SUBMAT

PIPELINE PROTECTION
AND
STABILISATION SYSTEMS
Submat's range of services is aimed at meeting the special requirements associated with the installation of offshore oil and gas pipelines / structures and their related works. Whatesoever your requirements.
1. Completed 150mm thick mattress being lifted from mould.
2. Completed 300mm thick mattress being lifted from mould.
3. 150mm thick mattresses storage area.
4. 300mm thick mattresses in storage area.

Submat Flexiform is a low cost flexible concrete mattress developed as an addition to Submat's proven range of Submat bitumen mattresses which have been successfully utilised for stabilisation / protection of marine pipework for over three decades.

Introduced at the beginning of 1991, Submat flexiform has itself established an impressive track record with various projects successfully completed on time, full details of which are available upon request.

Flexiform consists of high strength concrete segments linked together with a network of high strength polypropylene ropes to form a continuous flexible concrete barrier.

Flexiform by virtue of individually profiled concrete segments is able to provide a high degree of flexibility in two planes and as such allows for complete stabilisation / protection in most applications i.e. straightforward pipeline cover, at pipeline bends intersections on trenched / untrenched pipelines, for counter-action to seabed scouring or where there are pronounced undulations in the seabed profile.

Flexiform can be installed with a simple quick release installation beam / frame which can be provided as an integral part of the order.

Submat Flexiform is designed to provide a high quality, low cost solution for stabilisation / protection of subsea pipelines / structures and conforms to the requirements of BS8110 'The Structural Use of Concrete'.
SUBMAT FLEXIFORM TECHNICAL DATA

STANDARD THICKNESSES
150mm, 300mm, 450mm

STANDARD DENSITY
2.4 Tonnes / Cubic Metre.

Lightweight and Heavy Density options are available from 1.8 - 3.6 Tonnes / Cubic Metre.

WEIGHTS (Standard Density Approx. Weights / m² Tonnes)

<table>
<thead>
<tr>
<th>Thickness</th>
<th>In Air</th>
<th>Submerged</th>
</tr>
</thead>
<tbody>
<tr>
<td>150mm</td>
<td>0.275</td>
<td>0.152</td>
</tr>
<tr>
<td>300mm</td>
<td>0.510</td>
<td>0.279</td>
</tr>
<tr>
<td>450mm</td>
<td>0.770</td>
<td>0.430</td>
</tr>
</tbody>
</table>

STANDARD MATTRESS SIZES

Standard mould sizes are 10m x 3m, plan area. Mattresses may be manufactured in any size within mould dimensions subject to standard block sizes. Mattresses in excess of standard mould sizes may be manufactured to order.

STANDARD BLOCK SIZES (N.T.S)

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Measurement In MM</th>
</tr>
</thead>
<tbody>
<tr>
<td>150mm</td>
<td>194</td>
</tr>
<tr>
<td>300mm</td>
<td>290</td>
</tr>
<tr>
<td>450mm</td>
<td>440</td>
</tr>
</tbody>
</table>

LIFTING ARRANGEMENT

Integral lifting loops connected to quick release frame as illustrated on front of sheet.

CONCRETE DESIGN SPECIFICATION

C40 / C50 - N/mm² @ 28 days

Submat is a trading name of SLP Precast Limited, Hamilton House, Battery Green Road, Lowestoft, Suffolk NR32 1DE
First Point Assessment No.10044028

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United Kingdom contact information: Telephone No: +44 (0) 1502 548180 Fascimile No: +44 (0) 1502 548197 Email: albert.russell@slp-eng.com Website:www.slp-eng.com
1. Installation
2. Partially embedded
3. Permanent anchorage

Developed and patented by Submat in 1971, the Submat Bitumen Mattress is the original subsea pipeline stabilisation / protection mattress and is synonymous with the business of subsea pipeline stabilisation and protection.

The Submat Bitumen Mattress has been deployed on numerous projects throughout the world up to the present time, and remains today a proven cost effective solution to many applications associated with subsea pipeline technology.

