Life Extension Solutions for Offshore Structures and Pipelines

The experts in subsea grouting for the offshore energy construction industry
INTRODUCTION

Our seas and oceans are filled with offshore constructions whose operational lifetime expectancies are continually being extended through careful and well planned maintenance.

For nearly half a century FoundOcean has worked with the offshore construction sector to develop and deliver the technology to provide cost-effective repair and strengthening solutions to ageing or damaged offshore assets.

The requirement for such repair work may arise due to a number of reasons including fatigue, collision damage or localised scour. On the other hand strengthening projects are often associated with the upgrading of assets to comply with tighter regulations or planned modifications, as well as improved yield forecasts from a field or more attractive economic conditions, either of which may support an extension to the original anticipated operational lifetime of the asset.

MARINE GROWTH PREVENTION AND CONTROL

Until now, controlling marine growth has been an expensive and time-consuming process. This marine growth control (MGC) solution offers energy operators one of the most cost-effective solutions for extending the valuable fatigue life on both existing and new structures. Over 26,000 devices have been installed on 400 new and existing offshore structures throughout Asia, Europe & the Americas since 1990.

As well as increasing the static weight of an offshore foundation, marine growth build-up also increases the hydrodynamic loading a structure experiences due to its environment.

The MGC product line combines technology and nature to continually guard against marine colonization. Every minute of every day it washes away the microbial slime which in turn prevents the marine growth from affixing to subsea and splash zone members.

MGC can eliminate the need for hazardous and costly periodic cleaning by keeping structural members marine growth free, thereby promoting rapid and robust asset inspection.
JACKET MEMBER STRENGTHENING

Grouted member strengthening is the process of filling a platform jacket member with a grout formulation to reinforce it.

Filling a member with grout has the advantage of not increasing the diameter, and thereby the hydrodynamic loading, of the member. It provides improvement in the overall member strength and stability including axial compressive strength and increased tubular joint strength.

Once completed, the strengthened members can extend the structure’s service life beyond its original design life. This is achieved by providing improved stiffness and strength to the structure which could be needed to meet tighter operating conditions, or for the addition of new top-side modules.

Member strengthening can be performed both above and below sea level on vertical, horizontal and diagonal members. The preparation procedure consists of drilling a small hole in the bottom of the member to be strengthened, into which a special inlet hose connector is fitted. The top of the member is fitted with an outlet connector through which grout returns will flow when the member is full.

The grout used for structural rehabilitation work can be chosen from a variety of different formulations depending on the project-specific circumstances. The grout may consist of a blend of cement, aggregates, super plasticiser and anti-washout additives.

PROJECT FOCUS: VALHALL PLATFORM

Region North Sea
Depth 74m
Cement type Mapefill N-LH Mortar
Year 2010

Offshore structures are designed to withstand conditions which meet a defined Ultimate Limit State (ULS). Standards change and structures may need upgrading to meet more stringent regulations and ULS requirements.

This was the case for the Valhall Quarters Platform (QP) jacket which was installed in 1979. In 2010, the jacket underwent planned upgrade operations to increase its ULS and resistance to the ‘100 year wave’, the statistically predicted highest wave at that location. To achieve this, the four legs were injected with grout from sea level up to the cellar deck.

FoundOcean undertook an onshore trial at its Offshore Service Base in Livingston to demonstrate its offshore procedure for mixing and pumping grout in large volumes against gravity, as the platform legs were 44.25m tall and each required 20m$^3$ of grout.

Offshore, the platform was prepared for grouting by the client. This involved installing the hose handling equipment, inspecting the legs, and fitting the connectors. FoundOcean worked from a construction vessel to inject an aggregate-based grout into the platform legs. This type of grout was used to reduce the heat of hydration*. Sample cubes were taken to measure grout strength at 24 hours, 3 days and 28 days.

*Heat of hydration is the heat generated due to the chemical reaction which takes place when water is added to the cement. The heat causes the grout to initially expand, and then contract as it cools, which could lead to the grout cracking. Excessive heat generation is caused when material with a high cement content is used in very large volumes.

Grouted jacket member for increased strength.
Grouted member clamp for increased jacket strength.

