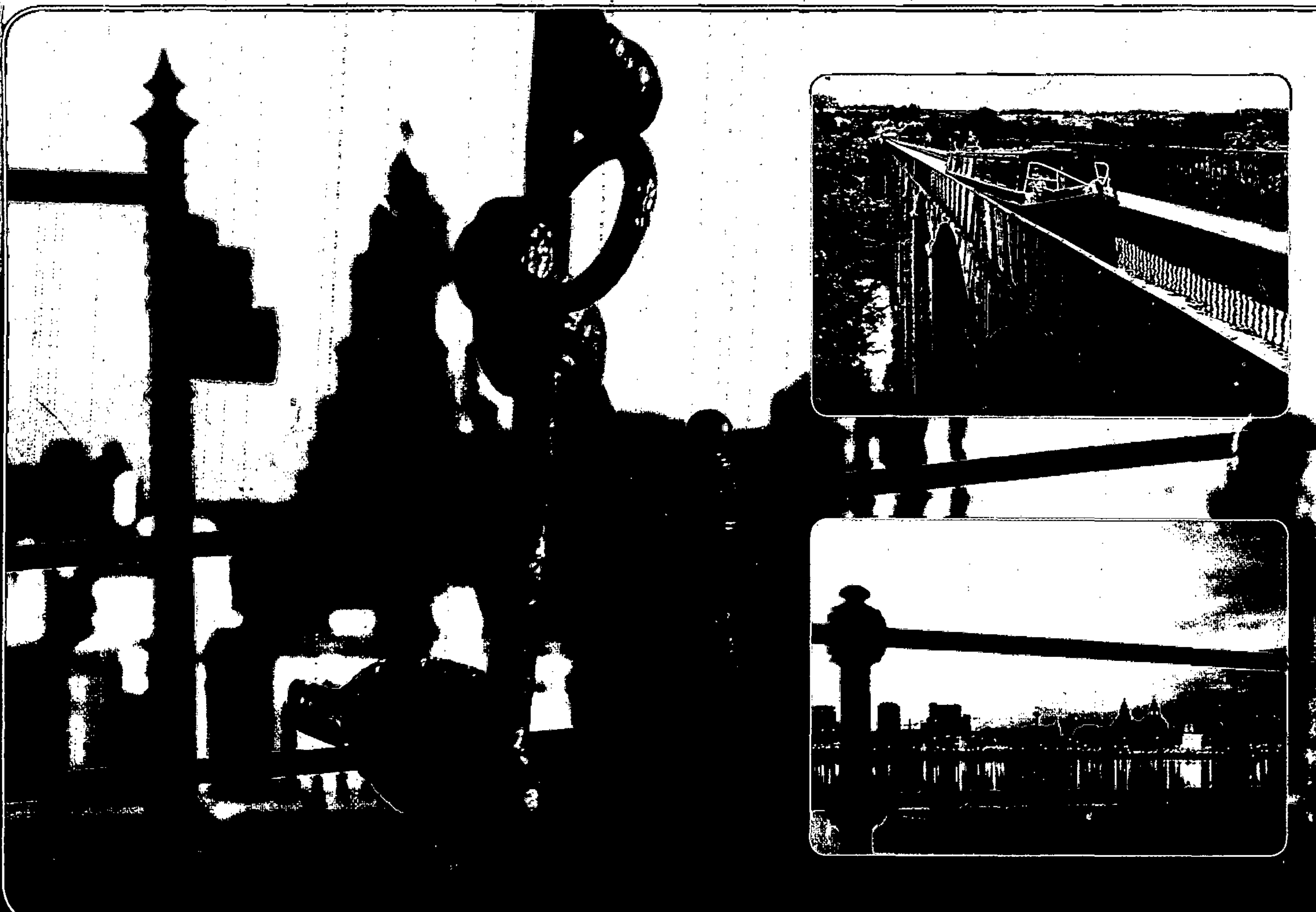
139 APRIL AVRIL 2010

ON COURSE

PIANC magazine



Special issue at the occasion of AGA 2010 in Liverpool, UK

News from the Navigation Community

The World Association for Waterborne Transport Infrastructure

Association Mondiale pour les infrastructures de Transport Maritimes et Fluviales

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'Setting the Course'
'Garder le cap'

ON COURSE

PIANC *magazine*

139 APRIL / AVRIL **2010**

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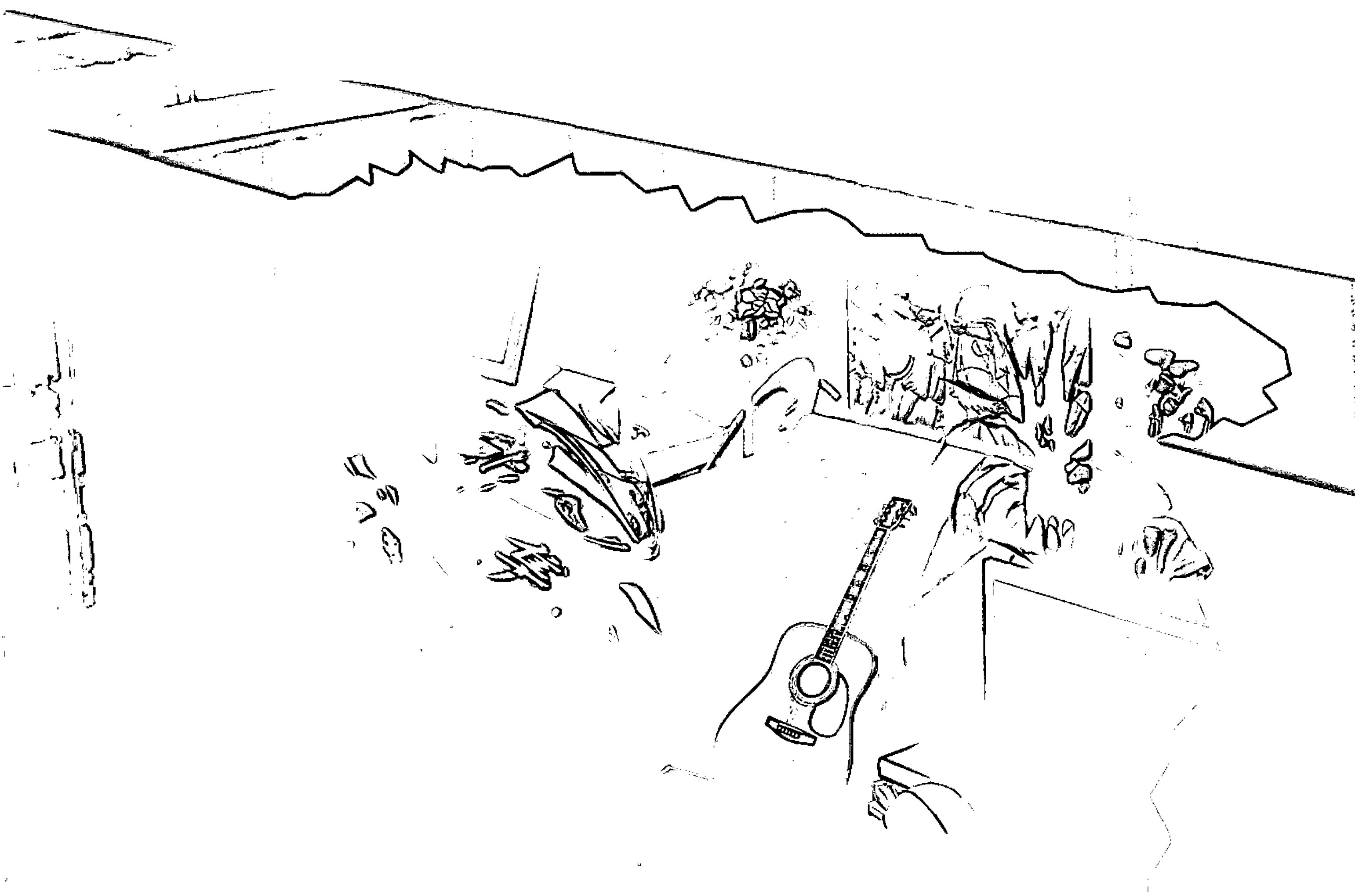

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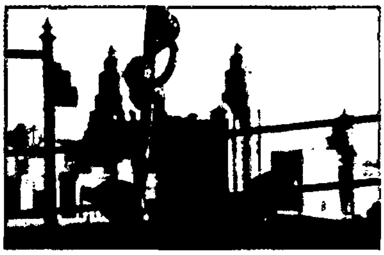
Liverpool, venue of PIANC Congress and AGA 2010.

Photo de couverture
Liverpool, lieu de rencontre du congrès et de l'AGA 2010



MESSAGE OF THE PRESIDENT

Dear member,

This issue of our Magazine is dedicated to the host country of this year's AGA and of the 32nd International Navigation Congress: the United Kingdom.

Another four years have elapsed since the successful Congress of Estoril, during which a lot has happened in the world and in our Association. Plans had to be cancelled or reconsidered, the exponential growth of international trade was reversed into a decline that urged all parties involved to adjust their forecasts and the global warming became a 'hot topic'.

We are confident that the MMX-Congress will be the scene for many excellent presentations. The 300 plus abstracts resulted eventually into 168 accepted full papers. In order to avoid lacking presenters, the Organising Committee, in accordance with HQ, decided to accept the papers only after the authors registered for the Congress. PIANC's YP-Awards for presenters under 35 years of age attracted over 30 candidates. As usual, also CEDA and IADC will grant their 2010 Awards during our Congress.

