The Netherlands
Mailing address:
2585 DB The Hague
Alexanderveld 84

www.iadc-dredging.com
+31 (0)70 352 3334

MEMBERSHIP LIST IADC 2009

Through their regional branches or through representatives, members of IADC operate directly at all locations worldwide.

AFRICA

Bookeyk International Egypt, Cairo, Egypt
Dredging and Reclamation Jan de Nul Ltd., Lagos, Nigeria
Dredging International Tanso Nippon Ltd, Tokyo, Japan

AQUA

Bookeyk Dredging Technology Co. Ltd., Beijing, P.R. China
Bookeyk (Uganda) Dredging Co. Ltd, Kampala, Uganda, Uganda

AUSTRIA

Bookeyk Austria Ltd., Vienna, Austria
Dredging Asia Pte. Ltd., Singapore

EUROPE

Baggerwerken Declieux & Zn., Ostende, Belgium
DEME Building Materials NV/SA (DBM), Zeebrugge, Belgium
Dredging International NL, Zeebrugge, Belgium

MEMBERSHIP LIST IADC 2009

Tema et Aqua is a quarterly publication of the International Association of Dredging Companies, emphasizing “marine solutions for a changing world”. It covers the fields of civil, hydraulic and mechanical engineering including the technical, economic and environmental aspects of dredging. Developments in the state of the art of the industry and other topics from the industry with actual news value will be highlighted.

As Tema et Aqua is an English language journal, articles should be submitted in English.

Contributions will be considered primarily from authors who represent the various disciplines of the dredging industry and professions, which are associated with dredging.

Students and young professionals are encouraged to submit articles based on their research.

Articles should be approximately 10-12 A4s. Photographs, graphics and Illustrations are encouraged. Original photographs should be submitted, as these provide the best quality. Digital photographs should be of the highest resolution.

Articles should be original and should not have appeared in other magazines or publications.

An exception is made for the proceedings of conferences which have a limited waiting period.

In the case of articles that have previously appeared in conference proceedings, permission to reprint in Tema et Aqua will be requested.

Authors are requested to provide in the “Introduction” an insight into the drivers (the Why) behind the dredging project.

By submitting an article, authors grant IADC permission to publish said article in both the printed and digital version of Tema et Aqua without limitations and remunerations.

All articles will be reviewed by the Editorial Advisory Committee (IAC). Publication of an article is subject to approval by the IAC, and no article will be published without approval of the IAC.

Tema et Aqua is published quarterly by the IADC, The International Association of Dredging Companies. The journal is available free of charge to all members of IADC.

For a free subscription go to www.terra-et-aqua.com

MEMBERSHIP LIST IADC 2009

All rights reserved. Electronic storage, reprinting or abstracting of the contents is permitted for non-commercial use only with permission of the publisher.

ISSN 0376-6411


Editor
Marsha R. Cohen

Editorial Advisory Committee
Hubert Fiers, Chair
Constantijn Dolmans
Bert Groothuizen
Neil Hawkins
Heleen Scheldeek
Marijn Schouten
Roberto Vidal Martin

iADC Board of Directors
Joc van Dijk, President
Y. Kallikots, Vice President
C. van Moerbeek, Treasurer
Th. Baertmans
C. Manero
N. Hawkins
G. Vandewalle

Guidelines for Authors

Tema et Aqua is a quarterly publication of the International Association of Dredging Companies, emphasizing “marine solutions for a changing world”. It covers the fields of civil, hydraulic and mechanical engineering including the technical, economic and environmental aspects of dredging. Developments in the state of the art of the industry and other topics from the industry with actual news value will be highlighted.

As Tema et Aqua is an English language journal, articles should be submitted in English.

Contributions will be considered primarily from authors who represent the various disciplines of the dredging industry and professions, which are associated with dredging.

Students and young professionals are encouraged to submit articles based on their research.

Articles should be approximately 10-12 A4s. Photographs, graphics and Illustrations are encouraged. Original photographs should be submitted, as these provide the best quality. Digital photographs should be of the highest resolution.

Articles should be original and should not have appeared in other magazines or publications. An exception is made for the proceedings of conferences which have a limited waiting period.

In the case of articles that have previously appeared in conference proceedings, permission to reprint in Tema et Aqua will be requested.

Authors are requested to provide in the “Introduction” an insight into the drivers (the Why) behind the dredging project.

By submitting an article, authors grant IADC permission to publish said article in both the printed and digital version of Tema et Aqua without limitations and remunerations.

All articles will be reviewed by the Editorial Advisory Committee (IAC). Publication of an article is subject to approval by the IAC, and no article will be published without approval of the IAC.

Tema et Aqua is published quarterly by the IADC, The International Association of Dredging Companies. The journal is available free of charge to all members of IADC.

For a free subscription go to www.terra-et-aqua.com

MEMBERSHIP LIST IADC 2009

All rights reserved. Electronic storage, reprinting or abstracting of the contents is permitted for non-commercial use only with permission of the publisher.

ISSN 0376-6411


Editor
Marsha R. Cohen

Editorial Advisory Committee
Hubert Fiers, Chair
Constantijn Dolmans
Bert Groothuizen
Neil Hawkins
Heleen Scheldeek
Marijn Schouten
Roberto Vidal Martin

iADC Board of Directors
Joc van Dijk, President
Y. Kallikots, Vice President
C. van Moerbeek, Treasurer
Th. Baertmans
C. Manero
N. Hawkins
G. Vandewalle

Guidelines for Authors

Tema et Aqua is a quarterly publication of the International Association of Dredging Companies, emphasizing “marine solutions for a changing world”. It covers the fields of civil, hydraulic and mechanical engineering including the technical, economic and environmental aspects of dredging. Developments in the state of the art of the industry and other topics from the industry with actual news value will be highlighted.

As Tema et Aqua is an English language journal, articles should be submitted in English.

Contributions will be considered primarily from authors who represent the various disciplines of the dredging industry and professions, which are associated with dredging.

Students and young professionals are encouraged to submit articles based on their research.

Articles should be approximately 10-12 A4s. Photographs, graphics and Illustrations are encouraged. Original photographs should be submitted, as these provide the best quality. Digital photographs should be of the highest resolution. Articles should be original and should not have appeared in other magazines or publications. An exception is made for the proceedings of conferences which have a limited waiting period. In the case of articles that have previously appeared in conference proceedings, permission to reprint in Tema et Aqua will be requested. Authors are requested to provide in the “Introduction” an insight into the drivers (the Why) behind the dredging project. By submitting an article, authors grant IADC permission to publish said article in both the printed and digital version of Tema et Aqua without limitations and remunerations. All articles will be reviewed by the Editorial Advisory Committee (IAC). Publication of an article is subject to approval by the IAC, and no article will be published without approval of the IAC.
# CONTENTS

## EDITORIAL

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>DREDGING AND DREDGED MATERIAL BENEFICIAL USE IN IRELAND</td>
<td>3</td>
</tr>
<tr>
<td>COLM SHEEHAN, JOSEPH HARRINGTON AND JERRY D. MURPHY</td>
<td></td>
</tr>
</tbody>
</table>

A review of current beneficial uses in Ireland demonstrates that it is possible to do two things at once with dredged material: Realize economic benefits and protect the environment.

## VESTING AND OWNERSHIP OF PLANT ON DREDGING PROJECTS: A FAIR REMEDY OR A RELIC OF THE PAST?

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>VESTING AND OWNERSHIP OF PLANT ON DREDGING PROJECTS: A FAIR REMEDY OR A RELIC OF THE PAST?</td>
<td>15</td>
</tr>
<tr>
<td>DAVID KINLAN</td>
<td></td>
</tr>
</tbody>
</table>

Dredging contractors should remain vigilant that vesting of plant provisions, that is, transferring ownership of the Contractor’s Equipment to the Employer whilst the Equipment is on the Site, still exists and can have consequences.

## GRAVITY BASE FOUNDATIONS FOR THE THORNTON BANK OFFSHORE WIND FARM

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRAVITY BASE FOUNDATIONS FOR THE THORNTON BANK OFFSHORE WIND FARM</td>
<td>19</td>
</tr>
<tr>
<td>KENNETH PEIRE, HENDRIK NONNEMAN AND ERIC BOSSCHEM</td>
<td></td>
</tr>
</tbody>
</table>

Innovative dredging technologies played a key role in the realisation of these novel Gravity Base Foundations, which can accommodate 5MW Wind Turbine Generators and be placed in very deep waters.

## BOOKS/PERIODICALS REVIEWED

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOOKS/PERIODICALS REVIEWED</td>
<td>30</td>
</tr>
</tbody>
</table>

The Hydraulic Society’s Proceedings and a new CIRIA guide give up-to-date technical information, whilst a new photography book shows the aesthetic side of dredging.

## SEMINARS/CONFERENCES/EVENTS

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEMINARS/CONFERENCES/EVENTS</td>
<td>32</td>
</tr>
</tbody>
</table>

WEDA, CEDA, PIANC are busy with new conferences and EADA has issued its first call for papers for WODCON XIX in China.
EDITORIAL

As world governments have been grappling with the financial crisis, the critical importance of dredging is now on the front burner. Renewed interest has been sparked in dredging and its contributions to long-term, worldwide infrastructure – to port, harbour and waterway maintenance and development, to ensuring coastal protection and to the exploration for energy and the supply of energy sources, be it oil and gas offshore or newly designed windmill farms at sea. From Australia to Germany to the United States and everywhere in between, public infrastructure spending, including ports and waterways, has become part of government stimulus packages, aimed at creating jobs and halting the economic downward slide.

And rightfully so. What better moment than now to allocate funds to take advantage of opportunities for improving and expanding some of the world’s greatest water-related assets and stimulating job creation in the maritime construction sector.

In China, hundreds of billions of euros have been stipulated for railway, highway, airport, port, urban and rural grid. Port construction and waterways development is expected to continue at the same rate as in the past several years as a stimulus against the recession. In Germany, as part of the Government’s € 80-billion stimulus package more than € 1.8 billion (US$2.5 billion) will flow into German waterway projects this year and next, double the amount in the previous two years. This clearly recognises the fact that waterways are a more energy and environmentally efficient way of moving large volumes of freight than the already congested roadways. In the Netherlands, the Government presented a € 6-billion (US$ 8.1-billion) economic stimulus plan to parliament, saying the funds would be spent over the next six years, primarily on infrastructure projects, unemployment prevention and sustainable energy.

Dredging is acknowledged as an integral part of all these projects. But the importance of dredging also puts a responsibility on the dredging industry for tackling complex challenges with innovative solutions, a responsibility which all members of the dredging community, from engineers to crews to project managers, take seriously.

This issue of Terra et Aqua examines two such ingenious approaches: An article on Ireland’s beneficial use of dredged material points out that in an island nation such as Ireland where dredging is essential, the search for more cost-efficient means of achieving coastal security, as well as port development, can be combined by using, rather than disposing of, dredged material. This comprehensive study demonstrates how the removal of sediment from harbours can be used to construct a coastal structure that is sustainable, rather than treating dredged material as a waste. Another article, from Belgium, describes how a new design approach and offshore marine operations have been developed for the construction of the foundations for the first phase of the Thornton Bank Offshore Wind Farm. Innovative dredging technologies played a key role in making the realisation of these foundations feasible.

Clearly, with the appropriate commitment, rivers, waterways and coastal areas are significant assets that will remain important both to business and the broader community. Dredging as always has a tremendous role to play in realising these goals, in helping to stimulate the economy and, literally and figuratively, in keeping things afloat.

Koos van Oord
President, IADC
DREDGING AND DREDGED MATERIAL BENEFICIAL USE IN IRELAND

ABSTRACT
This article provides an overview of the dredging industry in Ireland which may be small by international standards but is of critical importance to the nation’s Ports and Harbours. Open sea disposal of dredged material is most common, but a range of beneficial uses for the coarser fraction of dredged material has been practiced. Details on different aspects of dredging in Ireland are presented including a review of current beneficial uses. A specific site at Fenit Harbour in Tralee Bay is examined to assess the potential for a specific beneficial use of dredged material using geotubes in breakwater and revetment structures. By using the dredged material that is normally dredged and disposed at sea to fill the geotubes and construct a coastal structure a sustainable and feasible beneficial use of dredged material may be achievable. This case study may be applicable to other harbour sites in Ireland.

INTRODUCTION
The Port and Harbour industry, and by extension the dredging industry, are vital to Ireland’s economic performance. As an island nation located in the northwest of Europe, maritime transport accounts for 99% of Ireland’s imports and exports by volume and 90% of Ireland’s GDP representing a value in excess of €120 billion. The shipping and maritime transport sector has grown rapidly over the past decade, in line with general economic growth (Shields et al., 2005). However, owing to the current recession, the volume of ship traffic through Irish ports declined by approximately 20% in the second half of 2008 (Irish Maritime Development Office, 2009), with further reduction predicted as the global recession continues.

The twelve main commercial ports in the Republic of Ireland are primarily semi-state ports (two are privately owned) operating independently in a competitive environment. Fishery Harbours Centres, of which there are six in the Republic, are the primary fishing harbours in Ireland. A number of smaller commercial harbours operate under the auspices of local harbour commissioners or under the authority of local government.

Above: A site at Fenit Harbour in Tralee Bay was examined to assess the potential for the beneficial use of dredged material using geotubes in breakwater and revetment structures. Seen here, the R558 road to Fenit Harbour looking west with revetment structure on eroding shoreline in foreground and Fenit Harbour in background.

The authors wish to acknowledge the funding received from the Environmental Protection Agency under the Science, Technology, Research and Innovation for the Environment (STRIVE) Programme 2007-2013. They would like to thank Phil McGoldrick of GeoSolutions Ireland, Jonathon Wynn, Geosynthetics Consultant, Michael O’Carroll, Secretary & Harbour Master of Tralee & Fenit Harbour Commissioners and Ken Fitzgerald of Malachy Walsh & Partners Consulting Engineers. They also wish to gratefully acknowledge the input of personnel in the port and dredging industries, regulatory agencies and other organisations who have provided information for the project, as well as Dr. Tony Lewis and Dr. Jimmy Murphy, Hydraulics and Maritime Research Centre, University College Cork for their support.
Table I. Legislative framework for dredging projects in Ireland (adapted from Harrington et al., 2004).

