said filter means and said ports, means for decreasing the pressure within said conduit means to cause water to enter said ports through said filter means while said filter means excludes the particulated solid matter of said clayey bottom sediments thereby to consolidate the said particulated solid matter of the underwater bottom adjacent said bottom surface of said hull, and a downwardly depending skirt means formed around the periphery of said foundation raft to restrict the flow of water from the overlying body of water into said filter means and said ports.

2. Apparatus in accordance with claim 1 with the addition of a plurality of well means made of a material permeable to water and substantially impermeable to clayey underwater bottom sediments submerged into the underwater bottom below said raft, said well means being in communication with said conduit means and said ports

in the bottom of said raft foundation to permit withdrawal of interstitial water from the soil lying a predetermined depth below said foundation raft.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,895,301

July 21, 1959

Arthur Casagrande et al.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 45, for "weighing" read -- weighting --; column 2, line 8, for "when" read -- then --.

Signed and sealed this 29th day of December 1959.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents