

Technical Report

Moorings - Floating Fountain



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1. Introduction

1.1 The Main Works

The 'main contract' entails the design, construction, maintenance and operation of a floating fountain and Griffin-Woodhouse Ltd are acting as 'sub-contractor' to 'the main contractor', specifically in relation to the design and supply of an appropriate mooring system for the proposed fountain.

1.2 The Site

The Bay has witnessed rapid growth in tourism over recent years and is fast becoming a principal destination for recreational activities in the region.



In order to support and further develop the Bay's growing reputation the proposed fountain will focus international attention on the area whilst enhancing its aesthetic value.

1.3 Floating Fountain

The proposed fountain is a floating pontoon design, 11.5m x 11.5 m square with a 2.55m draft. The structure will be moored offshore with the fountain centre located at XX.XX'.XX"N, XX.XX'.XX"E .

1.4 Details of Site

1.4.1 Seabed Topography

The Bay is a semi-circular basin surrounded by two low plateaus. The beach slope is relatively steep and seawards, the depth changes at a higher rate to 10, 20 and 30 meters less than 500 meters offshore. Furthermore, the changes are irregular and several sub-water depressions are present however, the northern area is characterised by smoother gradients.

1.4.2 Soil Conditions

The seabed consists of layers of well-graded and poorly graded sand and gravel with silt and coarse to fine gravel-size coral fragments. Reported allowable bearing pressures, between 1 and 2 meters below the seabed, are 0.7kg/cm².

1.4.3 Currents

The general current pattern in the open sea off the Bay shows variations according to the wind regime. Furthermore, mean sea level variations in the Red Sea induce currents of circ. 10cm/sec.

Current speeds are greatly reduced within the bay and reportedly showed speeds between 2 and 8 cm/sec.

1.4.4 Waves

The Bay is slightly affected by waves from open water following their dissipation upon leaving local straits. The presence of a submerged sill, some 35 meters below the entrance to the Bay, is expected to have dampening affect restricting mean wave heights to below 1 meter inside the bay.

1.4.5 Conclusion

“The proposed site is suitable for installation of the fountain since the energy transmitted by waves to different parts of the bay is very small.”

2. Design Parameters

Griffin-Woodhouse Ltd are contracted to provide technical advice with respect to mooring the proposed floating fountain, which we are advised requires a “fixed 4-point mooring system for the anchoring of a floating pontoon in a sheltered bay. The system is based in the following data.”

Pontoon -	Length	11.5m
	Breadth	11.5m
	Depth	3.40m
	Draft	2.55m
	Displacement	240MT approx.

Environment - Depth of Water	10m
Max Tidal Range	1.0m
Tidal Race	3-4 knots
Wind	95% calm rising occasionally to 21 knots
Sea Bed	Sand

3. Design Concept

Based on all available data, Griffin-Woodhouse Ltd advise the application of a suitable 4 point, in tension catenary mooring system designed to achieve minimal movement of the floating pontoon. The design should take into consideration ease of installation and maintenance, visibility and longevity whilst minimising environmental impact.

3.1 Key Considerations

The following criterion should be factored into the technical specification and, in conjunction with relevant design parameters, form the basis of the design -

- Seabed Topography
- Geotechnical Results
- Hydrographic & Atmospheric Data, & resultant Loading Approximations
- Likely Ground Chain Wear Characteristics
- Electrolytic Degradation
- Visibility
- Environmental Impact

4. Design Recommendations

4.1 Topside Arrangement

Due to the presence of electrical currents on the floating pontoon Griffin-Woodhouse Ltd recommend a unique topside arrangement, which prevents the transfer of electric current to sub-sea moorings, thus significantly reducing electrolytic degradation.

In essence, the transfer of electric current between chain links promotes accelerated wear. The natural movement of a catenary mooring may induce an electrical current, however these are restricted by the proposed 'in tension mooring system'. By failing to control the transfer of electric current from the pontoon to the seabed, sub-sea moorings would degrade at a significantly increased rate therefore Griffin-Woodhouse Ltd recommend the inclusion of non-conductive synthetic rope within the topside arrangement, which also leads to a suitable reduction in its weight.

In order to facilitate ease of installation and maintenance of the floating pontoon the topside assembly incorporates chain links and shackles, which may be removed/detached as required.

In order to promote visibility of the topside arrangement, which will stand clear of the water between the buoy and pontoon, high visibility fluorescent whippings will be spaced equidistantly along the synthetic rope, the mooring buoys will be coloured bright orange and all chain items will be galvanised.

4.2 Sub-Sea Moorings

In conjunction with the topside arrangement, the sub-sea moorings form the basis of the 'in tension catenary system'. This 4-point system, extending at a 135° angle from each corner of the pontoon, is intended to closely maintain the positioning of the fountain. Appropriate materials have been selected on the basis of loading approximations and reported seabed conditions and conform to Grade U3 requirements (or equivalent) throughout.

4.2.1 Anchors

In the case of permanent moorings, purpose built anchors are required as conventional ship anchors are limited to an 8:1 weight to holding power ratio. The recommended SM12 high holding power anchor is specifically designed for permanent moorings and in sandy seabed conditions has a holding ratio of 30:1. Furthermore, this design is type approved by Lloyds Register of Shipping for high holding applications however, the anchor must be correctly embedded and pre-tensioned within the system.

4.2.2 Ground Chains

Ground chains, extending from the anchor to the riser chains, are designed with longevity and catenary stability in mind. The ground chains comprise two components, 44mm dia & 76mm dia Grade U3 stud link chain.

The 76mm dia chains, located at the riser end of the ground chains, are incorporated on the basis of their weight and longevity. The 76mm chain, whilst being grossly over engineered for the intended application in terms of loading capability, performs two other essential roles -

- Its weight acts as fundamental part of the catenary system, holding it in place under normal/benign sea conditions, and controlling buoy excursion under abnormal/ exceptional circumstances
- The seabed consists of sand and coral gravel, which is highly abrasive, thus flexing of the catenary will promote excessive wear. Therefore a larger diameter of chain is required in the 'thrash' area to achieve longevity through allowable wear of up to 1mm per annum
- Furthermore, it is also noted that Grade U3 material, a hardened and tempered carbon manganese steel, has good anti-abrasive characteristics

4.2.3 Riser Chains

The riser chains are selected on the basis of loading approximations and incorporate a swivel at the buoy end to reduce any torque, which may be brought about through natural movement of the moorings.

4.2.4 Mooring Buoys

Mooring buoys are selected on the basis of suitability to their intended application with reserve buoyancy appropriate to the mass of sub-sea moorings. Furthermore, they are constructed from impact resistant polyurethane elastomer, polyethylene foam fill and galvanised central steelwork.

4.3 Loading Approximations

Based on available hydrographic, atmospheric and environmental data; and in view of the pontoon's deep draft of 2550mm and minimal freeboard of 850mm, which provide for a very stable floating structure; we estimate that the maximum load likely to be applied to each mooring line under normal conditions is 2MT. Furthermore, we anticipate under storm conditions a maximum loading on each line of circ. 10MT.

Theoretically, the recommended mooring system's breaking load in new condition is that of the weakest component, the mooring buoy with a rated MBL of 60MT. Our design allows for a SWL up to 50% of rated MBL, which equates to 30MT.

Based on loading estimates and rated SWL/MBL calculations, it is unlikely that the mooring system will ever reach its working capabilities however, additional margin is built in to the design to allow for exceptional conditions.

4.4 Environmental Considerations

With exception of material evaluation covered in section 7. Environmental Impact Assessment, the recommended mooring system will have both visual and physical environmental impact.

Visually, the topside arrangement (including semi-submerged mooring buoys) will be visible from a distance and are specifically designed for high visibility within their immediate vicinity. This is an accepted and necessary consequence of the main works.

Ground chain moorings will sit directly on the seabed and will have a direct impact upon their immediate environment. 44mm chain weighs 41kg/m whilst 76mm chains weigh 126kg/m. The total 3T weight will be evenly distributed along the length of the mooring and, as the catenary is in tension, riser chains will not collect under the mooring buoys. Any physical environmental impact therefore should be limited however the 'thrash' section may cause more extensive impact, dependant upon prevailing sea conditions.

Anchors will have a comparatively larger short-term physical impact on the seabed due to their necessary embedment. This equipment can be set within a very short distance however, accurate and efficient installation of the moorings is essential to effectively restrict impact on the seabed.

One might also consider the likely effect of sub-sea turbulence created by vessels during installation of the moorings however, a minimum water depth of 10 meters in the proposed site may mitigate this factor.

5. Mooring Configuration

5.1 Overview

Attached drawings GW0800/1 Fountain Site Location and GW0800/2 Mooring Layout illustrate the position and configuration of the recommended moorings in relation to the proposed site. The floating pontoon will be orientated perpendicularly to the north-western shoreline of the Bay with 4 mooring lines extending at a 135° angle from each corner; two in an onshore direction, two in an offshore direction.

5.2 Topside Arrangement

Each mooring line will incorporate a Topside Stretcher, illustrated in attached drawing GW0800/3, connected at one end to a pad eye located on the floating platform by means of an 85T shackle, and at the other to a cylindrical mooring buoy, located approximately 40' from each corner of the pontoon, by a 35T shackle.

5.3 Sub-Sea Moorings

Each mooring line will incorporate a Sub-sea Leg, comprising an anchor and ground chains, extending along the seabed to a riser chain connected to the underside of the mooring buoy. Two configurations of mooring leg, shore and offshore, are illustrated in attached drawings GW0800/4 and GW0800/5, which take into consideration varying water depths between the buoy and anchor.

5.4 Installation

Moorings are designed to allow sub-sea equipment to be installed prior to their attachment, via the topside stretcher, to the pontoon. Additionally, this detachable design allows for easy maintenance of the entire system. Each of 4 anchor positions are indicated on Mooring Layout drawing GW0800/2 however, these are a guide as to the starting position for installation of sub-sea legs and may require adjustment accordingly.

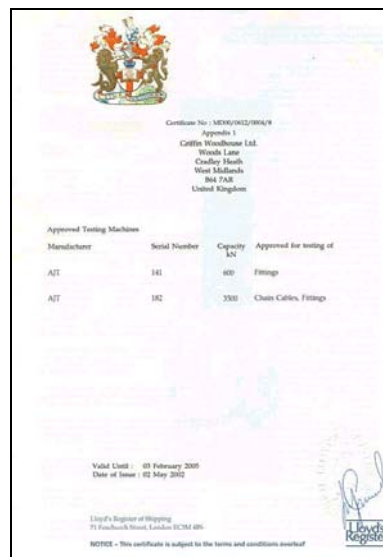
5.5 Maintenance

It is recommended that the moorings be visually examined after 12 & 24 months to establish any unusual wear characteristics and, if considered satisfactory, thereafter as deemed necessary or following exceptional storm conditions or collision events.

6. Bill of Materials

The following equipment, comprising the complete recommended mooring system (excluding spares), will be supplied by Griffin-Woodhouse Limited and certified under an LRQA approved ISO9001:2000 QA System in its Lloyds certified Proving Establishment -

Item	Qty	Details
01	4	85T SWL Safety Bow Shackle to Fed. Spec. RR-C-271C Galv. to BS1461
02	16	35T SWL Safety 'D' Shackle to Fed. Spec. RR-C-271C Galv. to BS1461
03	4	20' x 42mm dia. U2 Grade Open Link Chain Galv. to BS1461
04	4	25' x 64mm dia. 8 Strand Polysteel Rope c/w Galv. Thimble each end and 5 x 150mm equally spaced high visibility whippings
05	4	6' x 42mm dia U2 Grade Open Link Chain Galv. to BS1461
06	4	1500Kg Nett Buoyancy Cylindrical Mooring Buoy
07	4	35T SWL Safety Bow Shackle to Fed. Spec. RR-C-271C Galv. to BS1461
08	2	27.5m x 44mm dia. U3 Grade GWEC Integral Stud Link Anchor Chain c/w Enlarged & End Link each end plus Swivel at one end only
09	2	55m x 44mm dia. U3 Grade GWEC Integral Stud Link Anchor Chain c/w Enlarged & End Link each end plus Swivel at one end only
10	4	55m x 44mm dia. U3 Grade GWEC Integral Stud Link Anchor Chain c/w Enlarged & End Link each end
11	8	57mm dia. U3 Grade TH Pattern Forelock End Shackle
12	4	1500 Kg SM12 HHP Mooring Anchor
13	4	20' x 76mm dia. U3 Stud Link Anchor Chain (used condition)
14	4	56mm dia. U3 Grade Anchor Shackle c/w Nut & Forelock