The Submat Bitumen Mattress consists of a durable outer canvas envelope c/w integral lifting slings which is filled with a dense suitably re-inforced bitu-mastic filler material, all of which combine to produce a flexible mattress that is suited for dealing with all pipeline support, stabilisation and protection requirements. Submat Bitumen Mattress in its solid form retains a flexible nature even in the coldest operational conditions which enables the mattress to respond to ever changing seabed conditions which are particularly attributed to the problems of scour.

The Submat Bitumen Mattress with its relatively void-less mass and size versatility is particularly successful in applications such as pipeline crossovers whereby support piers may be constructed with a minimal number of offshore lifts.

The Submat Bitumen Mattresses is installed with a simple quick release frame which can be supplied as an integral part of each order.

See reverse for Technical Data
SUBMAT BITUMEN MATTRESS

TECHNICAL DATA

SIZE
The Submat Bitumen Mattress, can be manufactured to suit client specification generally up to 10m x 4m in plan area.

STANDARD DENSITY
Approx., 2.2 Tonnes per cubic metre, may be varied from approx. 1.5 to 3.2 Tonnes per cubic metre.

MIX SPECIFICATION (Standard Density)
48%  14mm down graded stone / crushed rock
30.5%  Sharp sand
11.5%  Limestone Filler
10%  200 penetration bitumen

ENVELOPE COVERS
The envelopes are manufactured from Duradon Extra or Regentex which are man made fibres.

Tensile strength in warp 2409N/50mm
Tensile strength in weft 2628N/50mm

Tear strength in warp 400N
Tear strength in weft 512N

LIFTING SLINGS
Each mattress is fitted with loomstate polyester lifting slings with a combined SWL of at least double the mattress weight in air.

Each sling has a break factor of 7 times the sling SWL, i.e. the combined sling break factor of a 10 Tonne mattress shall not be less than 140 Tonnes.

REINFORCEMENT MESH
Tensar Ar1 - Polypropylene
Weight 0.24kg/m³
Tensile strength Transverse 18kN/m
Tensile strength Longitudinal 14kN/m
Submat Pipeform is a flexible concrete mattress designed as a stabilisation and protection system for all marine pipework, cables and umbilicals.

Submat Pipeform has been developed as an alternative to the multi-flexible type concrete mattress, where flexibility is specified by the client or is primarily required as being parallel only to the axis of the pipeline.

Pipeform is particularly suited for pipeline stabilisation or pipeline cover.

Pipeform consists of high strength reinforced concrete logs linked together with appropriate strength polypropylene ropes which combine to offer a protective concrete blanket with a high degree of flexibility parallel to the protected pipeline.

Pipeform can be installed with a simple quick release installation beam / frame which can be provided as an integral part of the order.

Pipeform can be manufactured in various sizes / thicknesses and conforms to the requirements of BS 8110 ‘The Structural Use of Concrete’.

See reverse for Technical Data

A demonstration of a 4m x 1.5m x 4.5m mattress being lifted and draped over a 20” pipe. Approx. weight of example shown is 5.1 tonnes.
SUBMAT PIPEFORM
TECHNICAL DATA

STANDARD THICKNESSES
150mm, 300mm, 450mm, 600mm
Other thicknesses may be manufactured to order.

STANDARD DENSITY
2.4 Tonnes / Cubic Metre.
Lightweight and Heavy Density options are available from 1.8 - 3.6 Tonnes / Cubic Metre.

WEIGHTS (Standard Density)
Approx. Weights Per Metre Length of Log (Multiply x Log Length x No Logs for Mat weight)

<table>
<thead>
<tr>
<th>Thickness</th>
<th>In Air</th>
<th>Submerged</th>
</tr>
</thead>
<tbody>
<tr>
<td>150mm</td>
<td>0.054</td>
<td>0.031</td>
</tr>
<tr>
<td>300mm</td>
<td>0.180</td>
<td>0.104</td>
</tr>
<tr>
<td>450mm</td>
<td>0.379</td>
<td>0.219</td>
</tr>
<tr>
<td>600mm</td>
<td>0.648</td>
<td>0.372</td>
</tr>
</tbody>
</table>

STANDARD MATTRESS SIZES
Maximum log length = 10m
Maximum proposed mattress width = 3m
Width / length of mattress may be adjusted subject to adjustment of log length and No. of logs deployed

STANDARD BLOCK SIZES (N.T.S)

LIFTING ARRANGEMENT
Integral lifting loops connected to quick release frame

CONCRETE DESIGN SPECIFICATION
C40 / C50 - N/mm² @ 28 days
Blown Granular Marine Mastic, Grade D2/S is produced in accordance with our unique quality controlled process. The granular D2/S mastic has the appearance of loose, free flowing powdery granules, delivered in bulk bags ready for use. Bag size can be varied, but is typically around 1.2 to 1.3 tonnes.

**ADVANTAGES OF USING BLOWN GRANULAR MASTIC**

- Free flowing characteristics
- More rapid melt down
- More convenient transport system (bulk bags) for improved logistics & offshore efficiency
- Less likely to clump and to be tacky

Blown Granular Marine Mastic is designed to include a controlled moisture content to enhance the product’s free flowing characteristics. A product, which is user friendly, easy to handle and melts rapidly, speeding up the joint sealing process.

**RECOMMENDED STORAGE/POURING TEMPERATURES**

**Marine Mastic**

**Working Storage Temperature:** 170°C - 210°C

If due to operational requirements, there is a need to maintain the mastic at working temperature for an extended time, the following recommendations should be followed.

a) Do not hold at a temperature of 200°C for more than 6 hours or 8 hours at 180°C.

b) Pre-plan the storage time and if in excess of those in a) the holding temperature should be reduced to 150°C or lower to be consistent with maintaining movement of the mastic in the Dope Kettle.

c) When storage time is to exceed that in a) fresh material and or 85/25 Bitumen shall be added in sufficient quantity to maintain an acceptable flow characteristic.

d) For extended storage times, lids on the Dope Kettle, where fitted, shall be closed to restrict exposure to the air which may accelerate hardening.

e) After extended storage time at any temperature above melt, the mastic should be inspected and Pure Bitumen added when necessary to bring the mastic to an acceptable consistency.
**BLOWN GRANULAR MARINE MASTIC**

*(PATENT NO. GB2372251)*

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*BLOWN GRANULAR MARINE MASTIC in Bags waiting shipment*  
*Hot Pouring of Granular Marine Mastic*

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**PHYSICAL PROPERTIES**

D2/S Marine Mastic demonstrates the following key physical properties.

<table>
<thead>
<tr>
<th>TEST</th>
<th>METHOD</th>
<th>SPECIFICATION</th>
<th>TYPICAL MEAN VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact Resistance</td>
<td>A1 – SS7</td>
<td>0°C ≥ 5cm, 25°C ≥ 7cm</td>
<td>18cm, 14cm</td>
</tr>
<tr>
<td>Bending Resistance</td>
<td>A1 – SS7</td>
<td>0°C ≥ 25 s, 25°C ≥ 30 s</td>
<td>&gt;35 s, &gt;60 s</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>A1 – SS7</td>
<td>0°C ≥ 15 kg cm⁻², 25°C ≥ 8 kg cm⁻²</td>
<td>16.5 kg cm⁻², 8.6 kg cm⁻²</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>ASTM D695</td>
<td>0°C ≥ 650 psi, 20°C ≥ 220 psi</td>
<td>779 psi, 257 psi</td>
</tr>
<tr>
<td>Elasticity Modulus</td>
<td>ASTM D695</td>
<td>20°C ≥ 1100 psi</td>
<td>10,546 psi</td>
</tr>
<tr>
<td>Density</td>
<td>BS 594/598 Part 3</td>
<td>2.100 ± 50 kgm⁻³</td>
<td>2.158 kgm⁻³</td>
</tr>
<tr>
<td>Seawater Absorption</td>
<td>15°C 1 Bar, 40 Bar, 60 Bar</td>
<td>-</td>
<td>0.040%, 0.094%, 0.052%</td>
</tr>
<tr>
<td>Electric Resistance</td>
<td>BS 903/2044</td>
<td>-</td>
<td>&gt;58.9 GΩ cm</td>
</tr>
</tbody>
</table>
IMPACT RESISTANT COVERS

Submat specialises in the design and manufacture of impact resistant concrete covers against given performance criteria.