GROUTED CLAMPS

STRUCTURAL CLAMPS
The main reasons why offshore structures require repairs using grouted clamps are damage caused by ship impact, or by objects dropped overboard — typically during installation or heavy construction activities. Clamps may also be required to extend the fatigue life of node joints, or structural members.

Grouted clamps are fabricated in two or more segments which are placed around the member. These segments are then clamped together, and after pre-tensioning the bolts, grout is injected into the annulus between the clamp and the existing tubular.

Some of the key advantages of grouted repair techniques include:

- Normal clamp fabrication imperfections are easily accommodated by the grout
- Existing member survey tolerances are accommodated by the grout
- Full, and often additional, strength of damaged section can be easily restored
- Structural repair clamps can be fitted at any depth on the jacket

PIPELINE CLAMPS
Another common use of grouted clamps is to repair damaged pipelines. The design is similar; with the clamp being fabricated in two or more segments fastened together using bolts, prior to the annulus being filled with grout.

The repaired section of the pipeline will often be underpinned using fabric formworks to provide extra support given the additional weight of the repair clamp.

CATS, the 36” 233 mile long pipeline which, at the time, supplied 12% of the UK’s gas, had to be shut down due to damage caused by a vessel dragging its anchor along the seabed. A fast response and first time fix was vital to get supplies back up and running.

The steel repair sleeve was fabricated from two half shells secured together by bolted joints. The void between the clamp and the pipeline was filled with grout to fully restore the integrity of the pipeline.

The bolted flanges and the ends of the clamp were fitted with seals to retain the grout. The clamp had primary, secondary and tertiary grout inlets located on its underside through which grout could be pumped into the annulus. Three overflow ports, each equipped with a one metre high standpipe, were situated along the top of the clamp where grout returns were observed once it had filled the annulus.

The repair clamp was bolted into position and the grout hose was connected to the primary inlet. After grouting the annulus, three fabric formworks were then installed and grouted under the pipeline to support it. The formwork structure was manufactured with a wide base mattress to distribute the load applied to the seabed.
JACKET STABILISATION

Subsea structures may require remedial procedures if localised scour becomes such a problem that it compromises the structure’s stability.

To a certain extent, any object placed on the seabed alters the flow of the current around it. The accelerated flow created around the object has the potential to cause seabed sediment to be rapidly displaced, often known as scour. When excessive, the stability of a structure and its fatigue life can be jeopardised.

Using current and topographical data, engineers can evaluate if, when, and where scour may occur. The areas most often affected are at the extremities of a structure. In the case of certain types of structures this could be under and around any installed mudmats.

There are two common methods to rectify scour:
- Placing rocks around the structure to fill the void that the scour has created, and
- Placing fabric formworks around and under the structure to fill the void and provide additional support.

FoundOcean completed a recent project where localised seabed scour had occurred and hydrodynamic loading was causing the jacket to move about the driven piles. This movement could be felt in the steel platform and topside. The movement was expected to reduce the life of the jacket had it not been rectified.

The jacket was installed in 1990, and has six main legs which are fixed to the seabed by one pile driven through each corner leg. The jacket was secured to the driven piles by crown shims welded at the top of each corner leg. Prior to the remedial work, the structural integrity of the jacket was dependant on the welded crown shims and mudmats resting on the seabed.

After several years in the field, the jacket was no longer being supported by the mudmats due to scour at each leg. The solution was a two stage fix involving fabric formworks and leg pile annulus grouting.

Firstly, a donut-shaped fabric formwork was installed and grouted under and around each mudmat. The grout bag acted as a support for the mudmat and as a grout seal for the leg pile annulus. After the fabric formwork had cured, the remaining void was filled with grout to ensure even weight distribution.

Finally, the cement grout was injected into the leg pile annuli from EL -22m to EL-16m to strengthen the connection and eliminate jacket movement.
Region: West Africa
Depth: 1,244m
Cement type: CEM I 52.5N
Year: 2008

The Baobab field is 55 miles off the Ivory Coast. A 6” gas pipeline runs from a Floating Production Storage and Offloading (FPSO) platform at Baobab to the main gas export line in West Africa via a 1,244 m deep ravine.