Besides the technical sessions and visits, our British hosts also provide a nice social programme that will culminate in the closing banquet in the Anglican Cathedral.

Another highlight will undoubtedly be the presentation of PIANC's History Book at the occasion of the Association's 125th anniversary. All participants will receive a copy of this splendid publication, either in English or in French.

With regard to our publications, I can inform you about the latest developments. You will remember last year's AGA decision to discontinue all printed publications from 2010 onwards and the Council's decision of last October to postpone the execution of this decision and to look for a professional publisher to publish 'On Course' at no cost for the Association. This effort failed to be successful, which led the Council during its meeting of last February to fall back on the original decision of the AGA in Helsinki, which means that:

- From 2011 onwards, the printed 'On Course' and Working Group reports will be discontinued;
- Members will receive logins and passwords to allow them to access all publications for free;
- About 25% of the contents of Working Group reports will be published on Google Books, the full digital version can be purchased through the webshop;
- As from 2011, a printed 'Yearbook' will be published containing an overview of the activities of the previous year, technical articles about the host country of the AGA, summaries of Working Group reports and social news.

We hope that this new publication policy will satisfy our members and at the same time create a potential for experts throughout the world to get acquainted with PIANC through our Working Group reports.

I am looking forward to meeting you at Liverpool MMX.

Yours sincerely,

Eric Van den Eede,
President

MESSAGE DU PRÉSIDENT

Cher membre,

Cette édition de notre magazine est consacrée au pays hôte de l'AGA et du 32ème Congrès International de la Navigation de cette année: le Royaume-Uni.

De nouveau, quatre années sont passées depuis le Congrès réussi d'Estoril, à partir duquel beaucoup de choses se sont produites dans le monde et au sein de notre association. Quelques projets ont dû être annulés ou reconsidérés, la croissance exponentielle du commerce international s'est vue transformer en une diminution qui a forcé toutes les parties concernées d'adapter leurs prévisions. En outre, la question du réchauffement climatique est devenue très actuelle.

Nous sommes convaincus que le Congrès MMX constituera une plateforme pour beaucoup de présentations excellentes. De plus de 300 résumés, 168 rapports complets ont été acceptés. Afin d'éviter que certains conférenciers n'apparaissent pas, le Comité Organisateur, en coopération avec le Secrétariat Général, a décidé de n'accepter les rapports qu'après l'inscription des auteurs au Congrès. Les Prix pour les Jeunes Professionnels de PIANC pour des conférenciers sous l'âge de 35 ans ont attiré plus de 30 candidats. Comme d'habitude, CEDA et IADC remettront leurs Prix de 2010 aussi pendant notre Congrès.

Outre les sessions et les visites techniques, nos hôtes britanniques ont aussi élaboré un programme social intéressant duquel le banquet de clôture dans la Cathédrale anglicane constituera l'apogée.

Bien sûr, la présentation du Livre d'Histoire de PIANC, rédigé à l'occasion du 125ème anniversaire, sera sans aucun doute un autre apogée. Tous les participants recevront une copie de cette publication extraordinaire, tant en anglais qu'en français.

En ce qui concerne nos publications, je peux vous informer des développements les plus récents. Vous vous rappelez sans doute de la décision de l'AGA de l'année passée de discontinuer toutes les publications imprimées à partir de 2010, ainsi que la décision du Conseil du mois d'octobre dernier de remettre l'exécution de cette décision et de chercher un éditeur professionnel pour publier 'On Course' sans frais pour l'association. Cet effort a échoué, ce qui constitue la raison pour laquelle le Conseil, pendant sa dernière réunion en février 2010, a opté pour la décision originale de l'AGA à Helsinki, ce qui veut dire que:

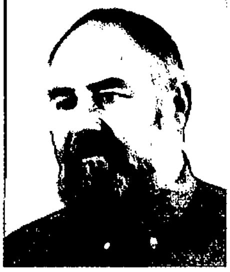
- *A partir de 2011, 'On Course' et tous les rapports des groupes de travail imprimés seront discontinués;*
- *Les membres recevront des codes d'accès et des mots de passe pour qu'ils aient accès gratuit à toutes les publications;*
- *Environ 25% du contenu des rapports des groupes de travail sera publié sur Google Books, la version digitale complète pourra être achetée via la 'boutique web';*
- *A partir de 2011, un 'annuaire' imprimé sera publié contenant un aperçu des activités de l'année précédente, des articles techniques consacrés au pays hôte de l'AGA, des résumés des rapports des groupes de travail et des nouvelles sociales.*

Nous espérons que cette nouvelle stratégie de publication plaira à nos membres et qu'elle créé au même temps du potentiel pour des experts dans le monde entier afin de faire connaissance avec PIANC par le biais de nos rapports des groupes de travail.

Je me réjouis de vous rencontrer à Liverpool MMX.

Bien à vous,

Eric Van den Eede,
Président



WELCOME TO LIVERPOOL

The UK Section of PIANC is delighted to be hosting the PIANC Annual General Assembly and 125th Anniversary PIANC MMX International Congress this year, to be held in Liverpool from 10th to 14th May 2010. We look forward to welcoming our PIANC friends and colleagues from around the world to share experiences and exchange ideas during the Congress sessions.

Liverpool is a flourishing Atlantic port in a region with a strong maritime and inland waterways heritage and the original home of "The Mersey Sound" and The Beatles. Recent investment in regeneration and modernisation has transformed Liverpool into a lively, modern waterfront city – chosen as the European City of Culture in 2008 – while retaining its maritime history as a UNESCO World Heritage Site.

The Congress will be staged in the BT Convention Centre in Liverpool, newly opened in 2008, which is perfectly sited on the waterfront, adjacent to the historic Albert Docks and the new cruise line terminal in the flourishing Port of Liverpool. Upwards of six hundred delegates and partners from more than forty countries are expected to attend the Congress. A choice of modern hotel accommodation has been reserved for delegates within close walking distance, and there is a wide variety of lively restaurants and bars nearby in the redeveloped Albert Docks and surrounding area.

The PIANC MMX Scientific Committee has received over 300 abstracts from experts worldwide offering technical papers. Around 200 of these abstracts have been selected to ensure a full programme of high-quality technical presentations made in four parallel sessions held over the four working days of the Congress. In addition, technical visit options to both the modern port of Liverpool and waterway developments and the historic inland canals have been arranged for delegates and partners.

Trelleborg Marine Systems have offered Major Sponsorship, joining Peel Ports, Westminster Dredging, Dredging International, Royal Haskoning, the International Association of Dredging Contractors (IADC), Atkins Global and HR Wallingford in pledging their support and sponsorship of the PIANC MMX Congress.

An integral technical exhibition will also be held during the Congress, with up to 50 companies and organisations exhibiting their expertise and creating their own personal PIANC MMX meeting place.

The Partners' Programme includes guided tours of Liverpool with lunch in the Liverpool Palm House, as well as tour options to the ancient walled city of Chester, and the historic workers village and art gallery of Port Sunlight – home of Sunlight Soap. Liverpool has many museums and art galleries, which will be visited during the week, as well as the opportunity to take an evening buffet cruise on the Mersey Ferry.

The Congress Reception will be held in St. George's Hall, one of the finest neo classical buildings in Europe, and the formal Congress Banquet will be held in Liverpool Cathedral, described as "one of the great buildings of the world".

The detailed programme includes the evening AGA Dinner in the Liverpool Maritime Museum on Sunday 9th May, the PIANC Annual General Assembly and Evening: Congress Welcome Reception on Monday 10th May, the Congress Opening Ceremony and Keynote address on Tuesday 11th May followed by three further days of technical presentations culminating with the Closing Ceremony and Evening: Congress Banquet at Liverpool Cathedral on Friday 14th May.

For further details please visit the web site on www.piancmmx.org.uk and we look forward to welcoming you all to Liverpool in May.

Stephen Cork
Chairman PIANC UK Section

BIENVENUE À LIVERPOOL

La section britannique de PIANC est ravie d'être l'hôte de l'Assemblée Générale Annuelle, du 125ème anniversaire, ainsi que du Congrès International MMX de PIANC de cette année, qui aura lieu à Liverpool du 10 au 14 mai 2010. Nous nous réjouissons d'accueillir nos amis et nos collègues de PIANC venant du monde entier afin d'échanger des expériences et des idées pendant les sessions du congrès.

Liverpool est un port atlantique florissant dans une région qui compte sur un fort héritage de voies navigables maritimes et intérieures, ainsi que le berceau du « Mersey Sound » et de The Beatles. Des investissements récents dans la régénération et la modernisation ont transformé la ville de Liverpool en une ville riveraine animée et moderne – élue comme Ville Culturelle européenne en 2008 – tout en conservant son histoire maritime en tant que Patrimoine Mondial de l'ONUESC.

Le congrès aura lieu au BT Convention Centre à Liverpool, qui vient d'être ouvert en 2008 et qui est situé parfaitement à la rive, juste à côté des fameux Albert Docs et le nouveau terminal croisiériste dans le Port florissant de Liverpool. Plus de 600 délégués et leurs partenaires venant de plus de quarante pays assisteront au congrès. Des logements modernes ont été réservés pour les délégués à deux pas et il y a une grande variété de restaurants et bars animés à proximité dans les environs des Albert Docks rénovés.