A standard semi-circular tunnel shape unit has been developed in addition to bespoke designed units for particular applications.

Submat covers have been designed to accept loading up to 800 kj due to dropped objects and 45 kj due to trawl boards.

The shape of the covers are designed to attract the least hydrodynamic loads and hence reduce scour. However, additional scour prevention systems (fronds) can easily be incorporated where necessary.

Covers can be stacked for economical use of deck space.

Sizes can be designed to facilitate road transportation. Where larger units prohibit logistical movements, covers can be manufacture at a load out quay.

Impact resistant covers (trawlboard and dropped object) for expansion spools on the TOTAL Dunbar Project.

Impact resistant covers (trawlboard and dropped object) for expansion spools on the TOTAL Dunbar Project.

Impact resistant covers (trawlboard and dropped object) for tee piece spools on the Elf Frostpipe Project.
GROUT / BALLAST BAGS

The use of grout and ballast bags when dealing with support / packing operations for subsea pipelines and structures is common place with subsea operators.

Although used independently, in many cases grout and ballast bags are installed to complement the primary method of protection i.e. mattresses / concrete covers etc.

Submat supply grout and ballast bags to complement the Submat protection systems or as an independent item.

See reverse for Technical Data
### TECHNICAL DATA

**GROUT AND BALLAST BAGS CAN BE SUPPLIED TO SUIT INDIVIDUAL CUSTOMER REQUIREMENTS / SPECIFICATIONS AS INDICATED BELOW**

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bags are available in sizes</td>
<td>10kg, 25kg, 30kg, 40kg etc</td>
</tr>
<tr>
<td>Bags are provided in either</td>
<td>polyprop or bio-degradable hessian</td>
</tr>
<tr>
<td>Grout bags have an inner</td>
<td>polythene damp-proof liner</td>
</tr>
<tr>
<td>Grout mixes / constituents may</td>
<td>be varied from neat O.P.C. (Ordinary Portland Cement) to 1:1, 2:1, 3:1, 4:1, 6:1 parts O.P.C to kiln dry sand or as otherwise specified by the client</td>
</tr>
<tr>
<td>Materials may be delivered on</td>
<td>either pallets shrink-wrapped or in bulk bags of 1 tonne, 2 tonne etc</td>
</tr>
</tbody>
</table>
DESIGN

Submat personnel can provide all necessary design expertise including all computing and CAD facilities to prepare detailed designs, studies and reports for all aspects of offshore design. In house software has been developed to enable impact data and pipeline stability to be analysed.

The development of concrete for use in a marine environment is well proven and the cost effectiveness of concrete as an alternative to traditional options has been demonstrated many times. Concrete is inherently a cheap material to produce and can be readily adapted. When properly designed the durability of concrete products in a marine environment out performs steel and requires no additional treatments such as cathodic protection or coatings. Used as gravity structures, no additional installation measures such as piling or ballasting are required to provide stability.

It is our policy to provide the client with a complete package by providing cost effective solutions which consider aspects such as lift limitations, ease of positioning on the sea bed, transportation and optimised use of the installation vessel.

Design aspects undertaken include:

- Stability calculations to optimise mattress sizing for site specific environmental loading.
- Calculations and detailed design for trawlboard and dropped object resistance.
- Mattresses, covers, pipe supports, ramps, bridge crossings, anchor blocks etc. can all be designed to site specific requirements.
- Foundation design for pipe support systems.
- Scour prevention and remedial design studies.
- Innovative designs using reinforced and pre-stressed concrete for subsea applications.
- Hazard studies for impact criteria and risk from trawlboard effects.
- Research into the use of alternative concrete mix designs, e.g. lightweight and heavy weight aggregates, fibre reinforcement etc.