An ROV survey indicated two unacceptable spans on the ocean floor: one was 0.6 m high on a 13º incline; the other was 0.3 m high on an incline of 22º. The inclines and extreme depths made the project challenging. FoundOcean used specialist grout umbilicals which were suitable for extreme depth, and also reduced the deck space requirements for the large quantity of hose required to carry out the project.

The grout umbilical was deployed to the ravine floor, followed by the deployment skid and grout bags. The grout took an hour to flow through the hoses to each of the bags. Due to the slope of seabed, concrete mattresses were also deployed to stabilise each of the fabric formworks.

Fabric formworks, also known as grout bags, are manufactured from a flexible, high strength synthetic woven fabric which is permeable to water but not to grout.

FoundOcean has an extensive grout bag track record, and offers a single-source for design, manufacture and installation of all types of high quality formworks.

The most common application for fabric formworks is to support pipeline freespans which are either encountered during the installation phase, or as a consequence of scour. FoundOcean Fabric formworks provide a cost effective solution which can be deployed by remotely operated vehicle (ROV) or diver.

FoundOcean has completed hundreds of freespan correction projects around the globe, and is the record holder for deploying the deepest fabric formwork, at a depth of 1,244m.
A 28" gas pipeline was installed by Hyundai Heavy Industries from the foot of the Platong Gas Platform to the onshore processing facility.

During the design phase, 102 potential freespans were identified along its route, but this could not be confirmed until the pipeline was installed and surveyed.

Ultimately, 26 diver-installed grout bags were required along the pipeline's route. The bags were filled in accordance with FoundOcean’s standard grouting procedures. Different sizes and types of grout bag were used according to the terrain, height, and length of the freespan.

The large base grout bags were designed with anti-scour protection skirt sleeves built into them, and required filling in stages due to their volume.

**J-TUBE BAGS**

In many instances J-tubes require supporting at the base of a jacket, wind turbine, or substation structure. J-tube bags are manufactured from a flexible, high strength synthetic woven fabric which is permeable to water but not to grout. These are cost-effective to manufacture and are simple to deploy by ROV or diver. Multiple grout bags can be used when more than one cable or pipeline need supporting.

FoundOcean offers a turnkey solution for the design and manufacture of J-tube bags, as well as the offshore grouting installation services.
**HEADQUARTERS**
Liston Exchange
Liston Court
Marlow
Buckinghamshire
SL7 1ER
United Kingdom

T: +44 1628 567 000
F: +44 1628 564 810

**GERMANY**
World Trade Center City
Airport Bremen
Hermann-Köhl-Straße 7
28199 Bremen
Germany

T: +49 421 9601 250
F: +49 421 9601 150

**MALAYSIA**
Dataran Hamodal, Block B, Level 2
No.4, Jalan Bersatu 13/4
Petaling Jaya
Kuala Lumpur
Selangor Darul Ehsan, 46200
Malaysia

T: +60 3 796 091 09
F: +60 3 796 091 08

**INDIA**
#701-702, Shri Sai Corporate Park
Goregaon Link Rd
Goregaon (West)
Mumbai 400090
India

T: +91 22 2673 2305
F: +91 22 2876 9473

**OFFSHORE SERVICE BASE - UK**
Units 3-5 Telford Square Business Park
Houstoun Industrial Estate
Livingston
West Lothian
EH54 5PQ
Scotland

T: +44 1506 440 330
F: +44 1506 440 340

**OFFSHORE SERVICE BASE - SOUTH EAST ASIA**
Batam Offshore Service Base
First Triangle Industrial Park
Tanjung Uncang
Batam Island
Indonesia

T: +60 3 796 09109
F: +60 3 796 09108

**ABOUT FOUNDOCEAN**
FoundOcean is the world’s largest dedicated offshore construction grouting company with nearly 50 years’ experience of subsea grouting for oil and gas and offshore renewables construction firms.

FoundOcean also provides life extension solutions for offshore structures which include inspection, repair, and maintenance services, marine growth control products, fabric formwork grout bags, and pipeline/cable support and protection services.

And that’s why, to offshore installation contractors, FoundOcean is the subcontractor of choice to reduce their project risks.

www.foundocean.com