<table>
<thead>
<tr>
<th>Legislation</th>
<th>Responsible Agency</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fisheries Act 1959 to 2006</td>
<td>Regional Fisheries Board</td>
<td>Responsible for maintaining and improving environmental quality and the fishery resource.</td>
</tr>
<tr>
<td>Water Services Act 2007 (Water Framework Directive (2000/60/EC))</td>
<td>Local Authority (under the auspices of the Department of Environment, Heritage and Local Government)</td>
<td>Ensures water is maintained to a standard consistent with its various uses. This potentially can introduce additional controls on dredging and dredge disposal activities with potentially significant cost implications.</td>
</tr>
<tr>
<td>Dumping at Sea Act (1996 &amp; 2004)</td>
<td>Department of Agriculture, Fisheries &amp; Food</td>
<td>Application assessed by the Marine Licence Vetting Committee (MLVC) and may involve consultation with Local Authorities and Regional Fisheries Board. Typical permitting timeframe of 4 to 6 months.</td>
</tr>
<tr>
<td>Waste Management Act (1996 to 2005) - Licenses</td>
<td>Environmental Protection Agency (EPA)</td>
<td>Applied to any waste material segregated, stored or disposed onshore. Licenses are required from the EPA and take an average of 6 months to acquire. More complex cases can take up to 18 months. Applies to quantities greater than 100,000 tonnes.</td>
</tr>
<tr>
<td>Waste Management Act (1996 to 2005) - Permits</td>
<td>Local Authority</td>
<td>Applied to any waste material segregated, stored or disposed onshore. Permitting timeframe of 21 days. Applies to quantities less than 100,000 tonnes.</td>
</tr>
<tr>
<td>Foreshore Act (1933-1998)</td>
<td>Department of Agriculture, Fisheries &amp; Food</td>
<td>Disposal between Mean High Water Mark and 12 nautical mile limit. Application assessed by the MLVC and may involve consultation with Local Authorities and Regional Fisheries Board. Typical permitting timeframe of 4 to 6 months.</td>
</tr>
<tr>
<td>Planning Permission (Planning &amp; Development Act, 2000)</td>
<td>Local Authority</td>
<td>Generally required for all developments. Public Consultation process required. Typical 3 month permitting timeframe (in parallel with other required permits)</td>
</tr>
<tr>
<td>EC Quality of Shellfish Waters Regulations 2006</td>
<td>Department of Agriculture, Fisheries &amp; Food</td>
<td>These prescribe shellfish water quality and designate the waters to which they apply. Designation of shellfish areas (as advised by the EU) may impact on dredging.</td>
</tr>
<tr>
<td>Natural Habitats Regulations, 1997 (92/43/EEC)</td>
<td>National Parks and Wildlife Service (DEHLG)</td>
<td>413 designated Special Areas of Conservation (SAC) with some impacting on dredging projects.</td>
</tr>
<tr>
<td>Wildlife Acts 1976-2000</td>
<td>National Parks and Wildlife Service (DEHLG)</td>
<td>This is an area considered important for the habitats present. Over 1100 proposed National Heritage Areas (NHA). Many overlap with SAC/SPA. Some may impact on dredging</td>
</tr>
<tr>
<td>National Monuments Act (1930 –2004)</td>
<td>National Monuments Service (DEHLG)</td>
<td>120,000 protected archaeological sites, some potentially impacting upon dredging.</td>
</tr>
</tbody>
</table>
Table II. Dredging Questionnaire Details.

<table>
<thead>
<tr>
<th>Type of Organisation</th>
<th>No. of Questionnaires distributed</th>
<th>No. of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ports</td>
<td>13</td>
<td>10 (77%)</td>
</tr>
<tr>
<td>Harbours</td>
<td>26</td>
<td>17 (65%)</td>
</tr>
<tr>
<td>Marinas</td>
<td>43</td>
<td>8 (19%)</td>
</tr>
<tr>
<td>Other *</td>
<td>16</td>
<td>5 (31%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>98</strong></td>
<td><strong>40 (41%)</strong></td>
</tr>
</tbody>
</table>

* includes Irish Naval Base, Shannon Ferry Group, Bord Gáis Éireann, Electricity Supply Board, Government Office of Public Works and Local Authorities

introduced by the Department of Finance to raise money for capital projects (Department of Finance, 2009). Figure 1 shows the investment in Ireland’s Ports and Harbours from 2000 to 2007.

**THE IRISH DREDGING INDUSTRY**

The dredging industry in Ireland is small by international standards but is essential to the operation of Irish Ports and Harbours. The historic average annual maintenance dredge requirement for disposal at sea is approximately 1.2 million wet tonnes for the Republic of Ireland (OSPAR Commission, 1997-2006), accounting for approximately 73% of the total offshore disposal volume. Practically all maintenance dredged material is currently disposed off-shore with approximately 40% of capital dredge material (the coarser fraction) used in some form. An overview of the Irish Dredging Industry is presented in here based on an analysis of a dredging questionnaire survey supplemented by other available information.

**The Legislative Framework**
The legislative framework governing Ireland’s dredging industry is rigorous and stringent. Depending on the type of project planned the various licenses and permits required can take between 3 months for a relatively simple project and over 18 months for a complex project. A summary of the current legislative framework is presented in Table I.

**The Dredging Questionnaire Survey**
A dredging questionnaire survey was sent to individual ports, harbours, marinas and other relevant regulatory agencies and organisations in Ireland in 2007. The aim was to gain a general understanding of the current status of the dredging industry and to update a previous national dredging survey undertaken in 2003 (Harrington et al., 2004). A postal survey was undertaken with a follow up by phone. This survey information was supplemented by information gathered from the Department of Agriculture, Fisheries and Food (formerly some of its responsibilities were under the Department of Communication, Marine and Natural Resources) website on recent dredging projects. The locations for which data is available are shown in Figure 2.

Questionnaires were sent to 98 groups/organisations with an overall response rate of 41%. Details are presented in Table II. Additional information was gathered from regulatory agency data yielding information for a total of 47 locations. The data gathered included a wider range of dredging projects and locations than the previous 2003 survey (where 63 questionnaires were distributed with a 53% response rate).

The two-page questionnaire required information on the last major dredging project undertaken by the relevant organisation and specifically requested details on:
- Type of dredging project
- Volume dredged
- Equipment utilised
- Dredged volume used
- Type of beneficial use practiced
The survey returned a significant amount of information that is stored in a database and has been analysed. This database is a MySQL database management system and will shortly be made available online to allow relevant organisations and regulatory authorities access to the data. The online system will allow additional information to be uploaded as necessary and will provide a key resource for the industry in Ireland.

Analysis of the survey data shows that 46% of the total dredged volume is from capital projects with the remainder from maintenance dredging projects. The dredged materials particle size distribution is 6% gravel, 38% sand and 55% silt and clay. Sediment contamination was found at a limited number of sites including the fishery harbours of Killybegs and Castletownbere (presence of TBT) where large scale dredging has been undertaken as part of pier developments. Approaches to dealing with the contamination varied – at Castletownbere the contaminated layer was dredged using an environmental grab dredger, brought ashore, stabilised with a cement product and then exported to Germany for treatment. However, at Killybegs the contaminated material was left undisturbed.

The proportion of capital dredged material (46%) is significantly down from 71% in the previous survey of 2003, indicating that the amount or size of capital dredging projects around the country has decreased relative to the 2003 survey. This trend is likely to continue as funding for such developments is now more limited.

Recent capital dredging projects of note include:
- Warrenpoint Harbour (25,000 m³) in Northern Ireland that deepened 300 m of quay from 5.4 m to 7.5 m and reinstated an old turning circle which had suffered extensive siltation.
- Rossaveel Harbour (66,100 m³), in County Galway, where dredging was required to create a new ferry basin, a small craft harbour basin and to widen existing berths.
- The Electricity Supply Board (ESB) upgraded one of their generating stations at Aghada in County Cork which involved the laying of a new pipeline 400 m from the shoreline. The total quantity dredged was 16,500 m³ of which 2,500 m³ of granular material was used as backfill.
- Dublin Port dredged 80,000 m³ to improve its bulk handling facilities.
- Castletownbere Harbour dredged 140,000 tonnes of mixed sediment and 29,000 tonnes of rock as part of a 120 metre pier development. A portion of the uncontaminated dredged material was used in land reclamation.

---

![Figure 1. Investment in Irish Ports and Harbours from 2000 to 2007 (McNally, 2008; O’Brien, 2008).](image)

![Figure 2. Locations of dredging projects with available data.](image)
A number of dredging projects are currently underway or recently completed:
- The Limerick Tunnel is one of the largest dredging operations in Ireland in recent years with 900,000 m³ of material being dredged; it is currently under construction. 500,000 m³ of this dredged material is to be used in backfilling the tunnel.
- The dredging of approximately 18,000 m³ of material for a 2 km gas pipeline in County Mayo has just been completed.
- Caladh Mór in the Aran Islands in County Galway has recently completed dredging works of 35,000 m³, the majority of which is rock and has been used on site.
- The pier of Cill Ronain in the Aran Islands has also been dredged generating approximately 100,000 m³.
- A new € 300 million deepwater port for Bremore, County Louth is currently at design stage.
- A reclamation of 300,000 m² of land for a new port area for Waterford Port is planned.
- Other planned developments of note are the proposed Port of Cork relocation, development of Greystones Harbour, with Dublin Port and Belfast Harbour also planning reclamation works for expansion purposes.

The annual maintenance dredge requirement for the commercial ports is presented in Table III based on the survey analysis and other available information. The five ports with the largest dredge requirement contribute approximately 90% of the Republic of Ireland’s total annual national maintenance dredge requirement. The larger ports currently operate under 5 year Dumping at Sea Licenses with a number of small harbours such as Bunbeg Harbour, Drogheda Harbour, Fenit Harbour, Portmore Harbour, Buncrana Harbour and Greencastle Harbour operating under or have applied for similar licensing arrangements.

The questionnaire survey indicates that 57% of the volume dredged is undertaken by the main commercial ports (see Figure 3). The harbours account for 21% of all dredged material generated with only 2% of the volume dredged attributed to marinas with the remaining 20% classified as ‘Other’ which consist of projects such as gas pipeline laying and tunnel construction.

In capital dredging only 16% of material was generated by the commercial ports while harbours account for 35%, marinas 2% and other projects, as outlined above, account for 47%.

The method of dredging/type of dredging plant used was also investigated in the survey. The most popular type of plant for maintenance dredging was the trailing suction hopper dredger (TSHD) while for capital dredging the backhoe dredger was the most popular. In maintenance projects in recent times the TSHD and bed leveller have been used to achieve the optimum output for the dredging project. For the volume dredged the THSD is the most productive, dredging over 62% of the total; 88% of maintenance dredgings and 32% of capital dredgings.

External contractors are now used for all large-scale dredging works. These include, for example, Tideway, Royal Boskalis, UK Dredging, Dutch Dredging B.V., and Van Oord. There are a number of Irish ports and harbours who have purchased dredgers
in recent years. In some cases this has been a multi functional vessel that can be used for other activities on site. The most used is the grab hopper dredger (GHD), the Hebble Sand, which is based in Dundalk Harbour. The harbour purchased this dredger in 2004 as there was a gap in the market place for a dredger that would undertake dredging work in smaller harbours. This dredger has been used in various sites around Ireland, in conjunction with Dundalk’s regular maintenance dredging. Shannon Foynes Port Company also has a GHD, the M.V. Curragh gour II, which is based in Limerick Harbour all year round. Recently in 2007, Shannon Foynes Port Company invested €2.4 million in a new multi-purpose vessel, the Shannon I.

The boat is involved in dredging, bed levelling and the maintenance of jetties. The Port of Londonderry also purchased two dredgers in recent years. The Trailing Suction Hopper Dredger (TSHD), the Lough Foyle, was purchased for €2.2 million to replace an older TSHD and to supplement the use of the Harbour’s other dredger, the Otterbank, which is a plough dredger.

The Otterbank is leased out to several local sites annually. The Ports of Cork and Dublin recently purchased multi-purpose vessels. The Rosbeg and the M.V. Denis Murphy are used for buoy handling, plough dredging, towing and anchor handling.

**BENEFICIAL USES: AN OVERVIEW**

Based on analysis of the questionnaire survey approximately 20% of dredged material is being beneficially used with practically all coming from capital dredging projects. The use of maintenance dredged material is approximately 1% (see Figure 4), which may be unfavourably compared with some European countries. When questioned as to why beneficial uses were not practised, the main reasons given were the engineering aspects of the material, economic viability, transport logistics, environmental constraints and the length of time involved in instigating such a process owing to the licenses and permits required.

Figure 5 shows the beneficial uses practiced for the coarser grained fraction of dredged material. Some examples of use include, 16,000 m³ in the Castletownbere Harbour Development, 238,000 m³ in the Killybegs Harbour Development and 1000 m³ in the Port of Larne for land improvements on site. Londonderry utilised its port owned dredger to bring ashore approximately 34,000 tonnes of sandy material annually for use by the general public. However, with the purchase of the new larger dredger, the Lough Foyle, this activity will no longer take place (McCann, 2008).

**CURRENT ISSUES/TRENDS IN THE IRISH DREDGING MARKET**

The larger ports (Cork, Dublin, Drogheda, Shannon Foynes and Waterford) now operate under 5 year Dumping at Sea Licenses. A number of smaller ports and harbours are currently investigating the possibility of acquiring a long term dredging contract or are operating under this licensing regime.

The Department of Agriculture, Fisheries and Food is encouraging the ports to apply for these licenses allowing timely and full consideration of alternatives to disposal at sea. These types of contracts benefit both parties as it ensures the dredging required is carried out for the port authorities while ensuring that the dredging contractor is guaranteed work over a longer time period.

Some ports and harbours have or are looking into the option of purchasing a small to medium sized dredger. This can provide additional income to the harbour through leasing if the market exists (O’Carroll, 2008). For example, The Shannon I can be leased from its base in Limerick for a basic charge of €2,750 per day (8 hours) including fuel and crew. It also provides the harbour authority with greater control and flexibility over its dredging operation.
The presence of contaminated sediments has to date been a localised problem in Irish ports and harbours but has involved export for treatment, at Castletownbere Harbour, for example. This will continue to be an issue and will need to be addressed, for example, in the proposed Bantry Bay Harbour Development.

The beneficial use of the fine fraction of dredged material in Ireland is limited and long term planning is essential for the development of any such beneficial uses. It would be fair to state that in all but the larger capital dredging project that involve an Environmental Impact Statement (EIS) the potential for the use of the dredged material in the past may not have been fully explored.

The Department of Agriculture, Fisheries and Food has recognised this and now states on its Dumping at Sea License application form that “The dumping of dredge spoil at sea is only acceptable when other means of disposal are ruled out for ecological or sound social or economic reasons. Even so, for ecological/environmental/fisheries reasons the dumping of the waste may not be permissible in all cases” (Department of Agriculture, Fisheries and Food, 2009).

This combined with the encouragement to operate under 5 year Dumping at Sea Licenses indicates the efforts being made to achieve a greater amount of sustainable use of dredged material.

Harrington et al. (2004) identified the limited number of beneficial uses of dredged material practiced in Ireland. Cork Institute of Technology has since undertaken research in this area with some results having been presented in Murphy et al. (2008) and Sheehan et al.

**SELECTIVE USE OF BENEFICIAL USE SITES**

Harrington et al. (2004) identified the limited number of beneficial uses of dredged material practiced in Ireland. Cork Institute of Technology has since undertaken research in this area with some results having been presented in Murphy et al. (2008) and Sheehan et al.
The current ongoing work has focused on analysis of proposed beneficial uses at specific dredging sites (where beneficial use of dredged material has not been practiced to date) to show the potential for such development at the site with possible application to other dredging sites. Analyses of beneficial uses for dredged material at the Port of Waterford and at Bantry Harbour, County Cork are near completion as part of this research effort. Another study is briefly presented below for Fenit Harbour in County Kerry.

**FENIT HARBOUR**

Fenit Harbour undertakes periodic maintenance dredging as required and is in the planning stages for a capital dredging project. The aim is to identify a potential beneficial use methods that can be utilised both for the proposed capital dredging project as well as subsequently for the irregular maintenance dredging on site. Fenit Harbour is typical of a number of small harbours around Ireland, allowing the research undertaken to be potentially applicable elsewhere and also to potentially influence more sustainable dredged material management.

Fenit Harbour is a small harbour in the south west of Ireland as shown in Figure 6. It is under the jurisdiction of Tralee and Fenit Harbour Commissioners. The harbour itself is on the north side of Tralee Bay and connected to the mainland by an 800 m causeway. The harbour includes a 130 berth marina which is full with a long waiting list (O’Carroll, 2008). The main deep-sea pier is 175 m long with extensive storage facilities available. Liebherr Cranes is the primary commercial user of the harbour.

The land surrounding Tralee Bay includes a number of protected areas. Fenit Island to the north of the harbour is a designated Special Protection Areas (SPA) for the protection of the local wildlife habitats. Most of Tralee Bay is a Special Area of Conservation (SAC).

Shoreline stretches along the bay suffer coastal erosion but available funding to address the problem is limited. Road collapses caused by the severe coastal erosion in the area have occurred; the most recent were in 2007 when two sections of road were damaged. The repair work for one section of road cost approximately €4 million and Kerry County Council is still in debt as a result of that project, limiting the scope for further investment in coastal protection works. County Kerry, for example, has a coastline of 684 km and it is estimated that approximately 41 km of this coastline is considered to require protection at a cost of over €30 million (O’Sullivan, 2006).

**Current Proposal**

The Harbour Commissioners currently envisage two proposed developments; one to extend the existing breakwater (Figure 7), the other to provide coastal protection for a stretch of road connecting Fenit Harbour to the nearby town of Tralee.

---

Figure 8. Local Irish coastline suffering coastal erosion.

Figure 9. Cross-section of proposed traditional breakwater construction (Malachy Walsh & Partners, 2008).
Alternative Proposed
This article proposes an alternative integrating the dredging activities into the construction of the breakwater and revetment using geotubes which have extensive applications in dewatering and marine structures. This would provide the benefits of reduced dredged material disposal at sea and an identifiable beneficial use. A further aim is to show that geotubes may be a practical, feasible and economic solution to local coastal erosion problems when combined with maintenance dredging, thus allowing future projects in the locality to consider this innovative solution, or alternatively at another similar location in Ireland.

Geotube Design and Construction
The type of dredger is generally the most important aspect of such a project as to fill the geotubes requires pumping at as high a volume of solids as possible, preferably to at least 40% solids. A specialised dredger that can pump this high density slurry is required as most inland/port dredgers provide only a fraction of the density necessary to fill the geotubes. These pumps are submerged in the dredging area by hydraulic arms from onshore or from a pontoon allowing most dredging locations to be accessible. Also, smaller versions of cutter suction dredgers with 6-8” pipes can...
The designs of the geotube breakwater and geotube revetment are based on two different approaches. The first, a geotube and riprap structure, is similar to the traditional construction as only the quarry run core material is replaced by the filled geotubes. The geotubes are stacked into position to form the desired shape and covered with a geotextile, rock underlay and a 1 tonne rock armour layer (this rock armour size is also assumed for the revetment). Some quarry run core material may be required to shape the surface of the stacked geotubes. The only difference between this method and the traditional method is in the volume of quarry run core.

The second method, a ‘Pseudo’ Geotextile Breakwater, is different as it utilises generally only geotextile materials on the inner wave protected harbour side of the breakwater to replace the quarried material protecting the geotube. The exposed side of the breakwater remains as outlined in Figure 9 above with rock armour. A small amount of quarry run core material may still be required to develop the desired shape. This method utilises the geotubes but covers them on the sheltered side of the breakwater with a geotextile fabric such as NAG 550 (an erosion control blanket) or a Triton Mattress (plastic gabion mattress).

After consultation with Geosolutions Ireland and Jonathan Wynn (a geosynthetic consulting engineer), the design of the geotubes for the breakwater was 5 metres wide by 2 metres high. The revetment geotubes are slightly smaller at 3 metres wide by 0.75 metres high owing to the slope they are lying at and the size of the revetment required in comparison to the breakwater (for analysis purposes it is assumed to be similar in dimension to the revetment constructed in 2005 which included quarry run material under geotextile).

Utilising smaller tubes gives several benefits. With stacked tubes, as designed for the suggested breakwater, a better shape can be achieved. There is drainage between the geotubes and they can be tailored to the

Table IV. Particle Size Distribution of sediment in Fenit Harbour (Aquatic Services Unit, 2005).

<table>
<thead>
<tr>
<th>Sampling Location</th>
<th>% Gravel &gt;2mm</th>
<th>% Sand 63µm-2mm</th>
<th>% Silt/Clay &lt;63µm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berths</td>
<td>0.0</td>
<td>45.6</td>
<td>54.4</td>
</tr>
<tr>
<td>Pier</td>
<td>0.0</td>
<td>40.7</td>
<td>59.3</td>
</tr>
<tr>
<td>Entrance to harbour</td>
<td>0.0</td>
<td>72.6</td>
<td>27.4</td>
</tr>
</tbody>
</table>

Table V. Amounts of quarry material required for the breakwaters.

<table>
<thead>
<tr>
<th>Quarry Material</th>
<th>Traditional Breakwater (tonnes)</th>
<th>Geotube and Riprap Breakwater (tonnes)</th>
<th>‘Pseudo’ Geotextile Breakwater (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core</td>
<td>388,930</td>
<td>56,873</td>
<td>56,873</td>
</tr>
<tr>
<td>Filter</td>
<td>41,194</td>
<td>41,194</td>
<td>21,659</td>
</tr>
<tr>
<td>Armour</td>
<td>41,997</td>
<td>41,997</td>
<td>41,997</td>
</tr>
<tr>
<td>Total</td>
<td>472,121</td>
<td>140,065</td>
<td>120,529</td>
</tr>
<tr>
<td>Quarry Material Saving</td>
<td>0</td>
<td>332,056</td>
<td>351,592</td>
</tr>
</tbody>
</table>

Table VI. Amounts of quarry material required for the revetments.

<table>
<thead>
<tr>
<th>Quarry Material</th>
<th>Traditional Revetment (tonnes)</th>
<th>Geotube and Riprap Revetment (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core</td>
<td>4,855</td>
<td>1,456</td>
</tr>
<tr>
<td>Filter</td>
<td>3,140</td>
<td>3,140</td>
</tr>
<tr>
<td>Armour</td>
<td>8,757</td>
<td>8,757</td>
</tr>
<tr>
<td>Total</td>
<td>16,752</td>
<td>13,353</td>
</tr>
<tr>
<td>Quarry Material Saving</td>
<td>0</td>
<td>3,399</td>
</tr>
</tbody>
</table>

Table VII. Cost of construction for the different coastal structures.

<table>
<thead>
<tr>
<th>Type</th>
<th>Cost per Metre (€)</th>
<th>Total Cost (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional Breakwater</td>
<td>€ 17,754</td>
<td>€ 7,921,000</td>
</tr>
<tr>
<td>Geotube and RipRap Breakwater</td>
<td>€ 11,545</td>
<td>€ 5,124,000</td>
</tr>
<tr>
<td>‘Pseudo’ Geotextile Breakwater</td>
<td>€ 10,669</td>
<td>€ 4,737,000</td>
</tr>
<tr>
<td>Traditional Revetment</td>
<td>€ 1,325</td>
<td>€ 265,000</td>
</tr>
<tr>
<td>Geotube and RipRap Revetment</td>
<td>€ 1,382</td>
<td>€ 276,500</td>
</tr>
</tbody>
</table>

The sediment in the area was found to be more than 40% sand which is sufficient to allow the geotubes to be used as a structural core. The particle size distribution for three locations within the harbour are shown in Table IV. Chemical testing was also undertaken on the material and showed that the material complied with all relevant quality standards.

The material in Fenit Harbour has been tested for its suitability for filling geotubes. The filling of the geotubes from the dredger must be continuous until the geotube reaches its design height as interruptions allow consolidation of the material within the geotube, which may deform the final shape.

The sediment in the area was found to be more than 40% sand which is sufficient to allow the geotubes to be used as a structural core. The particle size distribution for three locations within the harbour are shown in Table IV. Chemical testing was also undertaken on the material and showed that the material complied with all relevant quality standards.

The sediment in the area was found to be more than 40% sand which is sufficient to allow the geotubes to be used as a structural core. The particle size distribution for three locations within the harbour are shown in Table IV. Chemical testing was also undertaken on the material and showed that the material complied with all relevant quality standards.
Dredging and Dredged Material Beneficial Use in Ireland

13

does not cover the capital costs of purchasing the geotubes and hiring the necessary dredging and pumping equipment for this transport distance. The impact of transport is outlined in Figure 12. For transport distances greater than approximately 25 km the geotube with riprap revetment is estimated to be more cost effective.

**Table VII** presents estimated current costings for the breakwater and revetment designs. The breakwater analysis shows that the traditional method is the most expensive with the geotube with riprap and the ‘Pseudo’ geotextile breakwater both being less expensive. The primary factor is the cost of transport from the local quarry.

For the traditional breakwater the transport costs account for approximately 33% of the overall cost of the project. The cost reduction in the two alternative geotube breakwaters results not only from the reduction in the volume of the quarried material required but also from costs in the delivery and placement of this material. From this it may be concluded that the delivery distance from the quarry is a key factor in the decision making process. This is highlighted in Figure 11 which shows the influence of an increase in the delivery distance.

The revetment is a smaller structure (at an assumed 200 m in length) with the estimated costs presented in Table VII. The geotube with riprap revetment is estimated to be more expensive for an 11 km quarry distance. The savings made in transporting and placing the reduced quarry material does not cover the capital costs of purchasing the geotubes and hiring the necessary dredging and pumping equipment for this transport distance. The impact of transport is outlined in Figure 12.

**Figure 11. Influence of delivery distance on Overall Cost of Breakwater.**

**Figure 12. Cost comparison for revetments with increased delivery distance.**
is in operation with a current 5 year Dumping at Sea License in place allowing 44,800 tonnes of material to be dredged annually. There is potential for the proposed geotube coastal protection scheme to be constructed in tandem with the capital or maintenance projects.

However, good communication, co-operation and consistent objectives amongst all the relevant parties are essential for successful implementation.

The geotubes require a dredger that is not normally used in Ireland in standard dredging projects as it needs a higher density of slurry to sustain the required fill rate. Coordination would be needed amongst all parties including the Harbour Commissioners, the consulting engineers, the Local Authorities and the dredging contractor. This would allow one dredger to carry out the capital and/or maintenance dredging for the harbour but also produce a raw material for the geotubes.

The amount of dredged material that would be required for the proposed geotube breakwater is approximately 162,000 m³ and approximately 3,500 m³ per 200 m constructed of geotube revetment constructed. By using the dredged material that is normally dredged and disposed at sea to fill the geotubes and construct a coastal structure a sustainable and feasible beneficial use of dredged material may be achievable.

**CONCLUSIONS**

The analysis presented above suggests the cost savings associated with the use of geotubes for a breakwater development such as at Fenit Harbour and the potential for coastal revetment development. These economic benefits are also supported by the environmental benefits which would occur from a reduced volume of quarried material, with a consequent reduction in the transport demand and a reduced disposal at sea volume.

This research may be applicable to a variety of sites around Ireland once the coastal protection structure being considered is within pumping distance of a port or harbour with a dredging requirement. From a coastal protection point of view, for example, a report on Coastal Zone Management in Ireland identified 1500 km of coastline that is at risk from erosion, with some 490 km in immediate danger (Department of the Environment, Heritage and Local Government, 2001). Geotubes, with the use of dredged material, may provide a sustainable beneficial use for dredge material based on local site conditions.

**REFERENCES**

Aquatic Services Unit (2005). Fenit Harbour Dredge Spoil Testing, Environmental Research Institute, University College Cork, Cork, Ireland.


Department of Agriculture, Fisheries and Food (2009). Application Form for a Dumping at Sea Permit, Dublin, Ireland.


ABSTRACT

Vesting of Plant refers to the transfer of ownership or title of the Contractor’s Equipment from the Contractor to the Employer for the period the Equipment remains on the Site. It may even include the right to sell the Equipment to recover monies as a debt due. The intention of a vesting provision is that in the event of Contractor default or insolvency the Employer can retain the Contractor’s Equipment in order to complete the Works. Vesting of Plant clauses originated from the Institution of Civil Engineers (ICE) Conditions of Contract and its use has spread around the world. Despite it falling out of favour in the United Kingdom, under FIDIC contracts and in other jurisdictions it can still be seen in a number of countries’ standard conditions of contract most notably in parts of the Middle East, Malaysia, Hong Kong and Australia.

Although there has been lobbying to remove draconian vesting provisions from international contracts such as FIDIC, these provisions have not been abandoned. The question remains: Are such provisions a workable contract solution for clients in economically uncertain times or should they be consigned to history?

INTRODUCTION

The right of vesting or right to claim title of ownership is generally used in construction contracts when it applies to materials and goods supplied and delivered by the Contractor for incorporation into the Work. This is to enable the Employer to complete the Works by using the materials and goods supplied in the event that the Contractor’s employment is terminated. It is generally accepted that the materials and goods change ownership when they are clearly identified as the property of the Employer upon delivery to the Work Site or upon payment by the Employer when they are incorporated into the permanent works, whichever comes first.

However the position regarding the Contractor’s Equipment deployed on the Work Site is different. The Employer whilst gaining title to materials and goods supplied for the permanent works will not have the right to use the Contractor’s Equipment following termination unless there is a “Vesting of Plant” clause.

Vesting of plant refers to the transfer of ownership or title of the Contractor’s Equipment from the Contractor to the Employer for the period the Equipment remains on the Site. It may even include the right to sell the Equipment to recover monies as a debt due. The intention of a vesting provision is that, in the event of termination of the contract by the Employer for Contractor default or insolvency, the Employer can retain the Contractor’s Equipment in order to complete the Works.

A BALANCED PERSPECTIVE

There are opposing interests with respect of a vesting of plant clause. In the event of the Contractor’s default and the subsequent termination of the contract then the Employer will wish to secure the completion of the Works by the quickest and most economically advantageous method. If the Employer is able to use it, then the Contractor’s Equipment is essential for this. The Employer would then
not be liable to pay the Contractor and the additional expenses incurred by the Employer in completing the Works would be chargeable to the Contractor. If the costs of execution and other expenses incurred by the Employer were to exceed the amount otherwise due to the Contractor, then the Employer would be entitled to recover such excess amount as a debt due.

In a vesting of plant situation, as the Employer has title in the Contractor’s Equipment, the Employer would be able to sell the Contractor’s Equipment to recover the debt. One of the obvious and immediate problems of this arrangement is that the Employer often does not have the expertise or insurance cover to operate marine equipment and would more than likely have to employ another contractor to use the dredging equipment.

The Contractor on the other hand has a significant capital investment in this equipment which may be several times the value of the work to be undertaken. Two questions are often asked: Should the Contractor be required to complete the Works when the contract has been terminated for default? And should the equipment be sold to recover a far minor debt?

In the Dredging Handbook for Engineers 2nd Edition, the authors question whether the Employer would not be better advised to increase the value of the performance bond instead of resorting to a vesting of plant clause. In practice, a more important provision is the Employer’s right not to release a vessel from the work site until the work related to that vessel has been completed.

VESTING CLAUSES AROUND THE WORLD

The vesting of plant provision was first used in the Institution of Civil Engineers (ICE) Conditions of Contract as far back as 1945 and its use has spread around the world, particularly in Commonwealth Countries. Use of the ICE Contracts was slowly replaced by the FIDIC (Fédération des Ingénieurs-Conseils) Contracts which were largely based on the ICE 4th Edition.

FIDIC Red Book versus ICE Contracts

The first edition of the FIDIC Red Book for Construction was issued in 1957, the second in 1969 and the Red Book 3rd Edition was issued in 1977. The latter drew heavily on the experience of the ICE 5th Edition issued in 1973. The FIDIC Red Book 3rd Edition largely took over as the basis for use in international dredging and reclamation projects. The FIDIC Red Book 3rd Edition departed from the ICE Contracts upon which it was based by including an optional Part III set of particular conditions. This Part III was solely meant for dredging and reclamation works and excluded the vesting of plant provisions and the right for the Employer to sell the Contractor’s Equipment (Figure 1).

A typical Vesting of Plant Clause would be as follows:

“All Contractor’s Equipment owned by the Contractor, or by any company in which the Contractor has a controlling interest, shall, when on Site, be deemed to be the property of the Employer. Provided always that the vesting of such property shall not prejudice the right of the Contractor to the sole use of the Contractor’s Equipment for the purpose of the Works nor shall it affect the Contractor’s responsibility to operate and maintain the same. Upon removal, with the consent of the Engineer, the Contractor’s Equipment shall be deemed to revest in the Contractor”.

International Applications

Some countries such as Oman and Bahrain took the FIDIC 3rd Edition and used it as the template for their standard conditions of contract but without including the Part III amendments for dredging and reclamation works. This had the unfortunate result of re-instating the vesting of plant requirements. Dredging contractors working in these countries are faced with the potential of the vesting of plant provisions being enforced in event of contractor default and would be expected in all cases to qualify such tenders.

Other countries such as Malaysia, which used the former ICE Contracts as their template, incorporated the vesting of plant clause in their Public Works Contracts. However, with the privatisation of the port and infrastructure market, Employers increasingly turned to either FIDIC or their own drafted contracts and the vesting of plant provisions were for the most part largely discarded.
Vesting and Ownership of Plant on Dredging Projects: A Fair Remedy or a Relic of the Past?

It is of interest to note that in Australia the Australian Standard General Conditions of Contract both the AS 2124-1992 and the later AS 4000-1997 have incorporated a vesting of plant procedure. In the event of default of the Contractor, the Employer may take work out of the hands of the Contractor and perform that work and take possession of such Contractor’s Equipment in order to do so. If the Contractor is indebted to the Employer then the Employer may retain the Contractor’s Equipment until the debt is satisfied, or, if the Contractor fails to pay the debt, the Employer may sell the Contractor’s Equipment. Similar provisions also exist in the Hong Kong General Conditions of Contract for Civil Engineering Works 1999.

The principle of title and vesting of plant has undergone considerable transformation under the UK’s ICE Conditions of Contract. The pure vesting of Contractor’s Equipment included in the ICE 5th and 6th Editions has been discarded and was not used in Clause 54 of the 7th Edition published in 1999.

UK Legal Judgment
It has been held that the wording stating that the Contractor’s Equipment is deemed to be property of the Employer does not create a legal change of ownership in the Contractor’s Equipment, rather that the Employer has a floating charge on the Contractor’s Equipment if the Contractor becomes insolvent.

In the absence of registration in accordance with Part XII of the Companies Act 1985, such floating charge will be void against the Contractor’s administrator. The relevant case is Smith (as Administrator of Cosslett (Contractors) Ltd) v Bridgend County Borough Council [2001] UKHL 58; [2002] BLR 160 which went to the Court of Appeal and was finally decided in the House of Lords in 2001. The case demonstrates that whilst the right of the Employer to use the Contractor’s Equipment to complete the Works following contract termination may be legally enforceable, any right to sell the Contractor’s Equipment to recover debt is likely to fail.

Increasingly in the United Kingdom the Engineering & Construction Contract (ECC) is being used for civil engineering projects. This provides that on termination of the contract, the Employer may use any Equipment to which the Contractor has title to complete the Works. Title in equipment refers to a legal right of possession or control. The ECC Guidance Notes indicate that the Employer can only use Equipment to which the Contractor has title, so that Equipment from, for instance, subcontractors or hired equipment would be exempted.

FIDIC’S USE OF THE VESTING OF PLANT PROVISION
In 1987 FIDIC updated its 3rd Edition Red Book contract with the issue of the Red Book 4th Edition. Part III of the 3rd Edition was discarded and the title and vesting of plant clause, although watered down, was brought back as an optional provision. In the 4th Edition Part II Particular Conditions where vesting of the Contractor’s Equipment is required, Clause 54 recommends wording similar to that of the earlier ICE Contracts.

The wording of FIDIC Red Book 4th Edition Clause 54.1 provides that all Contractor’s Equipment shall, when brought on Site, be deemed to be exclusively intended for the execution of the Works and the Contractor shall not remove the same without the consent of the Engineer.

FIDIC Red Book 4th Edition Clause 63.1 provides that on termination the Employer or another contractor employed by the Employer may use for completion so much of the Contractor’s Equipment as the Employer may think proper. Clause 63.2 provides that the Engineer shall on termination certify the value of the Contractor’s Equipment.

Dredging contractors working with FIDIC 4th Edition Part II Particular Conditions Clause 54.2 are faced with the potential of the more onerous part of the vesting of plant provisions being enforced in event of Contractor default.

FIDIC 4th Edition Part I General Conditions Clause 54.5 provides that, in the event of termination for Contractor’s default, the Employer may take over any hired equipment agreements and agrees to pay the hire charges from the date of termination.

This gives some degree of protection to the dredging vessel owner, as quite often the registered vessel owner is a different entity to that of the Contractor. This clause thus ensures that payment will be made to the owner if the Contractor’s Equipment is to be used to complete the Works.

The Rainbow Suite
In 1999 FIDIC introduced the new “rainbow suite” of contracts which included:
- a new Red Book Contract for Construction,
- a Yellow Book for Design-Build and
- a Silver Book for EPC/Turnkey Work.

The rainbow suite of contracts all follow the same formatting and include identical termination clauses. The rainbow suite was never intended for dredging contracts. Consequently, shortly thereafter in 2001 a test edition blue form for dredging was issued, with the first Blue Book edition subsequently issued in 2006 (Figure 2).
Since the issue of the vesting of plant in relation to marine dredging vessels was no longer an issue to the writers of the rainbow suite, not unexpectedly, vesting of plant crept back into the new rainbow suite. In addition, there were no provisions which dealt with the Employer being able to take over hire agreements. Clause 15.2 provides that following termination the Employer may complete the Works and/or arrange for any other entities to do so.

Although it does not clearly state that the Employer or other entities may use the Contractor’s own or hired equipment, it does say that the Employer shall then give notice that the Contractor’s Equipment will be released to the Contractor at or near the Site. The presumption is that the Employer only releases the Contractor’s Equipment when the Works are completed.

There is no express right regarding Employer’s use of the Contractor’s Equipment, and if the Employer did use the Equipment there is no provision for payment by the Employer for such use of the Contractor’s Equipment after termination. It then goes on to provide that if a payment due is not made to the Employer then the Employer may sell the Equipment to recover the payment.

**The Blue Book for Dredging**

In 2006 FIDIC issued the long awaited Form of Contract for Dredging and Reclamation Works (the Blue Book in the rainbow suite). In it Clause 12.1 provides that in event of Contractor’s default the Contractor shall demolish from the Site, but leave behind any Contractor’s Equipment which the Employer instructs is to be used until the completion of the Works.

There is no provision that the Employer can sell the Contractor’s Equipment in order to recover a debt due nor is there any arrangement to pay hire charges from the date of termination.

In the Blue Book Notes for Guidance (12.3) it states in respect of insolvency (FIDIC 2006, p. 33):

“The right of the Employer to retain the Contractor’s Equipment may clash with the right of the liquidator or receiver to realize the assets of an insolvent Contractor. Reference to the applicable laws, both in the country of the project and in the insolvent Contractor’s country, would be necessary”.

**CONCLUSIONS**

Vesting of Plant provisions have come a long way since their initial use in the ICE Conditions of Contract and their later adoption by FIDIC. Smith v. Bridgend County Borough Council demonstrates that whilst the right of the Employer to use the Contractor’s Equipment to complete the Works following contract termination is a contract requirement and is legally enforceable, any right to sell the Contractor’s equipment to recover debt is likely to fail.

The dredging industry has urged the removal of the more draconian vesting provisions from international contracts such as FIDIC. Nonetheless, dredging contractors should remain vigilant that vesting provisions still exist in the construction market and that payment for use of Contractor’s Equipment following termination is not dealt with in either the new FIDIC rainbow suite nor included in the more recent Form of Contract for Dredging and Reclamation Works.

Employers who are concerned as to the possibility of contractor default or insolvency are advised to review either their own or standard termination clauses and consider recourse to other forms of contract security as they will not be entitled to sell the Contractor’s equipment in order to recover a debt due.

Employers are also advised to consider wording similar to FIDIC 4th Edition Clause 54.5 to secure that any hired equipment may be used to complete the Works following termination of the Contract for contractor’s default. Contractors will also benefit from such wording as there is an arrangement whereby the Contractor’s Equipment will be paid for should the Employer use it.

**REFERENCES**


House of Lords Judgment Index http://www.publications.parliament.uk/pa/id200102/ljudgmt/jd011108 smith-1.htm

ABSTRACT

A new design approach and offshore marine operations have been developed for the construction of the foundations for the first phase of the Thornton Bank Offshore Wind Farm, located some 30 km off the Belgian Coast. In contrast to the monopile foundations commonly applied to offshore wind farms, a novel Gravity Base Foundation (GBF) concept has been selected as the result of an extensive risk assessment and technical evaluation.

Innovative dredging technologies play a key role in the realisation of these foundations. Concrete caisson foundations for offshore wind turbines have traditionally been applied in near-shore wind farm projects, in relatively shallow and sheltered waters as they were believed to become uneconomical and technically too difficult with increasing water depths.

The Thornton Bank project owner has opted for the latest generation 5MW wind turbine generators (WTGs). This first offshore application at this exceptional scale represented a significant leap for the offshore wind industry and also required a different approach for the foundation structures. The large water depths up to 28 m, the harsh North Sea environment and complex soil conditions led to a monopile basic design with excessive diameters and wall thicknesses. The general increase in steel prices on world markets and the concerns raised with regard to the feasibility of pile driving gave advantage to the choice of the GBF.

The versatility of a GBF versus a monopole also resulted in less sensitivity of the design with regard to a particular type of WTG. The detailed design resulted in a slim concrete structure with a shape that can best be compared to an “Erlenmeyer” or a champagne bottle.

The construction works offshore started with the dredging of foundation pits to create a foundation level that safely caters for the movements of the surrounding sand dunes. Afterwards, the installation of a two-layer gravel bed within very narrow vertical tolerances created the subfoundation on which the GBF is installed. The latter installation and positioning works were performed by a twin shear leg crane heavy lift vessel, which loaded the GBF from the onshore construction yard for subsequent transport to the offshore site.

Following installation of the GBFs, the foundation pits were backfilled by means of a purpose-built backfill spreader barge fed by a trailing suction hopper dredger. The same multi-purpose barge is also fitted with dedicated installations for the ballast infill of the GBF and the installation of a two-layer scour protection system around the GBF.