Submat has a proven track record in designing against given performance criteria and is pleased to provide this service as part of an E.P.C contract or on a consultancy basis.
The “Frond Flexiform” Mattress combines all the features of both a flexible concrete mattress and a buoyant frond scour control mat in one: and in particular it offers the following benefits:

- installation is simple and swift, and it provides both instant stabilisation / protection and immediate hold down;
- the creation of long term fibre reinforced, consolidated and vibration compacted sediment bank build up over the mattress substantially adds to the degree of stabilisation / protection afforded and provides an exceptional reduction in scour potential close to structures;
- it provides scour protection for an area somewhat greater than the actual area covered by the mattress;
- the individually profiled concrete segments provide a high degree of flexibility in two planes and allow for a complete stabilisation / protection of subsea structures and pipelines and offer a linked flexible foundation to ensure that load is spread evenly over an area; and
- the fronds prevent edge scour and also halt intermecine block (or rock) scour, this eliminates any requirement for the use of geotextile filter screens under a Frond Flexiform mattress.

The submerged weight of the mattress on first installation will increase as the scour control system creates a fibre-reinforced bank over the base mattress. The rate of build up and size of such bank varies from site to site.

The build up of the material bank within the Frond Flexiform mattress is non-linear. The 1.25m high fronds create the greatest viscous drag when first deployed and the initial 200mm to 300mm of mat/mattress infill occurs quickly in normal tidal conditions given the sort of sediment sizes at most offshore sites. As the material bank forms, the exposed frond length is reduced, the mat creates less viscous drag and the rate of formation of the material bank slows until a steady state is reached.

The sediment bank created is considerably more stable and more dense than the natural surrounding seabed: many surveys have confirmed that it is considerably consolidated by the vibratory movement of fronds during the sedimentary period and once in place it is permanently reinforced by the frond material.

Any sediment bank so formed extends out from the frond area to cover the sides of the base mattress extending out in descending curve to seabed level for a distance slightly greater that the height of the formed bank – the final shape of such a “curve” depends upon the coefficient of friction of the seabed particles.
FROND FLEXIFORM CONCRETE MATTRESS

SEDIMENT BANK PROJECTION

For offshore sites after some 20 to 45 days a significant, compacted and solid sediment bed will be in place and a height of not less than 450mm is normal; the final height of bank with a frond height of 1,250mm should should safely exceed 900mm in height after some 40 to 75 days. The formation of such a sediment bank over the Mattress provides submerged weigh or “hold down”. A typical submerged weight of sand particles is 819.5kg/m³, but the range is large thus the submerged weight of the fibre reinforced material bank can vary. For a 5.0m x 3.0m Frond area this should be:

- after 20 days: in the range 6.67 tonnes to 5.5 tonnes – this is additional to the base mattress’ concrete block weight (with 150mm base blocks = 2.28t submerged weight and with 300mm base blocks = 4.18t submerged weight).
- after 40 to 75 days: in the range 15.0 tonnes 11.08 tonnes + base mattress’ concrete block submerged weight.

BUOYANT FROND MATERIAL

UV stabilised Polypropylene. Fully tested “Chemically Resistant”. Specific gravity 0.908 and 0.92. Full fibrillated and with profiled film.

FROND LENGTH & ATTACHMENT

Buoyant Fronds are attached to Mattress in successive continuous rows providing substantial and unbroken overlap of fronds to those in the neighbouring rows. Frond clumps are NEVER used. Frond Length (height when deployed) of the lines of buoyant frond material is 1250mm. In riverine (and other special situations) lesser frond heights allied to a proportionate increase in frond density (spacing) in the frond rows may be used. A “Safe Net” frond release is provided for diver and ROV safety.