Le Comité Scientifique de PIANC MMX a reçu plus de 300 résumés de rapports techniques d'experts venant du monde entier. A peu près 200 de ces résumés ont été sélectionnés pour garantir un programme complet de présentations techniques de haute qualité, divisés en quatre sessions parallèles dans les quatre jours du congrès. En outre, des options de visites techniques à tant le port moderne de Liverpool et les développements de ces voies navigables qu'aux canaux intérieurs historiques ont été arrangées pour les délégués et leurs partenaires.

Trelleborg Marine Systems s'est présenté en tant que sponsor majeur, ainsi que Peel Ports, Westminster Dredging, Dredging International, Royal Haskoning, the International Association of Dredging Contractors (IADC), Atkins Global et HR Wallingford en donnant leur support et sponsoring au congrès MMX de PIANC.

Il y aura aussi une exposition technique intégrale à l'occasion du congrès, avec approximativement 50 entreprises et organisations qui exposeront leur expertise, créant ainsi leur propre lieu de rencontre MMX de PIANC.

Le programme pour les partenaires comprend des tours guidés à Liverpool avec un déjeuner au Liverpool Palm House, ainsi que des options de tours à l'ancienne ville de Chester entourée de remparts, au village d'ouvriers historique et à la galerie d'art de Port Sunlight – l'origine du savon Sunlight. Liverpool compte beaucoup de musées et de galeries d'art, qui pourront être visités pendant la semaine et il y aura aussi l'occasion de jouir d'une croisière sur le Mersey Ferry qui inclut un buffet du soir.

La réception du congrès aura lieu au St. George's Hall, un des bâtiments néoclassiques les plus sophistiqués en Europe et le banquet formel du congrès aura lieu dans la Cathédrale de Liverpool, décrit comme « un des édifices les plus formidables dans le monde ».

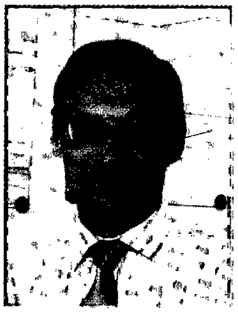
Le programme détaillé inclut le dîner de l'AGA au Musée Maritime de Liverpool le dimanche 9 mai, l'Assemblée Générale Annuelle de PIANC et la réception de bienvenue au congrès le lundi 11 mai, suivie par trois jours de présentations techniques et atteignant son point culminant avec la cérémonie et la soirée de clôture: le banquet du congrès au Cathédral de Liverpool le vendredi 14 mai.

Pour plus de détails, je vous prie de jeter un coup d'œil sur www.piancmmx.org.uk. Nous nous réjouissons de vous souhaiter la bienvenue à Liverpool en mai.

Stephen Cork
Président de la section britannique

PARALLEL MOTION FENDERS; SOME DESIGN CONSIDERATIONS, INCLUDING THE IMMERSION OF FENDER CONES

by



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KEY WORDS

Parallel motion fenders, torsion arm fenders, immersed cones

MOTS-CLEFS

Défenses d'accostage à translation, défenses d'accostage à bras de torsion, cônes immergés

1. INTRODUCTION

Parallel motion or 'PM' fenders are a relatively recent development in fender technology and there is currently no published guidance for their design. PM fenders offer a number of advantages but are significantly more complicated in their mode of operation than conventional fender systems; PM fenders can be less tolerant of exceptional berthing events outside the design envelope. The loadings within the PM mechanism can be difficult to define, especially when an angled berthing is combined with sliding frictional forces. A number of PM fender installations have experienced structural problems; this article considers how some of these problems might be avoided.

2. WHAT IS A PARALLEL MOTION FENDER?

2.1 Conventional fenders

In locations where there is little tidal range single level fendering systems can be used; a simple fender may consist of a rubber unit fixed to or suspended from a quay edge but for larger vessels where it is necessary to spread the fender reaction force over a larger area of the vessel's hull plating a fender panel is usually provided; the panel will typically be backed by energy absorbing rubber fender units. A wide range of fender units of various shapes is available but cellular units, and particularly cones, are popular because they are stable and efficient in that they provide large energy absorption for their size. Where there is little tidal range the fender panel and rubber unit are unlikely to ever be immersed in the water.

In locations with larger tidal ranges, such as the UK, a fender panel on a single fender unit is often insufficient and a ship, or her belting if she has one, might get beneath the fender panel at low tide. The solution is to use a taller panel to provide a contact surface throughout the tidal range. This tall panel will require at least two fender units behind it, one near the top and one near the bottom. The bottom unit will inevitably be immersed at high tide.

The tall fender panel is effective but it has a number of disadvantages. For an impact near the top or bottom of the panel only the upper or lower fender unit (assuming there are just two) will be compressed so each fender unit has to be designed to be capable of absorbing all the ship's berthing energy. When a berthing occurs at mid tide the energy is shared between both fender units which are compressed more or less equally; as a result the overall fender reaction is stiffer than during a top or bottom impact and the reaction force on the ship and the support to the fender unit is greater. This increased reaction force may not be of much consequence when the fender is mounted on a solid structure such as a quay wall but if it is mounted on a piled dolphin the reaction force can have a significant impact on the dolphin's design and therefore its cost.

A further disadvantage with the tall panel is that when a ship with a belting contacts the panel near the bottom the panel angles outward so that the top of the panel can strike the ship at high level. This has caused difficulties for vertically sided ships with windows or vents at high level which have been damaged by fender panels. It is also a difficulty for lightweight ships built of aluminium which can only accept fender loads on their beltings.

2.2 PM Fenders

PM fenders were conceived to overcome these shortcomings of conventional fenders. A PM fender consists of a fender panel, similar to a conventional panel but backed by only a single fender unit (or pair of units mounted together) at its centre. To support the fender panel and to restrain it so that it is always vertical, it is mounted on a pair of arms which project from a torsion tube. The connection between the arms and the panel is hinged and the torsion tube itself is mounted on hinges. Figure 1 shows the arrangement of a typical PM fender although a number of different geometries have been used including some double arm scissor arrangements. In practice the panel does not remain truly vertical due to deflection of the PM mechanism and play in the hinges.

The articulation of the hinges in the system permits the panel to rotate in plan and to move backwards from the berthing line compressing the fender unit

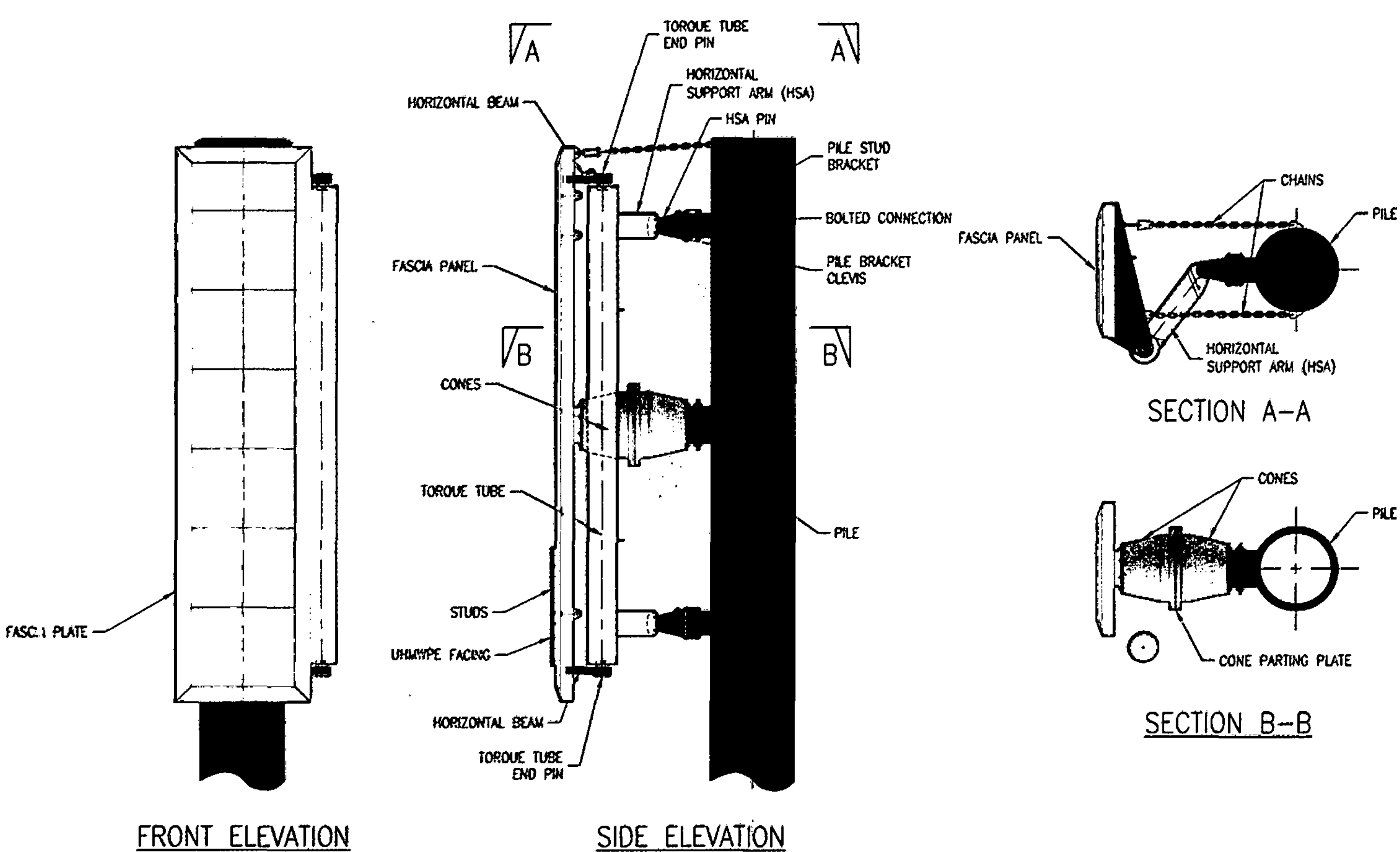


Figure 1: General arrangement of typical parallel motion fender (drawing courtesy of Tony Gee & Partners)

but the mechanism does not allow the panel to move vertically or longitudinally.

If a vessel impacts the PM fender panel at mid height then the load is transferred directly into the rubber units. If the impact is near the top of the fender panel then the reaction force is transferred into the upper arm which in turn applies a torsion to the torsion tube which is resisted by a moment applied by the lower which pulls the bottom of the fender panel away from the ship. The panel is therefore moved away from the berthing line by a combination of the ship impact at the top and the torsion arm tension at the bottom. Resisting the action is the rubber unit in the centre of the panel. Under the influence of these three forces the fender panel is subject to a bending moment. If the ship contact is near the bottom of the panel then the action is similar but the force in the arms and the torsion in the torsion tube is reversed.

This relatively simple load path becomes more complex when secondary forces are taken into account. Because the fender panel is mounted on radial arms it does not move back from the berthing face perpendicularly but in an arc. This radial movement imparts a forced shear into the rubber fender units as they are compressed which needs to be taken into account in the calculation of the unit's performance.

The radial motion also causes the fender panel to slide horizontally along the ship's side as it compresses which, through friction at the contact surface, imparts a horizontal force into the fender panel. Typically fender panels will be faced with a low friction facing such as UHMW-PE panels but the actual coefficient of friction very much depends upon the condition of the ship's side or belting and an uneven belting can significantly increase the horizontal load in the panel's support mechanism. The effect can be exacerbated if the vessel is moving along the berth while the fender is being compressed. Unlike conventional fenders which will tend to deflect to shed loads which are not applied perpendicular to the berthing line, a parallel motion fender has no such ability, due to its inbuilt geometry.

2.3 Fender edges

Fender panels are generally fitted with top and edge chamfers. The top chamfer is to protect against a belting over-riding the panel and then bearing down on the panel's top edge as the ship rolls. If this happens to a conventional fender it can usually deflect sufficiently on its rubber supports to absorb the impact. If it happens to a PM fender then there is no give in the support mechanism other than by deflection of the steelwork. The top flare needs to be large enough to accommodate the largest belting and the panel support mechanism needs to be designed to carry the vertical component of the fender reaction when applied to the angled flare.

The side flares are required to accommodate angled berthing and irregularities in the ship's side as she moves longitudinally along the berth. Most PM fender systems are asymmetrical in their design with the fender reacting differently to an angled berthing on one side to the other. This difference is partly the result of the shear on the rubber fender unit being either ameliorated or compounded depending upon which way the panel is angled. However the asymmetry becomes a more significant factor if an angled berthing is combined with horizontal friction from longitudinal movement of the ship. Under this combination of effects the horizontal force either works with the support mechanism's movement or, if the first contact is on the torsion tube side of the panel, the friction can work to prevent the free movement of the mechanism which will greatly increase the axial load in the torsion arms.

Compared to a conventional fender the design of a PM fender involves the consideration of very many more variables and the interaction between these variables is complicated. PM fenders are generally bespoke in that they are purpose designed for each installation. So while they can offer cost savings on the design of their supporting dolphins this is to a degree offset by the increased design complexity and therefore design cost. More concerning for clients is perhaps the absence of design guidance for PM fenders and the high maintenance cost which can result from an inadequately designed PM fender.

3. SOME PM DESIGN DEFECTS

3.1 Failure history

PM fenders have been in use for over ten years and in this time they have experienced a number of failures; as with any fender system some of these failures can be attributed to abnormal events and abuse but other failures are the result of the relative complexity of the PM system and a lack of appreciation of the interaction of the various forces in their design. All the examples of defects that follow have occurred early in the life of the fenders, generally within the first two years of use.

3.2 Torsion arms

The most common structural failure on PM fenders is to the torsion arm to torsion tube joint; typically this manifests itself in the heat affected zone of the joint weld and in most cases the cracking starts at the 3 o'clock and 9 o'clock positions which indicates that it is the normal operation of the fender rather than a top edge loading that has caused the failure. The failure is indicative of inadequate design of the joint and remedial work has been done to a number of PM fenders by adding gusset plates to the joint. Figure 2 shows one of these joints with a cracked weld.

Figure 2: A torsion arm to torsion tube joint with cracked weld

3.3 Bearings

The bearings of a PM fender are critical to its performance; there are typically four bearings, two at high level and two at low level. The low level bearings can spend much of their life under water and can therefore be difficult to inspect and maintain; they need to be designed accordingly.

Manufacturers of PM fenders offer 'sealed for life' bearings consisting of a stainless steel pin within spherical composite bearings within a sealed housing. Some manufacturers offer a remote greasing facility as an optional extra. The life of a sealed bearing is very much dependent upon the functioning of its seal and whether a seal can be relied upon for the 15 year or so design life of a fender system is questionable. Figure 3 is a photograph of a 'sealed for life' bottom bearing from a PM fender after only two years in service; the bearing was not fitted with a greaser. Externally the bearing showed no defect but when it was disassembled it was found to be full of silt and corrosion product. Remote greasers are an additional cost but they do improve the chances of keeping silt out of the bearings, provided they are combined with a proper maintenance regime.

Apart from seal failure PM fenders have also experienced failures of the bearing pin in bending although whether this is the result of inadequate design or other factors is still to be determined.

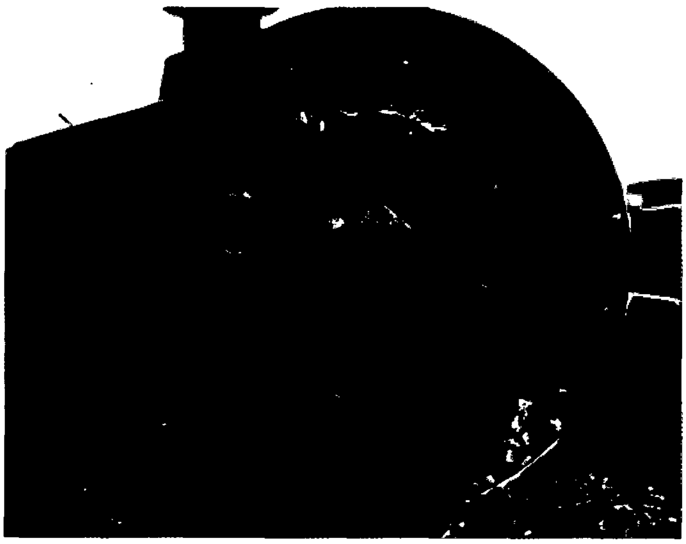


Figure 3: Inside a PM bottom bearing after two years in service

3.4 Panel facings

Inadequate facing panel fixings is a defect which occurs on all types of fenders but the consequences of the resulting increase in friction forces has greater significance for a PM fender than for a conventional fender. Loss of UHMW-PE panels can occur where the panel fixing relies upon studs welded to the panel face; if the studs are of inadequate diameter or the stud welds are inadequate the studs shear off under the friction load. Figure 4 shows an example of the failure of stud welds on a PM fender panel. An improved detail is to weld shear bars to the panel face so that the transfer of shear force does not rely on the studs alone.

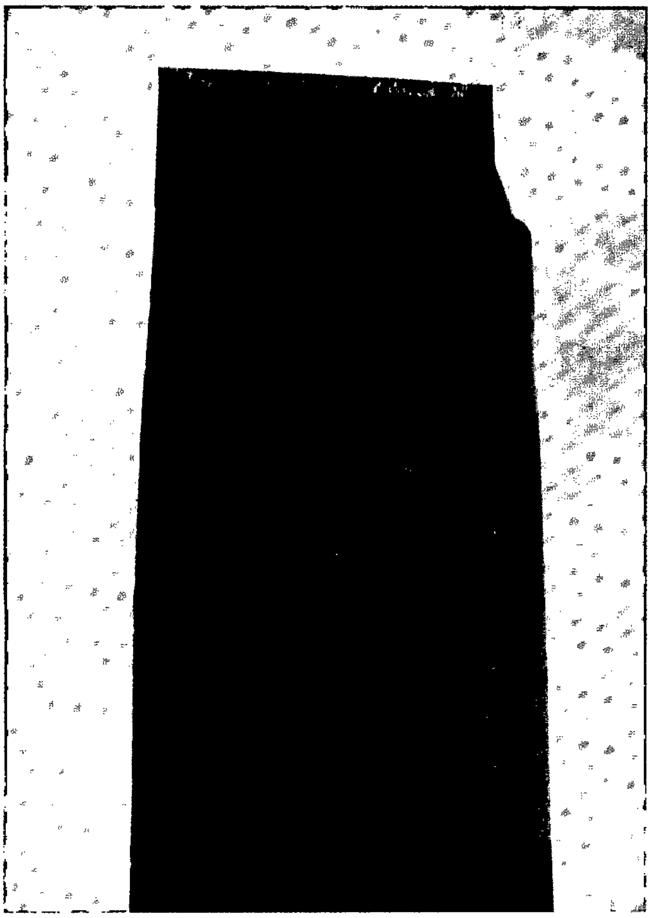


Figure 4: Loss of facings due to failure of fixing stud welds

3.5 Fender Cones

On many PM fenders the energy absorbing unit is a rubber fender cone, or pair of cones, mounted back to back in series. In this case the outer cone is usually a softer rubber compound than the inner one in order to provide a more progressive reaction force. On a PM fender the cones will be mounted at around mid tide and therefore will be immersed in water at high tide. The effect of the immersion of cones is not unique to PM fenders but the significance of cone immersion has only been appreciated as the result of PM fender failure analysis.