The development of the offshore wind turbine support structure for the Thornton Bank Offshore Wind Farm demonstrates that the economic operating range of offshore wind farms can be significantly extended by innovative design and state of the art marine construction technologies, which build upon extensive experience gained in the dredging and marine construction industries. This article was first presented at the CEDA Dredging Days 2008 and is published here in a slightly revised form with permission.
INTRODUCTION

Concrete caisson foundations for offshore wind turbines have traditionally been applied for wind farms close to shore, in relatively shallow and sheltered waters. Steel monopiles on the other hand have become the semi-standard solution for North Sea offshore wind farm developments to date.

The present article deals with the design and construction of the Gravity Base Foundations (GBFs) for the Thornton Bank Offshore Wind Farm, located some 30 km off the Belgian Coast. The project owner has opted for the latest generation of offshore wind farm developments to date.

The Thornton Bank Wind Farm is the first offshore wind farm in Belgian waters (Figure 1). The project has been developed by C-Power, a project development company owned by a variety of shareholders with different backgrounds. These shareholders are DEME, a Contractor Group specialising in the fields of dredging and marine construction, SRIW Ecotech Finance, the Environmental Holding Company of Walloon Investment Company, SOCOFE, the Investment Company of the public administrations of the Walloon Region, NUHMA, an Investment vehicle for the participation in electricity and utility ventures and EDF Energies Nouvelles, a private company in which EDF holds 50% of the shares.

This results in 2 sub-areas, A and B, across which a total of 60 Wind Turbine Generators (WTGs) are planned. Sub-area A is intended to accommodate 24 WTGs (4 rows of 6 WTGs each), whilst sub-area B caters for 36 WTGs (6 rows of 6 WTGs each). Sub-area A is located to the West of the Concerto South 1 telecommunications cable and sub-area B to the East of the Interconnector Gas Pipeline.

During the first phase of the project, 6 WTGs were built on row D of sub-area A. The distance between these WTGs is 500 metres. The selected WTG is the Repower 5M model with a rotor diameter of 126 m, one of the largest and most powerful wind turbines in the world.
 Kenny Peire

 Graduated in 1995 as an MSc in Civil Engineering and worked as a Project Engineer on the master plan for safeguarding Venice before joining DEME in 1997 as a Superintendent. He then became Project Manager for offshore oil & gas projects and coordinated tenders in a variety of disciplines and business areas. For the realisation of the first phase of the Thornton Bank Offshore Wind Farm he was Project Manager Marine Operations. At present he is Engineering Manager for the second phase of the project.

 Hendrik Nonneman

 Graduated in 1992 as an MSc in Tropical Agriculture working on African development and irrigation projects before joining Dredging International in 1998 as a Project Engineer. His assignments were in dredging, remediation, wreck removal and reclamation works in Europe. He then joined the Research Method and Estimating Department, Benelux Division. He was Tender Coordinator and Design Coordination Manager for the first phase of the Thornton Bank Offshore Wind Farm and is presently Project Coordinator for Design and Build Projects in general and for Offshore Wind Farm Projects in particular.

 Eric Bosschem

 Graduated as an MSc in Electro-mechanical Engineering and joined DEME’s Technical Department in 1976 to manage maintenance and repair for several dredgers. Since 1980 he has managed diverse projects. As General Project Manager for the Thornton Bank Offshore Wind Farm he is responsible for the construction of the Gravity Base Foundations and associated Electrical Infrastructure. He previously held similar positions for the New Doha International Airport platform project and marine infrastructure works at Le Havre’s Port 2000 container terminal development.

 Specifically designed for offshore installation. The rated power of the WTG is 5MW, which is achieved at a rated wind speed of 13.0 m/s. Cut-in wind speed (at which the WTG starts power production) is 3.5 m/s (Beaufort scale 3), whilst cut-out speed is 30.0 m/s (Beaufort scale 11).

 Power production is controlled by electrical blade angle adjustment, resulting in pitch and speed control. The rotor consists of 3 blades, each of 61.5 m vane length and rotates at 6.9 – 12.1 rotations per minute. 33kV in-field cables ensure the connection between the turbines; a 150kV cable ensures the connection to shore.

 The total investment for the first phase of the project amounts to approximately €150 million, whilst the overall project is anticipated to require an investment of €850 million. Part of the investment of the first phase is to be depreciated over the entire project. The expected annual generation capacity of the wind farm matches 6% of the total Belgian household consumption.

 Contract Strategy

 A multi-contract strategy has been adopted for the realisation of the first phase of the project. This approach was the result of a number of tendering exercises, cumulating into the award, in spring 2007, of three main contracts with following scope:

 - The first contract has been awarded to Seawind, a consortium between Dredging Marine and Electrical Infrastructure Works (MEC)
 - Design, Supply, Transport and Installation of the WTGs (WTC)
 - Supply and connection of the marine export (150kV) and in-field (33kV) power cables (ABB)

 International and Fabricom GTI, whilst the second and third contracts have been awarded to REpower and ABB respectively. The Marine and Electrical Contract (MEC) between the Seawind consortium and C-Power is of an Engineering, Procurement and Construction (EPC) nature and includes, among others, the detailed design and construction of the Gravity Base Foundations (GBFs). Within the consortium, Dredging International is in charge of all marine infrastructure works, whilst the transformer station and cable works onshore are for account of Fabricom GTI.

 The detailed design of the GBFs has been performed on behalf of Dredging International by the Danish engineering consultancy COWI. It includes, among other things, the design of the concrete structures and appurtenances, the design of the gravel beds on which the GBFs are placed and the design of the ballast infill of the GBFs.

 The detailed design has been developed on the basis of the Final Design Basis (FDB) and of the Basic Design (BD) prepared by the Owner’s Engineer (OE), in which the overall layout and dimensions of the support structures were defined. The Owner’s Engineer (OE) is a joint venture between Technum and IMDC from Belgium and DONG Energy from Denmark.

 Other parties involved in the project are DNV Danmark A/S as the Project Certification body and SECO (Technical Control Bureau for construction) with regard to the ten-year liability insurance policy.

 The project was financed through a non-recourse project-financing scheme with DEXIA as Mandated Lead Arranger and Rabobank as Mezzanine Lender. This approach resulted in the involvement of Mott MacDonald as Lenders’ Engineer, to which C-Power reports on a monthly basis.

 The weather risk included in the contract price is based on average weather statistics and workability criteria for the vessels envisaged for the execution of the works. Actual reimbursement of weather downtime is based on equipment day rates and effectively incurred weather delays. For each major vessel, criteria have been established beyond which reimbursement of vessel downtime is granted, provided that the vessel was operational and ready to work and did indeed incur downtime as a result of inclement weather conditions.
A thorough site investigation programme was performed in 2004, consisting of a geotechnical and a geophysical part. The six turbine locations of phase 1 were covered, including the offshore transformer station and the cable trajectories offshore and onshore.

The geotechnical investigation comprised borings with undisturbed sampling, borings for pressure meter testing and cone penetration tests with the measurement of pore water pressures (CPTU), all performed from a jack-up platform. In addition, vibrocore borings and seabed CPTUs were performed from a work vessel. An extensive laboratory testing programme was performed by the Geotechnical Division of the Ministry of Mobility and Public Works of the Flemish Government.

The geophysical investigation consisted of bathymetric surveys of the seabed using Multi Beam Echosounder (MBE), Side Scan Sonar Surveys (SSS) to obtain a morphological image of the seabed and to detect any obstacles present, Seismic Surveys to assess the subsoil’s Quaternary and Tertiary layers and Magnetometric Surveys to detect any metallic objects (wrecks, anchors, UXO,...) at or below the seabed.

A 3D geological model was established on the basis of the seismic results, calibrated using the data from the geotechnical campaign. In general the following soil layers can be distinguished (from top to bottom):
- Coarse to medium dense sand with a gravelly horizon at the bottom, thickness 10 metres
- Stiff clay (tertiary layer), at the bottom a transition to more silty or sandy material, thickness 10 metres
- Dense sand, slightly silty to clayey, thickness 3 metres
- Very to extremely dense (aged) slightly silty to clayey fine sand with seams or pockets of clay, thickness 8 metres
- Stiff tertiary clay down to the end of the boreholes.

DESIGN

The design life requirements are 30 years for the foundations and 20 years for the WTG components (tower, rotor, turbine generator system).

The versatility of a GBF versus a monopole foundation structure results in a design that is less sensitive to a particular type of WTG. Furthermore, the presence of a homogeneous very dense fine sand layer at approximately 28 metres below the seabed, resulted in significant basic dimensions for the monopiles and associated concerns with regard to driveability and cost, also as a result of the increase in steel prices on world markets. Following an extensive risk assessment and technical evaluation, the monopile foundation concept, which was considered in parallel with the gravity base structures in the basic design stages, was ruled out.

The GBFs are designed as concrete caisson structures ballasted with infill material (Figure 2). The foundation level (i.e. the level of the bottom slab of the GBF) differs from location to location as indicated in Table I. All levels are referenced to the Belgian reference system TAW. In sub-area A, TAW is located 0.18 m below MLLWS, and 2.29 m below MSL. The tidal range is approximately 4 metres at spring tide.
performed by C-Power as Project Owner, taking into account the anticipated maintenance of these protective rock berms. This was an iterative process as the Owner’s Engineer’s assessment of the scour protection system had to incorporate feedback from COWI’s geotechnical design. A similar iterative process resulted in the detailed design of the sand-backfill of the dredged foundation pits, an activity to be performed directly after the installation of each GBF and prior to the installation of the scour protection system.

CONSTRUCTION OF THE GRAVITY BASE FOUNDATIONS

Construction of the GBFs was performed at a dedicated yard located at the “Halve Maan” site on the eastern side of the access channel to the port of Ostend. The Port of Ostend has provided the site in concession to C-Power, whilst the Maritime Access Division, a division of the Ministry of Mobility and Public Works of the Flemish Government, provided the quay facilities (Figure 3).

The site has been upgraded to accommodate the GBFs and now allows for design loads of 10 tonne/m². To achieve this, over 800 concrete piles were driven into the soil, which is further covered with a 0.75 m thick layer of reinforced concrete. The quay wall has been upgraded and now safely allows for the mooring of the Heavy Lift Vessel (HLV) Rambiz, which performed the lift off, transport to site and installation of the GBFs.

On the “Halve Maan” site, construction of the GBFs was performed at 6 pre-defined positions. At each of these locations, concrete beams supported the base plate of the GBF. These beams allowed the passage underneath the base plate of Self Propelled Modular Trailers (SPMTs), which transported the GBFs from their construction position towards the quay platform for lift-off by the HLV Rambiz.

Table I. Gravity Base Foundations by location.

<table>
<thead>
<tr>
<th>GBF #</th>
<th>Foundation level (m TAW)</th>
<th>Reference Seabed Level (m TAW)</th>
<th>GBF Height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>-21.50</td>
<td>-18.00</td>
<td>38.50</td>
</tr>
<tr>
<td>D2</td>
<td>-23.50</td>
<td>-20.00</td>
<td>40.50</td>
</tr>
<tr>
<td>D3</td>
<td>-26.00</td>
<td>-22.50</td>
<td>43.00</td>
</tr>
<tr>
<td>D4</td>
<td>-26.00</td>
<td>-22.50</td>
<td>43.00</td>
</tr>
<tr>
<td>D5</td>
<td>-27.00</td>
<td>-23.50</td>
<td>44.00</td>
</tr>
<tr>
<td>D6</td>
<td>-27.00</td>
<td>-23.50</td>
<td>44.00</td>
</tr>
</tbody>
</table>

The platform (or transition) level of each GBF is at TAW + 17.00 m. The WTG hub height is established at TAW + 94.00 m.

The reference seabed level (RSBL) at a given foundation location is defined as the minimum level or design seabed level (SBL) that can be guaranteed during the lifetime (30 years) of the foundation, considering the mobility of sand waves and natural erosion and accretion. The RSBL is determined as the minimum SBL in a circular area of diameter 75 m, reduced with 0.75 m. At each location, foundation level is taken 3.50 m below RSBL, whilst backfill of the foundation pits is defined up to RSBL.

Each GBF consists of a base plate, a conical section, a cylindrical section, and a top platform. The ring-shaped base plate has an outer diameter of 23.50 m, an inner diameter of 8.50 m and a height of 1.265 m average. The conical GBF section extends 17.00 m (measured vertically) from the base plate, where it starts with a diameter of 17.00 m. The cylindrical section has an outer diameter of 6.50 m. The overall wall thickness is 0.50 m. The transition between the cylindrical and the conical section is at all times well below water, thus catering for safe mooring conditions for the maintenance vessels during the operational phase of the wind farm.

For accumulated effects of creep and settlement for the GBF, an off-vertical tilt of 0.25° is considered as design criterion. This corresponds to the difference between total design tolerance (1.00°) and installation tolerance (0.75°) of the GBF, whilst for the turbine towers, these values become 0.50° and 0.25° respectively.

The design of the scour protection system around the GBF structures has been performed by C-Power as Project Owner, taking into account the anticipated maintenance of these protective rock berms. This was an iterative process as the Owner’s Engineer’s assessment of the scour protection system had to incorporate feedback from COWI’s geotechnical design. A similar iterative process resulted in the detailed design of the sand-backfill of the dredged foundation pits, an activity to be performed directly after the installation of each GBF and prior to the installation of the scour protection system.

CONSTRUCTION OF THE GRAVITY BASE FOUNDATIONS

Construction of the GBFs was performed at a dedicated yard located at the “Halve Maan” site on the eastern side of the access channel to the port of Ostend. The Port of Ostend has provided the site in concession to C-Power, whilst the Maritime Access Division, a division of the Ministry of Mobility and Public Works of the Flemish Government, provided the quay facilities (Figure 3).

The site has been upgraded to accommodate the GBFs and now allows for design loads of 10 tonne/m². To achieve this, over 800 concrete piles were driven into the soil, which is further covered with a 0.75 m thick layer of reinforced concrete. The quay wall has been upgraded and now safely allows for the mooring of the Heavy Lift Vessel (HLV) Rambiz, which performed the lift off, transport to site and installation of the GBFs.

On the “Halve Maan” site, construction of the GBFs was performed at 6 pre-defined positions. At each of these locations, concrete beams supported the base plate of the GBF. These beams allowed the passage underneath the base plate of Self Propelled Modular Trailers (SPMTs), which transported the GBFs from their construction position towards the quay platform for lift-off by the HLV Rambiz.

Table I. Gravity Base Foundations by location.