STANDARD BLOCK THICKNESS

150mm, 300mm, and 450mm.

STANDARD BLOCK DENSITY

2.4 Tonnes / Cubic Metre. Lightweight and Heavy Density options are also available from 1.8 - 3.6 Tonnes / m³.

WEIGHTS (STANDARD DENSITY)

<table>
<thead>
<tr>
<th>Thickness</th>
<th>In Air (Tonnes)</th>
<th>Submerged (Tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150mm block</td>
<td>0.275</td>
<td>0.152</td>
</tr>
<tr>
<td>300mm block</td>
<td>0.510</td>
<td>0.279</td>
</tr>
<tr>
<td>450mm block</td>
<td>0.770</td>
<td>0.430</td>
</tr>
</tbody>
</table>
FROND FLEXIFORM CONCRETE MATTRESS
TECHNICAL DATA

TOTAL SUBMERGED WEIGHT

The submerged weight will increase due to the material bank formed by the fronds; the weight of the bank varies according to the seabed composition. A typical submerged weight of sand particles is 819.5kg/m³, but the range is large thus the submerged weight of the fibre reinforced material bank can vary. For a 6m x 4m mattress this should be in the range 23.9 tonnes to 19.9 tonnes - this is additional to the concrete weight which with a 150mm thick mattress at standard density would be 3.7 tonnes giving a total submerged hold down of 27.6 to 23.6 tonnes.

STANDARD MATTRESS SIZES

Standard mould sizes are 10m x 3m in plan area. Mattress may be manufactured in any size within mould dimensions subject to standard block sizes. For pipeline overlay either 4m or 5m width by 2, 3, 4, 6 or 10m length is preferred to provide cover 2 to 2½m either side of the pipeline as well as over & along the line in a single installation. Mattresses in excess of standard mould sizes may be manufactured to order.

STANDARD BLOCK SIZES (N.T.S.)

<table>
<thead>
<tr>
<th>Thickness (mm)</th>
<th>Measurement in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>194  394</td>
</tr>
<tr>
<td>300</td>
<td>290  590</td>
</tr>
<tr>
<td>450</td>
<td>440  890</td>
</tr>
</tbody>
</table>

CONCRETE DESIGN SPECIFICATION

C40 / C50 - N / mm² @ 28 days. Conforms to the requirements of BS8110: The Structural Use of Concrete

ADDITIONAL GROUND ANCHORS

Additional 1 tonne ground anchors certified by ABS and Lloyd’s may be attached at corners or edges to provide the additional edge hold down to increase stability / protection capability (e.g. against trawling).

LIFTING ARRANGEMENT

Integral lifting loops connected to quick release frame.
SLP has a wealth of experience in the design and build of offshore platforms and subsea structures. SLP has harnessed that experience to add to its portfolio the design and build of Mid Water Arch, Gravity Bases and Subsea Tether Systems.

In conjunction with our partners Keppel, SLP can offer an experienced design team based in London with the ability to fabricate in various locations:

<table>
<thead>
<tr>
<th>Fabrication</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowestoft</td>
<td>UK &amp; Europe</td>
</tr>
<tr>
<td>Singapore</td>
<td>Far East &amp; Australia</td>
</tr>
<tr>
<td>Brownsville, Texas</td>
<td>Gulf of Mexico &amp; Brazil</td>
</tr>
</tbody>
</table>

**Mid Water Arch**

**Flexible Riser Guide**

**SUBSEA TECHNOLOGY SOLUTIONS THROUGH EXPERIENCE, EXPERTISE, QUALITY AND INNOVATION**

MID WATER ARCHES, GRAVITY BASES AND TETHER BASES
Our strongly client orientated approach ensures that projects are executed as efficiently as possible and our world wide fabrication capability ensures that the client gets what they at the most economic rate.

Co-ordination between SLP the client and the installation company is vital to achieve the most economic design which SLP will tailor to match not only the riser and umbilical loading but also methods of the installation contractor.

Submat is independently certified to ISO 9001:2000.