Cellular fenders such as cones and cylinders contain a void space which is normally filled with air; as the unit is compressed it buckles and the volume of the void is reduced. The fender units are provided with grooves or flutes cast into their bases to enable the air trapped within the unit to escape. The cross-sectional area of the flutes on some manufacturer's cones do appear small in relation to the size of the void within the cone.

Fender manufacturers publish fender performance data which is derived from tests carried out on their fender units in air. To my knowledge no manufacturer publishes performance data for their fenders when immersed in water. Furthermore I am unaware of any manufacturer or technical standard that advises designers that the performance of an immersed cellular fender can be very different from one in air.

Intuitively one would expect water within a unit such as a cone to have the effect of stiffening the cone and increasing its reaction force; air within the cone is compressible but water is not so, with a restricted exit via the flutes, the pressure within the cone can be expected to be higher when an immersed cone is compressed. The flutes that manufacturers mould into their cones are designed only for use in air; they are typically the size of a small barnacle and when the unit is mounted at mid tide the flutes can become rapidly blocked by marine growth. Figure 5 shows cone flutes filled by barnacles while Figure 6 shows a damaged cone where it can be seen that the barnacle growth extends the full length of the flute. The effect of this marine growth is to reduce the effective cross section of the flute to a small fraction of its original dimension.

Figure 5: Barnacles filling fender vent flutes

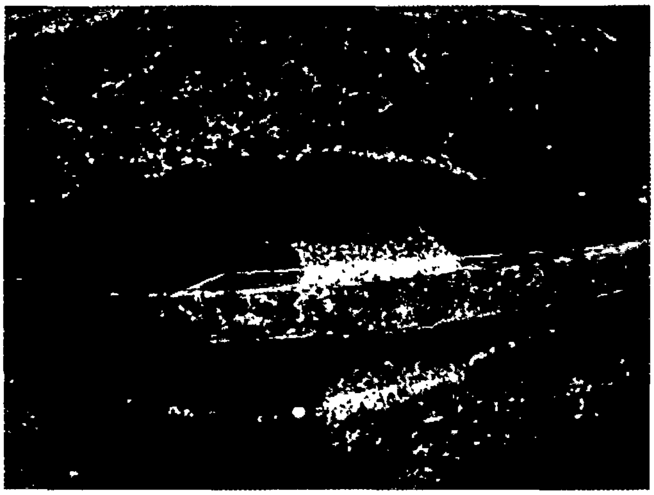


Figure 6: The barnacle growth extends the full length of the flutes

There are practical difficulties in carrying out full scale tests on immersed fender units especially if the effect of blocked flutes is also to be tested; the risk of a burst cone is probably not one that any testing laboratory would be willing to bear. Tests on model cones are less hazardous and City University carried out a series of model tests in 2007 as part of an investigation into the cause of a PM fender failure; the following summary of their findings is reproduced with their consent.

City University's tests were carried out on a pair of model rubber fender cones with a 288 mm diameter at the base and 178 mm diameter at the top, the internal depth of the cones was 157 mm. The cone under test was mounted base up in a 250 kN capacity test rig sitting on a spacer plate to enable a 70 % deflection of the cone to be achieved. A stiff circular plate was fitted to the upper (open) end of the cone through which the load from the test rig was applied. The circular plate was fitted with a pressure transducer to enable the internal pressure within the cone to be measured during the test.

Into a threaded hole in the circular plate could be screwed plugs with orifices of different sizes to simulate different degrees of blockage of the flutes. The initial orifice size was chosen as 5 mm diameter as this size was calculated to match the Reynolds number through the flutes of the full sized cones. The other plugs had a 4 mm and a 3 mm diameter orifice. A 3 mm orifice represents a 64 % reduction in cross-section area compared to a 5 mm orifice which is much less of a reduction in area than that shown in figures 5 & 6, but City University feared that using a smaller orifice would risk bursting the cone.

Tests were carried out measuring the cone reaction force against deflection at three different rates of compression, 10 mm/s, 15 mm/s and 20 mm/s. In line with full size testing procedure the cones were broken in by performing two compressions prior to testing. The tests were done first in air and then with the cone filled with water; the cone was enclosed in a perspex box to contain the ejected water. Figure 7 shows a cone in the rig prior to a test.

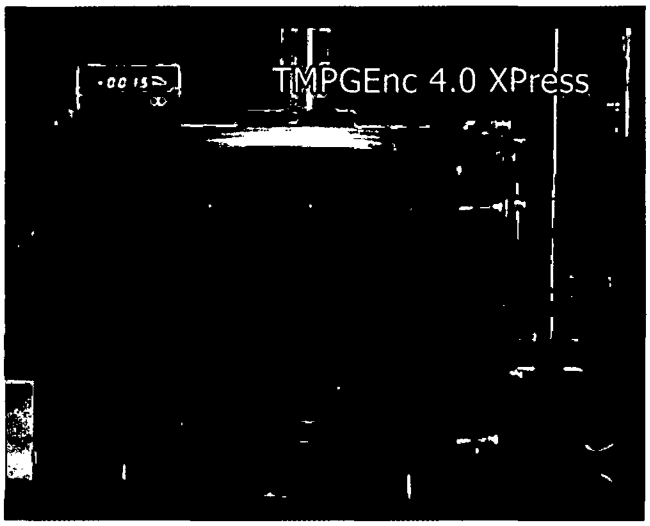


Figure 7: A cone mounted in the test rig; the digital readout shows cone internal pressure

3.6 Test results

A number of tests in air were carried out first and after 10 full compressions it was found that the reaction/displacement curve was essentially unaffected by the compression rate within the 10-20 mm/s test range. A further 9 tests were then carried out at the three speeds for the three sizes of orifice. The combined results of these tests is shown on the graph at Figure 8 with the solid red line being the result of the test in air.

In the early stages of the cone's compression there is little change in its internal volume so up to around 30 % compression water within the cone has negligible effect. As the compression increases further the effect of water becomes marked, especially for the smaller orifice and faster compression