<table>
<thead>
<tr>
<th>GBF #</th>
<th>Foundation level (m TAW)</th>
<th>Reference Seabed Level (m TAW)</th>
<th>GBF Height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>-21.50</td>
<td>-18.00</td>
<td>38.50</td>
</tr>
<tr>
<td>D2</td>
<td>-23.50</td>
<td>-20.00</td>
<td>40.50</td>
</tr>
<tr>
<td>D3</td>
<td>-26.00</td>
<td>-22.50</td>
<td>43.00</td>
</tr>
<tr>
<td>D4</td>
<td>-26.00</td>
<td>-22.50</td>
<td>43.00</td>
</tr>
<tr>
<td>D5</td>
<td>-27.00</td>
<td>-23.50</td>
<td>44.00</td>
</tr>
<tr>
<td>D6</td>
<td>-27.00</td>
<td>-23.50</td>
<td>44.00</td>
</tr>
</tbody>
</table>
The weight of each individual GBF varies between 2,800 and 3,000 tonnes. Per GBF, an average of 1,085 m³ of concrete was used and some 215 tonnes of reinforcement steel. The concrete complies with compression strength class C45/55, environment class ES4 and consistency class S3. Gravel used in the concrete has a 0-22 mm grading, whilst the cement type is Cem III HSR 42.5 LA. Cement was used at a ratio of 450 kg/m³, with a water/cement factor of 0.36. Post-tensioning tendons, 32 pieces, each of 1770 MPa tensile strength, are applied between platform level and anchorage blockouts on the lower part of the inner side of the conical section.

The construction of the GBFs was performed by MBG as a sub-contractor to Dredging International. An average of 135 working days was required for completion of each GBF.

**DREDGING OF FOUNDATION PITS**

At each offshore turbine location, a foundation pit was dredged to a depth of some 7 metres below the surrounding seabed. The target level for these dredging works was 1.30 metres below the target foundation level, which in turn was subsequently obtained through the construction of gravel foundation beds.

The foundation pits measured 50 m x 80 m at the bottom and had slopes of 1:8 along the main axis and of 1:5 across the width.

The weight of each individual GBF varies between 2,800 and 3,000 tonnes. Per GBF, an average of 1,085 m³ of concrete was used and some 215 tonnes of reinforcement steel. The concrete complies with compression strength class C45/55, environment class ES4 and consistency class S3. Gravel used in the concrete has a 0-22 mm grading, whilst the cement type is Cem III HSR 42.5 LA. Cement was used at a ratio of 450 kg/m³, with a water/cement factor of 0.36. Post-tensioning tendons, 32 pieces, each of 1770 MPa tensile strength, are applied between platform level and anchorage blockouts on the lower part of the inner side of the conical section.

The construction of the GBFs was performed by MBG as a sub-contractor to Dredging International. An average of 135 working days was required for completion of each GBF.

**DREDGING OF FOUNDATION PITS**

At each offshore turbine location, a foundation pit was dredged to a depth of some 7 metres below the surrounding seabed. The target level for these dredging works was 1.30 metres below the target foundation level, which in turn was subsequently obtained through the construction of gravel foundation beds.

The foundation pits measured 50 m x 80 m at the bottom and had slopes of 1:8 along the main axis and of 1:5 across the width.

These dimensions, combined with the orientation of the pits (heading +/- NE-SW along the main axis), were inspired by the prevailing current directions.

Dredging of the foundation pits was executed in two stages, using the recently commissioned, state of the art trailing suction hopper dredger (TSHD) *Brabo* with an 11,650 m³ hopper capacity (Figure 4): 1st stage: *Bulk dredging*: removal of the sand dunes and the top layer of the foundation pit. 2nd stage: *Precision dredging*: removal of the bottom layer of the foundation pit (a layer thickness of approximately 1 metre) to realise a surface within specified vertical tolerances.

Precision dredging was only executed in favourable sea conditions in which the vertical movement of the drag head of the TSHD was limited. Multi-beam echosounder (MBE) surveys, performed from a dedicated survey launch, were scheduled at least once a day per foundation pit in order to closely monitor progress and accuracy.

All dredged materials consisted of medium loose to very dense sands, which were disposed of within the concession area at 3 disposal locations, each at some 300 metres from the foundation pits. In order to limit dispersal of materials, these disposal locations were defined between the crests of the sand dunes that are present in the area. The identification of these locations was subject to approval of the authorities (MUMM) and duly considered the recommendations of the EIA. Disposal of the materials was performed through the bottom doors of the TSHD.

Part of these dredged materials, placed within the disposal areas, subsequently served a dual purpose:
1. As backfill materials for the backfilling of the foundation pits following the installation of the GBFs.
2. As ballast infill materials within the GBFs.

On average, some 90,000 m³ were dredged per foundation pit.

**INSTALLATION OF FOUNDATION BEDS**

As one of the most important interfaces in the project, the foundation bed ensures that the stresses induced in the base plate of the GBF remain within acceptable limits. The foundation bed also creates a first, crucial level for achieving the specified verticality of the turbine towers and further ensures that the weight of each GBF is properly transferred to the subsoil.

The foundation beds consist of two layers: a circular filter layer from the dredged level up to 0.55 m below foundation level, followed by a circular gravel layer up to target foundation level. Specifications were as in Table II.

The installation of the foundation beds was performed using the Dynamically Positioned Fallpipe Vessel (DPFV) *Seahorse*. The vessel is a DP Class 2 vessel with a rock loading capacity of 18,000 tonnes.

Figure 4. TSHD *Brabo* lowering her draghead.

Figure 5. Visualisation of D1 foundation bed level, 1.30 m above the surrounding bottom of the dredged pit (4x enhanced vertical scale)
used their hydraulic suspensions to lift the GBFs from these supporting beams.

SPMTs constitute a grid of several dozen computer-controlled wheels, in order to evenly distribute weight and to steer accurately. Each individual wheel can swivel independently from the other wheels, to allow the SPMT combination with the GBF to turn, move sideways, or even spin in place. A combination counting 112 axle lines, each capable of carrying 30 tonnes, was deployed to perform the onshore transport. This combination consisted of 3 trains of 24 axle lines and 2 trains of 20 axle lines. The GBFs were carried towards the quay wall at a very low speed, controlled by a centralised computer system.

Once the SPMTs had reached the quay wall, the GBF was released for lift off by the HLV Rambiz. Lifting of the GBFs was achieved using a purpose-built lifting frame catering for the safe transfer of loads between the suspended GBF and the Rambiz (Figure 6).

Purpose-designed lifting lugs were integrated in the GBF structure. The connection with the crane hoisting wires was via custom-made hydraulic pin release mechanisms, which were released once the structure was placed onto the seabed. This mechanism allows for safe installation procedures without the need for diver interventions.

An almost perfectly horizontal surface of the gravel layer was achieved on all foundation beds, whereas an allowance for tilt of 0.75° was included in the design. At 30 km from the shore, and in water depths of almost 30 metres, this is a unique achievement, especially considering the dimensions of the surfaces (approximately 700 m², equivalent to two adjacent basketball fields) (Figure 5).

**HEAVY LIFT, TRANSPORT AND OFFSHORE INSTALLATION OF THE GBFs**

The GBFs have been designed bearing in mind a lift-off from the quay by means of the Heavy Lift Vessel (HLV) Rambiz.

Prior to lift-off, an onshore transport from construction position towards the quay platform needed to be performed. This was achieved by means of Self Propelled Modular Trailers (SPMTs). The SPMTs were driven underneath the GBFs, in between the concrete supporting beams designed to accommodate these vehicles. They then used their hydraulic suspensions to lift the GBFs from these supporting beams.

Gravel complying with specific grading envelopes was loaded at Norstone’s Dirdal quarry near Stavanger in Norway. An average of 2,500 tonnes of filter layer material and 1,200 tonnes of gravel layer material was placed per location.

Gravel placement with a DPFV is achieved by transferring gravel from the vessel’s holds into a fallpipe system that can be accurately steered by means of a Remotely Operated Vehicle (ROV) equipped with thrusters. The fallpipe ROV (FPROV) is also equipped with state of the art survey equipment (including Multi Beam Echosounders) and cameras, which allow to verify and monitor progress of the works and to document the as-built status. All survey operations were performed and processed on board of the vessel.

Gravel was placed following pre-defined tracks. Once the required volume of material was placed, precision levelling was achieved with a purpose-designed levelling tool. This ensured the levelling of local overfills on the surfaces of both layers. The tool was attached to the lower end of the fallpipe and was carefully dragged across the area until the installation tolerances were achieved.

An almost perfectly horizontal surface of the gravel layer was achieved on all foundation beds, whereas an allowance for tilt of 0.75° was included in the design. At 30 km from the shore, and in water depths...
Backfill operations around the GBF structures were performed with sands dredged from the nearby disposal areas, which originated from the dredging of the foundation pits. Specifications for the backfill were as in Table III.

The requirement for a very low fines content was achieved by using sand that has been dredged twice (once during the dredging of the foundation pits, and once when dredging the same materials from the disposal areas for backfilling purposes) by means of TSHDs. Each time the material

Prior to lift off, the GBFs were physically weighed with an accuracy of less than 0.5% in order to be sure that the weight requirements for the Rambiz were met and to determine the structures’ Centre of Gravity (CoG). This allowed for a site decision whether the GBFs would be installed heading NW or SE. It was preferred to have the CoG nearer to the Rambiz as this allowed for verticality correction by means of the tugger lines.

During the engineering phase, extensive physical model tests were carried out by the Danish Hydraulic Institute (DHI), whilst numerical modelling was performed by MARIN. Dedicated current measurement campaigns were performed prior to and during the installation works in order to compare the actual conditions on site against the models. The entire operation has been scrutinised by DNV as Marine Warranty Surveyor for the project.

**BACKFILL OF FOUNDATION PITS**

Backfill denotes the filling of the dredged foundation pits following the installation of the GBFs. The requirement for backfilling is dictated by the geotechnical stability of the structures. As a result, erosion protection is equally important to ensure that the required amount of backfill material can be guaranteed throughout the design life of the structures.
Gravity Base Foundations for the Thornton Bank Offshore Wind Farm

The Vlaanderen XXI is a 1,750 m³ TSHD that was recently converted for supplying marine sand and aggregates for the building materials market. As a result, it is provided with on board drainage pumps to drain the dredged mixture and with a materials handling crane for offloading the materials to shore or onto other vessels or barges. For the purposes of the hydraulic infill works, the Vlaanderen XXI moored alongside the Thornton 1, each time positioned adjacent to one of the GBF structures, for transfer of the materials into the hold of the barge.

Pumping of sand from the Thornton 1 into the GBF was performed in a controlled way, limiting the pump flow. For structural design reasons, the mixture density was to be kept below 13 kN/m³. In order to bridge the difference in level between the deck of the Thornton 1 (level fluctuating with the tidal range) and the top of the GBF (level +17 m TAW), an infill tower was conceived, reaching several meters above the top of the GBF.

A total volume of approximately 2,000 m³ was required for the infill of each GBF. Two hopper loads of the Vlaanderen XXI were required to achieve this. The GBFs were filled hydraulically up to the target level of +14.50 m TAW, following which the infill mass was drained down to MSL. When the water level inside the GBF

BALLAST INFILL

The requirement for ballast infill of the GBF also originates from the geotechnical design. The required amount of infill is closely linked with the design of the backfill and, as a result, with the design of the erosion protection that covers the backfill. Design assumptions for the infill sands were unit weights of 15.80 and 19.24 kN/m³ for sand above, respectively below water level. Laboratory tests on dredged sand samples confirmed these assumptions to be conservative.

The infill of the GBFs was executed in 2 stages:
1. Hydraulic infill: Materials dredged at the disposal locations by means of the TSHD Vlaanderen XXI were pumped into the GBF via a dedicated infill tower on board of the Thornton 1.
2. Dry infill: Upon completion of the hydraulic infill and settlement of the materials, dry infill was executed with sands.

The hydraulic infill activities were separated into two distinct phases:
1. Dredging of the infill materials by means of the TSHD Vlaanderen XXI, and
2. Subsequently the hydraulic pumping of the materials into the GBF using the multi-purpose barge Thornton 1, previously deployed for the backfilling works.

Determination of these tracking speeds occurs in a dynamic and fully automated fashion by a dedicated computer system that controls the barge’s winches. The Thornton 1 is kept in position using six (6) hydraulic winches in combination with anchor wires connected to 7 and 12 tonnes flipper delta anchors previously installed at strict pre-defined locations. The system is capable of holding the barge in a very stable position regardless of the swell and current conditions.

The quantity of backfill material required per foundation pit was on average 60,000 m³, or the equivalent of 24 loads of the TSHD Jade River.
The required extent of this protection is closely linked with the geotechnical design and is summarised in Table IV.

At the 33 and 150kV cable bellmouth locations, where these cables enter the GBF structures, the design caters for the armour layer to be placed after the installation of the cables. The armour layer at these locations was further extended (10 m wide stretches extending 15 m from the edge of the scour protection system) to provide additional cover of the cable in the transition area between the edge of the scour protection system and the trenched cable (Figure 11). Specifications of the scour protection system are shown in Table V.

With the aim of processing standard quarry products, quarry run 0/120 mm was agreed to be used for the filter materials, whilst the armour grading was achieved using a 20%-80% mixture of 5-40 kg and 40-200 kg products respectively. Both products consisted of hard, compact limestone rock produced at Carrières Lemay. The materials were transported by trucks to a temporary storage and rehandling yard in the port of Zeebruges.

The Vlaanderen XXI was again used for supplying the rock materials from the stockpile area in the port of Zeebruges towards the Thornton 1, which in turn was equipped as a fallpipe barge for these works.

The barge’s position-tracking features and automotive movements along pre-defined tracks are also available in “fallpipe mode”. A belt weighing device is included in the system, allowing the continuous monitoring of the rock quantities transferred and installed. This data serves as input for the computer-controlled movements of the barge along pre-defined rock placement tracks.