7. Environmental Impact Assessment

7.1 Materials

Physical and visual impact of the proposed moorings has been considered in section 4.4 Environmental Considerations. The following section details material composition of the recommended equipment, their likely affect on the Bay environment (and beyond) and ultimate disposal of materials.

7.1.1 Chains & Shackles

All chain and shackle items are manufactured from either galvanised or self colour carbon steel and, with exception of their natural oxidisation, are anticipated to have little or no affect on the proposed environment. Galvanising constitutes a layer of 98% pure zinc, 80 microns thick, on the outside of the steel which has low toxicity and will have little or no environmental impact. Similarly, other items will be coated with a black bituminous material for aesthetic purposes, which naturally dissolves in saline conditions within a relatively short space of time. It has low toxicity and will have little or no environmental impact.

7.1.2 Mooring Buoy

The recommended buoys are constructed from galvanised carbon steel central framework, cured polyurethane polymer skin and polyethylene foam fill. The carbon steelwork will have little or no environmental affect, as described in relation to chain and shackles above. The polyurethane material used in the skin of the buoy is inert, non-toxic, UV stabalised and will not react with seawater. Consequently, the buoys are expected to have little or no affect on the proposed environment.

7.1.3 Polysteel Rope

The recommended polysteel rope assembly is constructed from polypropylene & polyethelene materials c/w high visibility polythene whippings and galvanised carbon steel thimbles. The galvanised steel will have little or no environmental impact, as described in relation to chain and shackles above. Furthermore, both the polypropylene, polyethelene and polythene material used in the ropes are inert, non-toxic, UV stabalised and will not react with seawater. Consequently, the ropes are expected to have little or no affect on the proposed environment.

7.2 Disposal

All material detailed above may be safely recycled, by appropriate authorities, following use which will have the added benefit of conserving the planet's natural resources and promoting environmental stability.

8. Mooring Installation

8.1 Plant & Equipment

The following plant and equipment will be required during installation -

- 20T Bollard Pull Tug c/w Load Monitoring Equipment
- Flat Top Barge or Flat Back Offshore Vessel c/w min. 10T Crane/Winch

Equipment should be manned by appropriate personnel and furthermore, a suitably qualified and/or experienced supervisor should be present throughout installation to direct and oversee all necessary activities. Griffin-Woodhouse Ltd will supervise installation if required.

8.2 Mooring Installation Procedure

As described in section 5.4 Installation, Mooring Layout drawing GW0800/2 shows approximate coordinates for the positioning of each anchor as a starting point for installation. Physical installation should strictly observe the following programme -

8.2.1 Anchor Embedment & Installation of Sub-Sea Catenary

Each anchor should be lowered into place by barge at the relevant coordinates on the seabed, through use of relevant sub-sea mooring legs, following which each ground/riser chain assembly should be paid out to their full length in the direction of the pontoon.

The chains should then be attached to the tug/work boat and a load, not exceeding 10T, should be progressively applied to the sub-sea assembly in order to embed the anchor. The chains should then be released, along the appropriate plain between anchor and pontoon, in order that they self-locate. The mooring buoy should then be connected to the 35T shackle and lowered into the water. The positioning of the buoys when released should be approximately 28m from the pontoon for Shore Legs 1 & 2, and 47m from the pontoon for Offshore Legs 3 & 4.

8.2.2 Connection of Topside Mooring Stretcher

When the pontoon is correctly located, topside mooring stretchers can be attached between the buoy and pontoon, with adjustment to the 20' length of Grade U2 open link chain to achieve a buoy position 50' from the pontoon.