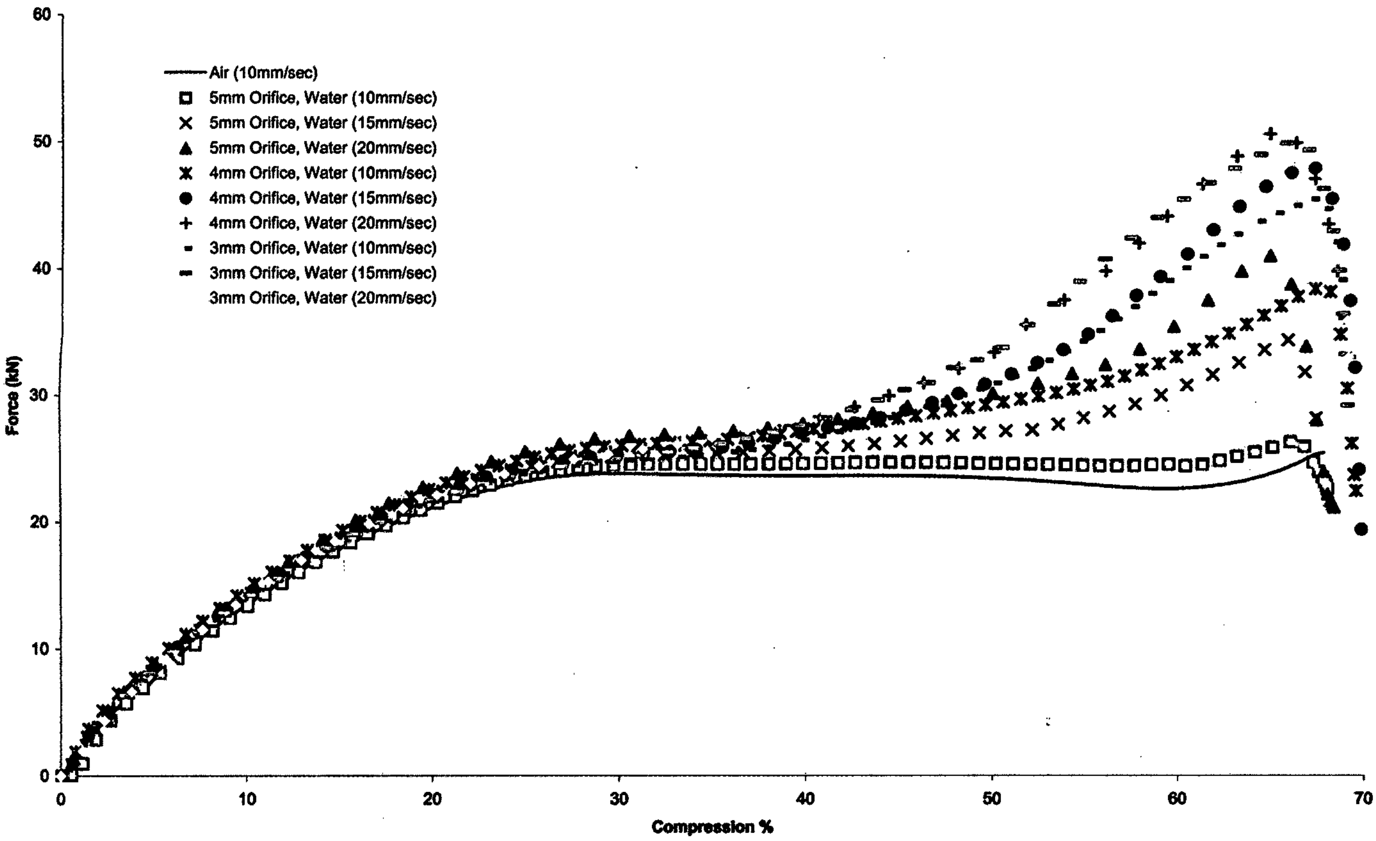


Figure 8: Model fender cone laboratory test results

speeds. While scale effects mean that the results need to be treated with caution the indication is that water within a cone might increase the cone reaction force by around 100 %, particularly if marine growth is present. Further testing, ideally at full scale, would be desirable to verify these findings but in the meantime designers should consider providing alternative means of venting for cellular fenders mounted below high tide level.

4. CONCLUSIONS

Parallel motion fenders are a useful addition to the range of fender designs available to a port designer; they are particularly useful in locations with a large tidal range where it is necessary to prevent the top of a fender panel contacting a ship's upperworks during a low tide berthing. Selecting a PM fender design on account of its ability to provide a lower reaction force on a supporting dolphin than a conventional fender panel requires caution. A PM fender is subject to significantly more complicated forces than a conventional fender and a well designed and constructed PM fender will inevitably be significantly more expensive than a conventional one.

In most applications a PM fender will need to be purpose designed for that location; as such it will be a 'bespoke' rather than a 'proprietary' design. Clients and specifiers should ensure that any PM design is adequately checked by an organisation experienced in PM fender design.

In situations where a PM fender's benefits of panel verticality and lower reaction force are not a necessity then a simpler conventional fender system may be a more appropriate solution.

Cellular fenders installed below high tide level should be provided with vent holes large enough to enable the free escape of water, even when the vent is fouled by marine growth.

SUMMARY

Parallel motion (PM) fenders are a relatively recent development in fender technology. PM fenders have two significant advantages over conventional fender units in that they remain close to vertical when compressed by an off centre berthing impact and they produce a reduced reaction force on their supporting structure. PM fenders are however significantly more complicated in their structural form than conventional fender systems and the loading within a PM mechanism can be difficult to determine. Perhaps as a result of this complexity PM fenders have experienced a number of structural failures in service. This article considers the reasons for some of these failures. The use of cellular rubber fender units below water level is one possible cause of fender failure and results from tests on model fender cones immersed in water are reported. These test results have significance for the design of any fender system where cell units are installed below high tide level.

RÉSUMÉ

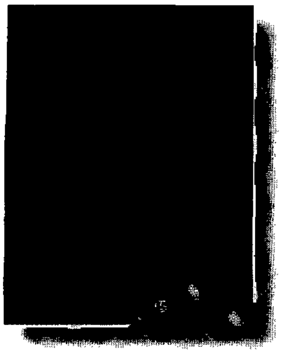
Les défenses d'accostage à translation (défenses PM) sont un développement relativement récent de la technologie des défenses d'accostage. Les défenses PM ont deux avantages significatifs sur les défenses d'accostage traditionnelles : elles restent proches de la verticale quand elles sont comprimées par le choc d'un accostage décentré et elles provoquent une force de réaction réduite sur l'ouvrage qui les supporte. Les défenses PM sont néanmoins significativement plus compliquées dans leur forme structurelle que les systèmes de défense traditionnels et les efforts dans leur mécanisme peuvent être difficiles à déterminer. Peut-être en raison de cette complexité, les défenses PM ont connu nombre de ruptures en service. Cet article étudie les raisons de certaines de ces ruptures. L'utilisation de défenses alvéolaires en caoutchouc en dessous du niveau de l'eau est une cause possible de la rupture de défense et des résultats d'essais sur des modèles de cônes immergés sont publiés. Ces résultats d'essai peuvent être utilisés pour la conception de tout système de défense d'accostage dans lequel des éléments alvéolaires sont installés en dessous du niveau des plus hautes eaux.

ZUSAMMENFASSUNG

Parallel verlaufende („Parallel motion", PM) Fendersysteme sind eine relativ neue Entwicklung in der Fendertechnologie. PM Fendersysteme haben gegenüber konventionellen Fendersystemen zwei bedeutende Vorteile: sie bleiben nahezu senkrecht, wenn sie durch einen dezentralen Stoß auf den Anleger zusammengedrückt werden, und sie erzeugen eine verminderte Reaktionskraft auf das sie stützende Bauwerk. PM Fendersysteme sind jedoch in ihrer Struktur komplizierter als konventionelle Fendersysteme und die Belastungen innerhalb eines PM Fendersystems können schwierig zu bestimmen sein. Vielleicht haben PM Fendersysteme als Ergebnis dieser Komplexität eine Reihe von strukturellen Versagensfällen im Betrieb erfahren. Dieser Artikel betrachtet die Gründe für einige dieser Versagensfälle. Die Verwendung von Zellkautschuk-Fendern unterhalb des Wasserspiegels ist ein möglicher Grund für ein Versagen der Fender und es wird über Ergebnisse von Versuchen mit im Wasser eingetauchten Modell-Kegel-Fendern berichtet. Diese Versuchsergebnisse sind für die Gestaltung aller Fendersysteme, bei denen die Zelleinheiten unterhalb Tidehochwasser installiert sind, von Bedeutung.

SEISMIC DESIGN OF HYDRAULIC GATES

by



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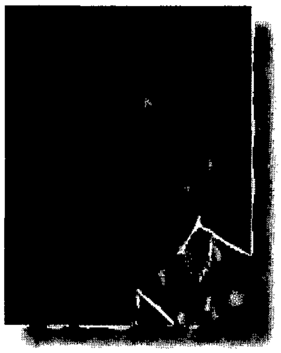


KEY WORDS

Seismic, gate, earthquake, dynamic, performance

MOTS-CLEFS

Sismique, porte, séisme, dynamique, performance

1. INTRODUCTION

In comparison to the loading carried by many structures, hydraulic gates typically carry much higher loading, for example the distributed live loading on most building floors is usually less than the equivalent of a 1 m head of water. In addition, full or near full loading is applied to the gate in many instances on each load cycle. The high loading on hydraulic gates in itself poses significant challenges in producing an economic design. The failure of a hydraulic gate can also create a significant risk to communities lying in the flood path and may in addition lead to large financial losses, for example on hydro-electric schemes and navigable waterways. Under these circumstances, the design should cater for abnormal and accidental loading in addition to the expected loadings under normal operation. Seismic loading is one such loading and has the potential to create very significant and particularly damaging loads on many structures including gates. It is prudent therefore to include seismic loading within the design basis. This is especially important in areas of high seismicity where the risk of a significant event may be sufficiently high that it becomes a likely occurrence during the lifetime of the structure rather than an abnormal or extreme event.

2. PHILOSOPHY OF DESIGN

2.1 Functional Requirements

Like any engineering design, a gate must satisfy a number of functional, safety and operational requirements such as resistance to gravity, hydrostatic loading, fatigue, extreme and accidental conditions, operational needs, maintenance and serviceability requirements. For the extreme or abnormal case of earthquake loading, it is common to adopt two levels of seismic event (PIANC, 2001), namely an operational basis and a maximum credible basis or survival event. The operational basis usually assumes that the gate is operable immediately following an event and may have some limited and easily repaired damage. The survival event defines a level at which the gate does not collapse but may sustain significant damage. The acceptable levels of damage depend on a number of factors such as risk and economics which, in combination with the event levels, define the performance criteria for the structure under this condition.

2.2 Design process

The design process needs a systematic framework to ensure that it addresses all operational, safety and functional requirements within the financial and other constraints of the client. An outline of this process is:

1 Definition of requirements, including load conditions, codes and standards to be adopted, acceptance criteria, etc
2 Definition of structural form and sizing
3 Analysis of structure
4 Structural performance checks
5 Detailing and drawing

In practice, the design will progress through a number of phases, as it evolves from concept through to a finished fully detailed design and, even within the detailed design phase, a number of iterations may be necessary to bring the design into balance, especially with the inclusion of a seismic load case due to the inter-relationship of loading with both mass and stiffness.

3. DEFINITION OF REQUIREMENTS

3.1 Characterisation of earthquake loading

Earthquakes are caused by the release of accumulated strain energy in the earth's crust when movement occurs on a fault. The energy is propagated away from the source zone by surface and body waves and these become attenuated with distance. The ground motions at a particular location are modified by site conditions and excite a dynamic response in structures which can be significantly amplified over that of the ground. This response can induce loadings both laterally and vertically which can be particularly damaging if not properly accounted for in the design process.