### Table III. Specifications for the backfill.

<table>
<thead>
<tr>
<th>Material characteristics</th>
<th>Sand from the Thornton Bank, D50 &gt; 200μm, silt content &lt;2%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top level of the backfill</td>
<td>Up to Reference Seabed Level (RSBL)</td>
</tr>
<tr>
<td>Extent of the backfill</td>
<td>Covering the full surface of the dredged foundation pits.</td>
</tr>
</tbody>
</table>

### Table IV. Required filter and armour layer for scour protection.

<table>
<thead>
<tr>
<th>GBF #</th>
<th>RSBL (top of backfill) (m TAW)</th>
<th>Crest diameter for the armour layer</th>
<th>Crest diameter for the filter layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>-18.00</td>
<td>44.0 m</td>
<td>48.5 m</td>
</tr>
<tr>
<td>D2</td>
<td>-20.00</td>
<td>44.0 m</td>
<td>48.5 m</td>
</tr>
<tr>
<td>D3</td>
<td>-22.50</td>
<td>44.0 m</td>
<td>48.5 m</td>
</tr>
<tr>
<td>D4</td>
<td>-22.50</td>
<td>50.0 m</td>
<td>54.5 m</td>
</tr>
<tr>
<td>D5</td>
<td>-23.50</td>
<td>51.0 m</td>
<td>55.5 m</td>
</tr>
<tr>
<td>D6</td>
<td>-23.50</td>
<td>58.0 m</td>
<td>62.5 m</td>
</tr>
</tbody>
</table>

### Table V. Specifications of the scour protection system.

<table>
<thead>
<tr>
<th>Filter layer (installed on top of the sand backfill)</th>
<th>Crushed gravel 10/80 mm D50 = 50 mm; wide gradation D85/D15 &gt; 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td></td>
</tr>
<tr>
<td>Layer thickness</td>
<td>min. 0.60 m</td>
</tr>
<tr>
<td>Armour layer (installed on top of the filter layer)</td>
<td>Quarried rock 10/200 kg D50 = 350 mm; wide gradation D85/D15 &gt; 5</td>
</tr>
<tr>
<td>Material</td>
<td></td>
</tr>
<tr>
<td>Layer thickness</td>
<td>min. 0.70 m</td>
</tr>
<tr>
<td>Top level</td>
<td>Reference Seabed Level + 1.30 m / + 1.45 m</td>
</tr>
</tbody>
</table>

had decreased and the sand had further settled, dry infill (using dredged sand) was used to make up for the loss of volume and to complete the infill up to the design level of +14.50 m TAW. These dry infill works were performed as a separate activity using the jack-up platform that was deployed at a later stage for the levelling and grouting of the transition piece on each GBF.

For GBF D6, the entire infill operation was performed using “dry materials”. This approach was adopted since, as a result of slightly less favourable underlying soil conditions, the geotechnical design called for part of the infill to be performed with heavy minerals. Infill with these heavy ballast materials was performed first as bottom fill, whilst the remaining infill was executed with dredged sands up to final level. All operations at GBF D6 were performed from a jack-up platform. The same infill approach was to a certain extent adopted at some of the other locations in these instances, however, dictated by operational priorities.

### SCOUR PROTECTION

Around each GBF, a scour protection system has been conceived, providing protection for the backfill materials against the impact of currents and waves. The design consists of a filter and armour layer of quarried rock materials (Figure 10).

The transition level for installation of the wind turbine towers was to be provided within a tolerance of 0.25° from horizontal level which is the specified vertical
installation tolerance for the turbine towers. The transition piece of each GBF consists of a levelling flange made out of 6 segments, each supported by plastic levelling nuts. The flange is the upper part of a cylindrical “anchor cage”, consisting also of a lower flange, cast in the upper cylindrical part of the concrete structure and connected to 180pcs. 2.6 m long tensioning bolts, which are protected from the surrounding concrete by a plastic casing. The bolts pass through the transition flange, which is conceived to correct any inclination of the GBF (Figure 12).

Since the installation of all GBFs was performed well within the specifications for final inclination of the transition level, no further adjustment of the levelness of the flange was required offshore. Fine-tuning of the flange sections was performed by the WTG supplier, following which the volume between the flange and the concrete top level of the GBF was filled with a self-levelling high strength, non-shrink grout.

A jack-up platform was deployed for these operations and also catered for the execution of the remaining dry infill, the lowering of the water table inside the GBF down to MSL and the installation of the remaining appurtenances (access ladders and so on).

CONCLUSIONS

The novel Gravity Base Foundation concept developed for the Thornton Bank Offshore Wind Farm has proven to be a viable and competitive wind turbine support structure for deployment in deeper North Sea waters. Innovative design resulted in a complex matrix of interfaces from design into construction, involving not only the detailed design engineer and the Contractor, but also the Project Owner, its Engineer and certification bodies. Many aspects of the offshore execution relied upon extensive experience gained in the dredging and marine construction industries. The design has meanwhile been patented and is being considered for marketing towards other offshore wind project developers.

REFERENCES

New Opportunities - Proceedings of the 16th European-based Biennial Conference of the International Federation of Hydrographic Societies
LIVERPOOL, UK. NOVEMBER 2008.
Published by The International Federation of Hydrographic Societies on behalf of the organisers, The Hydrographic Society UK. 108 pages. Softcover. ISBN 0-9548844-4-2, ISSN 0309-8303

The 16th European biennial hydrographic conference held in November last year was attended by over 350 delegates from 18 countries. These attendees were able to benefit from 23 quality presentations from leading survey specialists in Europe, North America and Australia. The papers covered a wide range of topics, as illustrated by the Session titles:

- Introduction
- Coastal Mapping Techniques
- Data Handling and Presentation
- Tides and Currents
- Standards and Training
- The Marine Environment
- Precise Positioning
- Hydrography for Marine Renewables
- Coastal Mapping Applications

The 23 papers (20 are presented in full; 3 only in abstract form) represent a fine collection of instructive examples of work being carried out in this fast-moving field. It is always difficult to obtain a snapshot “state-of-the-art” in any technical field, as the picture is blurred by the continually improving technology and developing practice. However, these papers give a good feel for where the technology is, and where it is currently heading.

With the use of increasingly sophisticated types of instrumentation, as described in Session 1, producing large amounts of data, it should not be a shock that Session 2 is devoted to the handling and presentation of such data. Imagine one’s surprise, therefore, when the following session begins with a paper that references Sir Isaac Newton, Laplace, Lord Kelvin and other luminaries in giving the historical context of the work now being carried out in harmonic tidal theory. It is interesting to note that the power of existing personal computing systems is now so great that we are able to go back to number-crunching with all the harmonic constants for tidal prediction, rather than using the clever variations developed over the last century that permitted short cuts to be made.

Most people in the maritime world have now got their heads round the workings of Acoustic Doppler Current Profilers. The GKSS paper in Session 3 gives us an insight into how a similar technique can be applied using radar to measure sea surface currents. Not all the papers, however, are devoted to research into new techniques, and a good proportion of these proceedings cover the practical application of hydrographic measurement to the various fields of maritime and marine engineering.

From the environmental viewpoint the use of hydrographic techniques applied to detecting archaeological features and other systems being developed to identify the presence of marine mammals and coldwater corals is of great interest.

No field of technological development would be covered adequately unless it devoted some time to the standardisation of working methods and to the promotion of training within academia and the industry that it supports. Session 4 sheds some light on this.

As bathymetric instrumentation becomes more complex and abstruse it is not unusual to find that manufacturers of this gear and those using it are keen to demonstrate that a) the instruments do what they say they will do and b) they do it with adequate accuracy. These aspects are covered in Session 7 entitled “Precise positioning”. Following on from this, Session 8 shows how hydrography is being utilised in the fast developing marine renewable energy sector, whilst Session 9 highlights the application of modern hydrographic technology in the more conventional fields of mapping and providing surveys to support engineering works.

Overall the conference papers are indicative of a thriving industry, where new techniques and experiences are readily shared amongst its fraternity. For anyone interested in obtaining the flavour of modern hydrography and requiring pointers towards developments in their particular area of interest, these proceedings are a valuable asset.

Publication enquiries should be made to Helen Atkinson, Operations & Publications Manager, International Federation of Hydrographic Societies, P O Box 103, Plymouth PL4 7YP, UK (Tel-Fax: +44(0)1752 223512 E-mail: helen@hydrographicsociety.org

NICK BRAY
Creating Land for the Future
EDITED BY TOM D’HAENENS AND JEAN-MICHEL JASPERS. TEXT BY ANN MULDERS. PHOTOGRAPHY BY TOM D’HAENENS. Full colour. 288 pages. ISBN 978 90 89 31 0354. Published by Unidia, Belgium.

Whoever thinks of dredging and land reclamation as just another heavy-duty industry should take a look at the new photographic study by Tom D’Haenens with text by Ann Mulders. D’Haenens, who trained at the Academy of Art in Ghent, Belgium and in Baltimore, USA, has built his reputation on industrial and architectural photography. This book, as well as his earlier books on Brussels Airport and the Port of Antwerp, testifies to his fascination with industry and globalisation in modern society.

Turning his lens to the dredging industry, he has revealed some of the magic behind the technology. As D’Haenens explains, with all the attention spent to climate change, to the melting of the polar icecap and the rising seawater levels and to the increasing threat of disappearing beaches and coastlines, he was drawn to an industry that is trying to find engineering solutions for these environmental challenges. This interest led him to make a photographic reportage about dredging and hydraulic engineering companies that are literally working to turn the tides. Fascinated with their monumental construction projects, for nine months D’Haenens followed the tracks of one of the larger dredging companies, watching the men and women building up this new land out of water.

During D’Haenens’ world tour – because these massive works take place everywhere – he discovered that dredging is much more than reclaiming and creating new land. In the United Kingdom he saw how a desolated “brownfield” – an abandoned, polluted industrial site – was transformed into a clean site to be used for the 2012 London Olympics. In Sweden he stood in the middle of an idyllic lakescape which until a couple of years before had been a dumping site for paper pulp. Cleaning land and water is also part of the range of duties of the “creators of the land of the future”.

This oversized coffee-table book with its full colour aerial and close-up photos captures and visualises the beauty of high-tech dredging that is often overlooked. For further information contact info@tomdhaenens.com or www.tomdhaenens.com.

EDITED BY R N BRAY
Published by CIRIA. London, UK. 64 pages. B/w. Some illustrations.

Dredging is a capital-intensive industry, often taking place in inhospitable environments. Site investigation costs can be high, risks frequently require re-measurement and occasionally disputes about valuation arise. For all these reasons, the capital and related costs of equipment are crucial to estimation of the costs of a dredging project.

In 2005 CIRIA published a guide to cost standards for dredging equipment, based on then accepted criteria. The extensive changes in base costs and technological improvements over the last four years demanded that the information be revisited. This new CIRIA publication has been thoroughly revised and audited. It is aimed for use by all stakeholders, including consultants, existing and potential clients, project financiers, insurers and dredging contractors. It offers a standard method to establish the capital and related costs of various types of dredging plant and equipment commonly in use.

The research was guided by an independent steering group involved in or interested in the dredging industry. They are John Brien, Jan Koeman, Roger Maddrell, Volker Patzold, Julien De Rouck and Wim Vlasblom. Established in 1960, CIRIA is a well regarded, industry-responsive, not-for-profit research and information association. Publication enquiries in the UK should be made to enquiries@ciria.org; elsewhere to www.iadc-dredging.com.

MC
The theme of the 29th Western Dredging Association (WEDA 29) Annual Western Hemisphere Conference/Exhibition and Texas A & M’s 40th Annual Dredging Seminar (TAMU 40) is “The Importance of Dredging”. This will be a forum for discussion amongst Dredging Contractors, Port Authorities, Government Agencies, Environmentalists, Consultants, Academicians, and Civic/Ocean Engineers who work in the fields of Dredging, Navigation, Engineering, and Construction.

Topics of interest include but are not limited to: Dredging & the Economy, River and Inland Dredging, New Dredging Equipments, Surveying & Mapping, Cost Estimating, Dredging Challenges, Project Case Studies, Environmental Dredging, Dredging for Flood Control, Dredging Systems & Techniques, Numerical Modeling, Geotechnical Aspects, Superfund Projects, Dredging for Beach Nourishment, Beneficial Used of Dredge Material, and Wetland Creation & Restoration.

The International Association of Dredging Companies Best Paper Award by an author under 35 years of age for a contribution to the literature on dredging will be presented.

For further information contact:
L. M. Patella, WEDA Executive Director
P.O. Box 5797, Vancouver, WA 98668
Tel: +1 360 750 0209, Fax +1 360 750 1445
Email: weda@comcast.net
www.westerndredging.org

The World Ocean Council is organising this first ever international, cross-sectoral conference on private sector leadership and collaboration in ocean sustainability around the theme, “Reducing Risk, Increasing Sustainability”. Sessions will include: Marine Spatial Management; Responsible use of the Arctic Ocean; Finance and Insurance; Ocean Sound and Marine Life; Controlling Marine Debris at Source; Ship Strikes - Developing best practices to reduce vessel impacts on marine mammals; Recycling Ships and Ocean Structures, Sustainable Ports; Biosecurity/Invasive Species; Climate Change - Advancing global emissions reductions through cross-sectoral industry leadership and collaboration.

Participants will include senior management from shipping, oil and gas, fisheries, aquaculture, seafood, marine tourism, renewable ocean energy, ports, marine technology, seabed mining, submarine cables, insurance, finance, legal issues and other areas. The ocean business community will identify priorities for addressing ocean sustainability in support of responsible operations. These will form the basis for World Ocean Council programmes to be implemented in partnership through the growing global WOC alliance of ocean industry leaders in Corporate Ocean Responsibility.

For more information about the World Ocean Council and on-line registration see www.oceancouncil.org.

The Smart Rivers 2009 conference is being organised by TINA Vienna Transport Strategies and will include technical sessions, industry exhibits, and networking events.

The Smart Rivers ’21 is the result of the efforts of major international organisations and companies in Europe and the USA to ensure and expand the rightful place of inland water transportation in the overall volume of traffic. The signers of the initial agreement were the European Federation of Inland Ports (EFIP) and TINA Vienna with the support of Via Donau on the European side and the Ohio River Authority and the Port of Pittsburgh on the US side. Meanwhile, PIANC USA has assumed a leadership role in Smart Rivers in the USA, which led to PIANC Austria and in turn PIANC International supporting Smart Rivers.