Ground motions can be represented by a set of time histories defining acceleration or displacement in three orthogonal directions over the duration of the earthquake. Analysis of structural response using time histories can be time consuming and creates very large amounts of output data, which can be difficult to interpret and manipulate for design. An alternative approach characterises the motions by response spectra, which define the peak response of single degree of freedom oscillators to a given input against the natural frequency (or period) of any oscillator, see figure 1 which illustrates the principle underlying the construction of a response spectrum. The frequency of an oscillator is given by:

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} cycles/\sec = \frac{\omega_n}{2\pi} \quad \text{where } k = P/\delta.$$

Response spectra are simple tools that provide a powerful way of characterising ground motions. The plot illustrates where the energy of the motion lies with frequency and captures how resonance of the oscillator amplifies the motions during an event. An oscillator at the high frequency end (i.e. an effectively rigid oscillator) responds synchronously with the ground and therefore also displays the peak ground acceleration.

Response spectra are mathematically convenient and provide a simple means of defining the input to a modal analysis, a straightforward method of dynamic analysis, to determine structural response. Although the spectrum is defined for a single degree of freedom system, the analysis route can

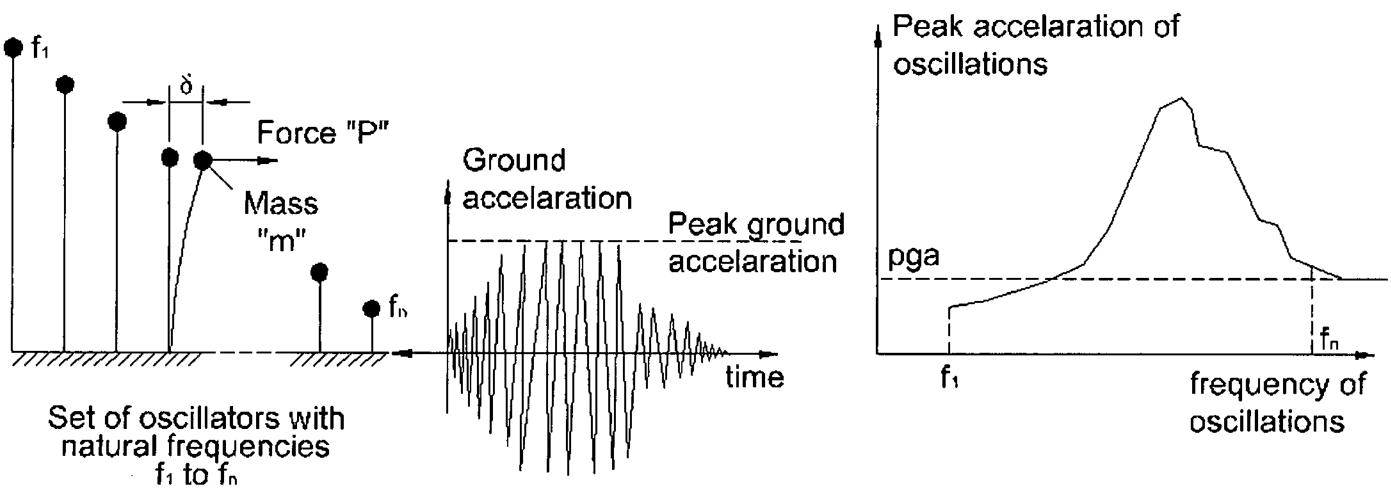


Figure 1 : Principles underlying the generation of response spectra

solve complex structures with many modes of vibration, as each response mode of the structure can be treated mathematically as being a single degree of freedom system. The various modes are then combined in a statistical process with a further process to combine the effects of the three orthogonal inputs. The principal drawback of the response spectrum method is that it solves linear systems and therefore does not easily address significant material or geometric non-linearities although approximate solutions can be obtained when used judiciously.

Both time histories and response spectra can be used to represent a single earthquake or can be manipulated to represent a range of possible events. The most convenient characterisation of an earthquake is through its response spectrum and a set of events can be characterised by an envelope of the individual spectra and this then creates a conservative input for design and this is the method for defining seismic events in most codes of practice. If time histories are required, synthetic time histories can be generated to match the enveloped or target spectrum. Because the interaction of the various modes of response of a structure is unique for a given time history set (as the phasing of energy content with frequency differs between time histories), it is normal practice to analyse a structure for a number of different sets of orthogonal motions and to design against the mean or alternatively the maximum response as appropriate to the time history set and its match to the target spectrum. The response spectrum method involves a statistical approach for the combination of modes and therefore avoids this need for multiple runs.

Depending on the characteristics of the site and the structure supporting the gate, both the response of the site and the interaction between the structure and the ground may need to be considered within the analysis path. These are specialist topics that lie outside the scope of this paper.

3.2 Load effects on hydraulic gate structures

The motions of the gate supports during an earthquake induce the loading from inertia of the gate, hydrodynamic loading from the water inside the gate, external hydrodynamic load effects and potentially also differential movement between the gate supports. The external and internal hydrodynamic loading has the effect of added mass on the gate structure and therefore affects the frequency and accelerations experienced by the gate.

Westergaard (1933) developed a classical solution for the hydrodynamic loading on a rigid body and also proposed a simplified formula for estimating the hydrodynamic pressure distribution on a rigid vertical face. Zangar (1952) proposed an alternative approximation which provides an answer closer to the full Westergaard solution. Subsequently Housner (1954) developed a solution accounting for a finite expanse of water. These formulae express the loading as a pressure distribution which is proportional to acceleration. Current practice is to convert this to a mass distribution per unit area that can be attached to the nodes of the finite element model used for the dynamic analysis. As these classical solutions are generated for rigid bodies vibrating in a defined manner, they will not be a true representation of reality but an approximation thereto. However, with the advent of powerful computer systems and parallel advances in finite element (FE) software, it is possible to model these hydrodynamic effects explicitly through the use of fluid elements to represent the water, although this level of rigour is not usually implemented.

Hydrodynamic effects are not straightforward. For example, vertical motions of the ground will generate compression waves in water. These vertically propagating compression waves will generate variations in water pressure which in turn will induce both horizontal loads on vertical surfaces and vertical loads on horizontal surfaces. This effect is recognised in modern codes of practice such as Eurocode 8 (BS EN 1998-4:2006). Further complications arise when looking at the detail of the structure and this is discussed further in sections 5 and 6.

Hydraulic gate structures are designed to resist, as a minimum, both gravity and hydrostatic loading from the water. Design against these conditions is relatively uncomplicated as the applied load effects are not controlled by both mass and stiffness. However seismic loading is dependant on the frequency of response of the various modes of the structure and, as such, is dependant on both these quantities. Under static loading, the determination of the critical load case is governed by the combination of load factors and the relevant maximum head difference across the gate for a range of scenarios. Under seismic loading, the worst case can be one with water on both sides of the gate and an intermediate head differential. This condition can be the most onerous as the hydrodynamic effects from each side of the gate are additive and can outweigh the balancing effects of the hydrostatic pressure on elements of the gate.

4. APPROACH TO DESIGN

4.1 Gate and Model Forms

The functional requirements provide the parameters for a gate design. These may allow the design to be of several different forms. When designing for a seismic event, careful attention must be paid to factors such as the anticipated structural response, stiffness distribution, load paths and boundary conditions, as these will significantly influence the practicality of the design.

A common structural form for a large hydraulic gate, such as used in locks or dry docks, is a multicellular box section of steel construction that acts as a planar structure supported on three sides by the substructure, the supports being a sill at the bottom and a quoin at each side as demonstrated in figure 2.

Typically it consists of vertical skinplates on the upstream and downstream faces, connected by horizontal decks and stiffened by vertical web frames and possibly diaphragms at intervals along the structure. The horizontal decks divide the gate into several chambers, stacked one above the other. The skin plates, decks and any diaphragms are also normally stiffened by flats or angles. For global effects, the skin plates act as flanges to the webs formed by the decks and also to the vertical web frames or diaphragms. The web frames or diaphragms provide racking or torsional stiffness. Depending on operational or other requirements, some chambers may provide permanent or variable buoyancy, while other chambers may be tidal or permanently filled with water.