The US Army Corps of Engineers has also become an important supporter of the Smart Rivers Initiative. Thus far there have been three conferences in Pittsburgh, Pennsylvania (2005), Brussels, Belgium (2006), and Louisville, Kentucky (2007). Vienna will host the fourth. The theme of this 4th International Congress of Smart Rivers ’21 is “The Future of Inland Navigation.”
Technical papers will address technical subjects as well as the institutional, business and economic aspects of inland waterway navigation. Scientific papers will concentrate on research and scholarship. Subjects include:

- Availability of infrastructure
- Economic development
- Climate and Environmental protection
- Water bound tourism
- Contribution of IWT to economic needs
- ICT in IWT
- Transport policy
- Impact of extreme weather conditions
- Role of ports
- Education & Training

For more information contact:
Otto Schwetz, TINA Vienna Transport Strategies
Email: otto.schwetz@tinavienna.at
www.smartrivers.org

SPE Offshore Europe
ABERDEEN, SCOTLAND
SEPTEMBER 8-11 2009

SPE Offshore Europe is the largest upstream oil and gas event outside North America, and is held every two years in Europe’s energy capital, Aberdeen. The theme of this year’s event is “Energy At A Crossroads: Making Choices”, a highly-relevant choice as the offshore industry along with many others now finds itself in a situation where very important choices need to be made to ensure long-term success. There are four main sub-themes, focusing on climate and energy, industry operating models, breakthrough technologies, and people issues.

The biennial SPE Offshore Europe conference attracts industry professionals from some 100 countries worldwide and the technical sessions are put together under the guidance of the Society of Petroleum Engineers (SPE). This year a new hall has been added to the site for which priority was given to Aberdeen-based SMEs (Small and Medium-Sized companies).

Other innovative developments will include a new feature entitled the “People Zone”, which will center on areas such as training, career development and travel. Another new addition is on the show’s final day, traditionally known as Education Day, where engineers of the future are encouraged to come learn more about the energy industry and the opportunities it holds for them. “Energize Your Future at OE” is being run in association with OPITO, the UK oil and gas industry skills academy.

For further information:
www.offshore-europe.co.uk

Coasts, Marine Structures and Breakwaters 2009 Conference
INTERNATIONAL CONFERENCE CENTRE
EDINBURGH, SCOTLAND
SEPTEMBER 16-18 2009

The conference will address the design, performance, installation and maintenance of the structures necessary to extract marine energy around nearshore seas and coasts. It will also offer new material on coasts, marine structures and breakwaters. This is the ninth conference in the international breakwaters series, which is recognised for its balanced presentations on research, design and construction with a strong emphasis on practical application

The conference will comprise technical plenary sessions with each paper introduced by the authors. Papers will be issued to registrants beforehand, to allow informed discussion during the conference.

The following themes will be covered:
Climate change and major storms; Service re-assessment and adaptation; New techniques and innovations; Construction methods, equipment and experience; Environmental and social awareness; Procurement approaches, economics and finance; Growing knowledge and understanding, and uncertainties; Emerging markets and requirements; and Analysing, refurbishing or replacing ageing infrastructure

For further information contact:
ICE Conferences and Events Department
Institution of Civil Engineers
One Great George Street,
London SW1P 3AA, UK
Tel: +44 (0)20 7665 2293,
Fax: +44 (0)20 7233 1743
Email: events@ice.org.uk
www.ice.org.uk
6th International SedNet  
HAMBURG, GERMANY  
OCTOBER 6-8 2009

This SedNet event will take place in two phases: “Sediment Management in River Basin Management Plans” will be held on October 6-7 as a Round Table discussion for invited persons and “The Role of Sediments in Coastal Management” conference will be held October 7-8 and is open to all sediment experts. Both events are hosted and co-organised by Hamburg Port Authority.

In Europe the largest amounts of sediments are dredged in the North Sea region, where the natural sediment regime leads to high sedimentation in ports, harbours and waterways. Additionally, sediments gain in importance owing to sea level rise and loss of fine-grained sediments in the Wadden Sea. Based on this background SedNet chose Hamburg as a good site, where ongoing river restoration challenges coincide with dredging needs and sediments play a central role. The region is thus a good place to discuss cross-cutting science policy issues.

For further information about SedNet and the conference visit: www.sednet.org

MTEC 2009  
DE DOELEN, ROTTERDAM, THE NETHERLANDS  
OCTOBER 21-23, 2009

The Maritime-Port Technology and Development Conference is the third in the series of conferences initiated by the Port of Rotterdam Authority and the Maritime and Port Authority of Singapore and is organised bi-annually in one of these two port cities. The following themes will be addressed: “Working together” on room for growth which includes port spatial planning and development, floating facilities and environmental zoning; on sustainable ports including climate change mitigation and adaptation, air and water quality, building with nature, clean energy, safety and security; and on accessible ports, including port infrastructure, modal split; mobility management and virtual infra/ICT.

The International Advisory Panel comes from Rotterdam, Singapore, Kenya, TU Delft and PIANC. In connection with the conference, an exhibition will be organised featuring R&D in the port and maritime industries. Technical excursions are planned for a day prior to the conference, October 20.

For further information see: www.mtec2009.com

Europort Maritime 2009  
AHoy ROTTERDAM, THE NETHERLANDS  
NOVEMBER 3-6 2009

"Connecting the Maritime World” is the theme of Europort 2009, a comprehensive international maritime exhibition. All sectors of the shipbuilding industry, from inland to sea shipping, construction vessels, naval specials, workboats and dredging, fishery and offshore, are brought together in one state-of-the-art exhibition. Europort takes place in one of the largest ports of the world – Rotterdam, and has a total exhibition space of 40,000 m² divided over 10 halls. CEDA Dredging Days Conference forms a part of the Europort events.

For further information contact: www.europortmaritime.nl  
Tel.: +31(0) 10 293 32 50  
Email: info@europort.nl

CEDA Dredging Days 2009  
AHoy ROTTERDAM, THE NETHERLANDS  
NOVEMBER 4-6 2009

The annual CEDA conference will be held November 4-6 2009 at Ahoy Rotterdam, the Netherlands. With the title “Dredging Tools for the Future”, CEDA invites stakeholders and the dredging equipment industry to present and discuss coming challenges and their suggestions for solutions. Many new possibilities have emerged since 2003, when Dredging Days focused on tools and technology.

Topics of the conference will include dredging tools and energy scarcity / high energy costs, climate change, extreme conditions, increasingly stricter environmental regulations and the dynamics of nature. The Conference and Exhibition takes place in conjunction with Europort Maritime 2009. Corporate members of CEDA are invited to sponsor the conference. Interested organisations should contact the CEDA Secretariat for information and to discuss details.
PIANC MMX
LIVERPOOL, UK
MAY 10-14 2010

The quadrennial PIANC International Navigation Congress is a leading technical forum for professionals engaged in navigation, ports and waterways. It is also a professional networking event. The 32nd Congress and 125th Anniversary celebration is to be held in the maritime city of Liverpool on the Mersey estuary in North West England. The Congress is open to all. Congress themes and topics are:

- Navigation for the future: Climate change, adaptation and mitigation and impact of ultra-large container ships, development of LNG terminals, in inland barge transport and in recreational navigation.
- Innovative design in ports and terminal infrastructures, inland waterways, locks and terminals and marinas and yacht harbours.
- Sustainable renovation: Upgrading old port areas, renovation of waterway infrastructure, ports and cities and life-cycle approach to maintenance.
- New major links and nodes: Inland waterways (incl. Seine-Scheldt), seaports and the Panama Canal.
- Working with nature: Dredging and sediments, breakwaters and shore protection and environmental management.
- Safety and security: Marine safety and risk analysis, modern mooring systems, information and communication technology and river information system.

For more information contact:
PIANC UK Section
The Institution of Civil Engineers
1 Great George Street, London SW1P 3AA, UK
Email: info@piancmmx.org.uk
www.piancmmx.org.uk

Ports 2010: Respecting the Past, Building the Future
JACKSONVILLE, FLORIDA, USA
APRIL 25-28 2010

The Ports and Harbors Committee of the American Society of Civil Engineer’s (ASCE) Coasts, Oceans, Ports, and Rivers Institute (COPRI) is pleased to announce the Ports 2010, the 12th in COPRI’s successful series devoted to port and harbor engineering. This continues ASCE’s partnership with the US Section of PIANC in the development of the ports engineering conference in the world. The conference will focus on current projects, practical issues, innovative engineering and construction, and state-of-the-art developments for port engineering. The 2010 conference will feature short courses, 36 technical sessions, keynote addresses, and social activities planned to facilitate ample professional interaction in an informal atmosphere.

The technical programme is enhanced by cooperation with the Jacksonville Port Authority (JAXPORT), a conference sponsor, which will offer technical tours of its facilities. Ports 2010 also will feature expanded programs for young professionals and students.

For further information on the conference programme contact:
Conference Organizing Committee Chairman
Dr. Stephen Dickenson,
stephen.dickenson@oregonstate.edu
Further updates are available at www.portsconference.org.

CEDA Secretariat
Radex Building, Rotterdamseweg 183c
2629 HD Delft, The Netherlands
Tel: +31 (0)15 268 2575
Fax: +31(0)15 268 2576
Email: ceda@dredging.org

The International Association of Dredging Companies Award for a contribution to the literature on dredging will be presented for the best paper of the conference by an author under 35 years of age.
CALL FOR PAPERS

Hydro9 Conference
CAPE TOWN, SOUTH AFRICA
NOVEMBER 10-12 2009

The Hydrographic Society of South Africa, on behalf of the International Federation of Hydrographic Societies (IFHS), is to stage the first African Hydro conference at Cape Peninsula University of Technology’s Cape Town Hotel School. It will feature 40 papers by leading world experts as well as an exhibition of equipment and services in addition to technical workshops and boat demonstrations.

Enhancing Global Capacity is the theme of the three-day event which will open with keynote addresses by officials of the International Hydrographic Organization and the South African Navy. Main conference topics include: Positioning, Geophysical, Metocean, Education & Standards, Data Management, Survey Platforms, Coastal Mapping, Tides & Currents, Marine Environments, Hydrography for Marine Renewables, and Case Studies.

English-language abstracts of 300 words in MS Word format for proposed presentations on any of the designated topics are now invited for submission by no later than June 15th. Abstracts should be forwarded to:

The Hydrographic Society of South Africa
PO Box 30532, Tokai, South Africa 7966
Tel: +27 21 460-3046, Fax: +27 21 460-3710
Email: admin@hydro9.co.za

Further general details on Hydro9, which will feature a wide range of social events in and around Cape Town, are available via a dedicated conference website: www.hydro9.co.za

WODCON XIX
GRAND EPOCH CITY RESORT & EXHIBITION CENTRE, BEIJING, CHINA
SEPTEMBER 8-12 2010

WODCON XIX Congress and Exhibition, with the theme, “Dredging makes the world a better place”, will be organised by EADA in association with CHIDA. The first call for papers has now been issued. Papers should cover the following suggested topics:
- Relationship between dredging and sustainable development
- Dredging technology and research
- Beneficial uses of dredged material
- Environmental aspects of dredging
- Survey and positioning technology and equipment
- Physical and numerical modeling
- Sediment dewatering, treatment and disposal
- Dredging equipment
- Dredging project case studies.

Papers should be original and not have been published previously and should be in English. 300 word Abstracts should be sent by September 30 2009 to one of the people below. Technical visits and tours will take place on September 13-14, after the Conference.

For further information contact:
Mr. Yang Zunwei,
Chinese Dredging Association CHIDA
No. 9, Dong Zhi Men Wai, Chun Xiu Road, Beijing 100027, China
Tel: +86 106 417 4496
Email: world.chida@yahoo.com.cn, www.chida.org

Capt David Padman, EADA
Tel: +60 331 688 211
Email: david@pka.gov.my

John Dobson, EADA
PO Box 388 Hamilton Central
Queensland 4007 Australia
Tel: +61 732 623 834
Email: do bsoncj@hotmail.com

CEDA Secretariat
PO Box 488
2600 AL Delft, The Netherlands
Tel: +31 (0)15 268 2575
Fax: +31(0)15 268 2576
Email: ceda@dredging.org

Dr. Ram Mohan, WEDA
Partner, Anchor Enviornmentl LLC
12 Paenns Trail Suite 138
Newtown, PA 18940 USA
Email: rmohan@anchorenv.com or

Dr. Robert Randall, Director Dredging Studies
Texas A&M University
College Station, TX 77843 USA
Email: r-randall@tamu.edu
State-of-the-art marine construction and dredging technologies played a key role in the realisation of
A new design approach called Gravity Base Foundations required innovative offshore marine operations to
environmental aspects of dredging. Developments in engineering including the technical, economic and
www.terra-et-aqua.com
www.iadc-dredging.com
+31 (0)70 352 3334

For a free subscription go to www.terra-et-aqua.com

Terra et Aqua is a quarterly publication of the International Association of Dredging Companies. It covers the fields of civil, hydraulic and mechanical engineering including the technical, economic and environmental aspects of dredging. Developments in the state of the art of the industry and other topics from the industry with actual news value will be highlighted.

As Terra et Aqua is an English language journal, articles must be submitted in English.

• In the case of articles that have previously appeared in other magazines or publications.

• Authors are requested to provide in the “Introduction” an insight into the drivers (the Why) behind the
dredging project.

• All articles will be reviewed by the Editorial Advisory Committee (EAC). Publication of an article is subject to approval by the EAC and no article will be published without approval of the EAC.

MEMBERSHIP LIST IADC 2009

The Americas

- Van Oord Australia Pty Ltd., Brisbane, QLD, Australia
- Dredging International Asia Pacific (Pte) Ltd., Singapore
- Dredging International Australia Pty Ltd., Singapore
- Van Oord Dredging and Marine Contractors bv Korea Branch, Busan, Republic of Korea
- Hyundai Engineering & Construction Co., Ltd., Seoul, Korea
- Van Oord Dredging and Marine Contractors bv Hong Kong Branch, Hong Kong, China
- Van Oord Dredging and Marine Contractors bv Singapore Branch, Singapore
- drillship Workboats
- drilling rig Workboats
- Anchor Handling Tug Supply Workboats
- Support Supply Workboats
- Casual Workboats

© 2009 IADC, The Netherlands
All rights reserved. Electronic storage, retransmitting or abstracting of the contents is allowed for non-commercial purposes with permission of the publisher.

ISSN 0376-6411

Terra et Aqua is published quarterly by the IADC, The International Association of Dredging Companies. The journal is available for free subscription at www.terra-et-aqua.com

Tema et Aqua is published quarterly by the IADC, The International Association of Dredging Companies. The journal is available for free subscription at www.terra-et-aqua.com

Through their regional branches or through representatives, members of IADC operate directly at all locations worldwide.

Downloaded from www.terra-et-aqua.com on March 5, 2023 at 22:36:00. For personal use only. No other uses without permission. All rights reserved by the publisher.