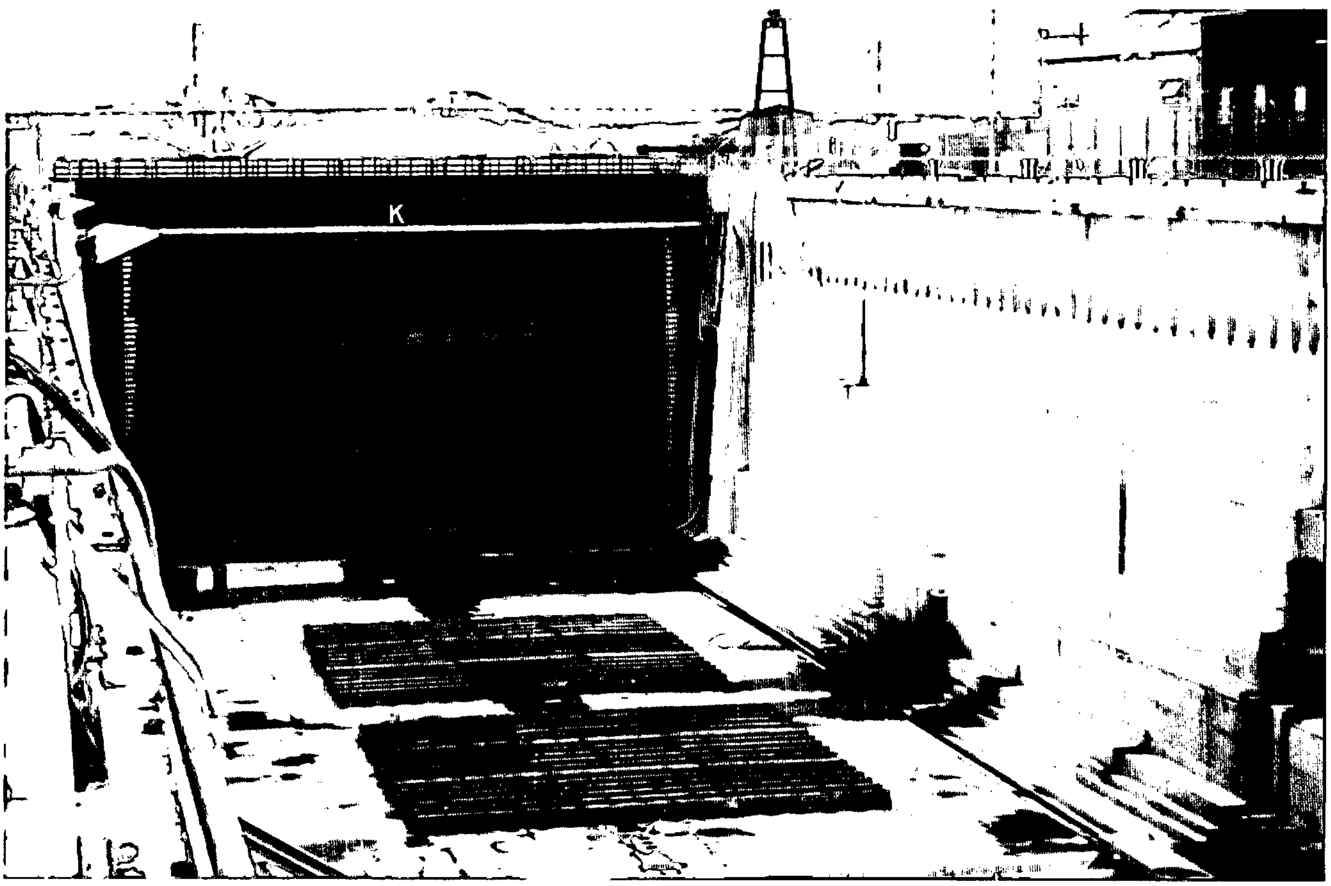
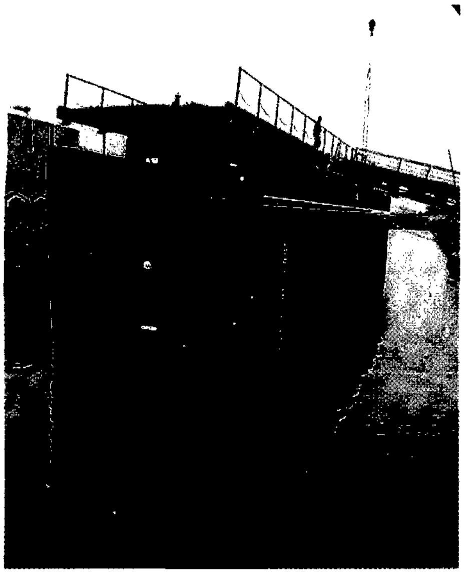


Figure 2 : K Caisson, Rosyth Dockyard, UK

An example of a large gate of this form is illustrated in figure 3 below.



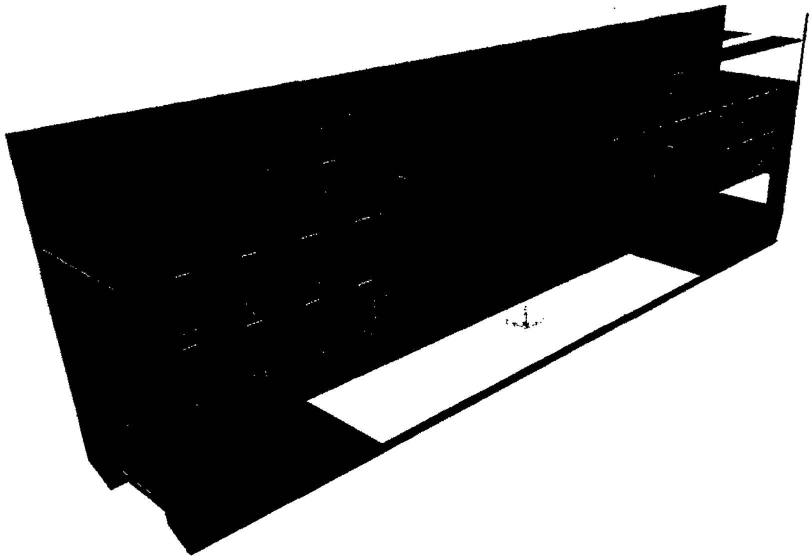


Figure 3 : (A) K Caisson, Rosyth Dockyard, UK on arrival
(B) M Caisson, Rosyth Dockyard, UK as modelled – cutaway section showing internal structure, omitting trusswork for clarity

It is desirable to minimise the mass high up in the gate as this is where the highest accelerations are experienced and therefore unnecessary mass in this part leads to significant additional inertial loads. Depending on the structural form of the gate and the relative magnitude of the seismic to hydrostatic loads, it is possible for the gate to lift off its supports especially near the top of the quoins. Under cyclic loading the gate will re-contact and there is potential for damaging pounding to take place. In the across waterway direction, the seismic loading can cause the gate to slide or roll depending on its support conditions. This motion tends to decouple the gate from the effect of the earthquake but can potentially "walk" the gate off its supports especially where these may well have a significant seismic response of their own. Such a scenario under significant loading could potentially cause catastrophic failure and must be guarded against.

The introduction of seismic isolation, for example through the use of laminated rubber bearings, can be used to reduce seismic loading where this can be conveniently introduced. For example on K and M caissons shown in figures 2 and 3, the bridge deck is isolated in this manner. This had a number of other beneficial effects as with these gates the deck was also hinged to lower it when the gate was withdrawn under the side of the lock structure.

4.2 Analysis Methodology

The analysis should be performed in several stages; an initial stage using simple models that can be checked for validity using hand techniques leading sequentially to more complex and sophisticated models used for a detailed design. This approach allows for a staged increase in confidence that the analysis model is behaving appropriately and that the designer understands the load paths and structural response. Early models with simplifications can allow overall effects to be rapidly assessed as part of an optioneering exercise, reducing the potential for unexpected problems later in the design.

Models may be constructed from plate or shell elements, as grillages, or as a combination of beams and shell/membrane elements. Different model forms may be used at different stages, and sub-models may be built to investigate particular issues.

Two main approaches are feasible. The response spectrum approach coupled to a modal analysis or a time history analysis. The advantage of the response spectrum method is that its output is limited to the peak value of all the items of interest. Therefore the quantum of data to manipulate is limited. With a time history approach, the analysis runs can take significantly longer and the volume of data produced can be very demanding to manipulate. The advantage of this latter approach is that non-linear effects, both in terms of material behaviour and non-linear geometry (such as gate separation from its supports or sliding), can be explicitly modelled.

The typical fundamental mode frequency for a large gate is of the order of 1-3 Hz and is below the main frequency band where earthquake energy is concentrated, where gates are founded on competent geological strata. However higher frequency global and local modes will also be excited and lead to significant amplification of ground motions with elevation in the gate. It is important that, where a modal analysis is used, the FE analysis identifies all of the significant modes and captures sufficient participating mass so that the resulting force actions on the structure are not underestimated. A time history analysis will give the interaction of these modes for the specific time history set used whereas, in the response spectrum method, the responses of the various modes need to be combined by a method appropriate to the overall response: a number of techniques are used varying from the SRSS (Square Root of the Sum of the Squares) approach to the more sophisticated CQC (Complete Quadratic Combination), which will capture the interaction of closely spaced modes.

It is not realistic to expect peaks from three orthogonal earthquake components to occur simultaneously, and there are various accepted statistical methods for combining these directional components, such as SRSS and the 100-30-30 (or more conservatively 100-40-40) rules.

Non-linear effects, such as lift-off, sliding or other non-recoverable movement, should be investigated as they can significantly affect peak loading and support conditions as outlined in section 4.1.

4.3 Design Codes

Gates have been designed using a wide variety of design codes, which tend to be used on a national or regional basis. Codes should be used which are consistent with the structural form and desired performance of the gate. For example, not all steel design codes are based on research related to box girders or stiffened plate structures, which are generally the preferred structural forms for large gates. Some codes do not specifically deal with combined high out-of-plane pressure and in-plane stress effects on stiffened plates. Many codes do not have any formalised approach for seismic design or the associated detailing. Care must be taken therefore to properly understand these various factors and have a properly structured approach to design.

Steelwork in gates normal includes a protective coating, often with a cathodic protection system, which is maintained to improve the gate's durability. Some design codes require that an allowance is made for loss of metal through corrosion. It may be necessary to analyse the gate for the corroded and non-corroded condition as loss of section and therefore change in the distribution of stiffness and induced load may be significant for some components.

4.4 Convergence of Design

The structural design of gates in a seismic environment requires the balancing of a number of competing design parameters. The stiffness of the gate and its mass under the seismic event induce load effects throughout the structure. Design of the gate components to accommodate these effects may change the mass and/or the stiffness, thus changing the load effects which then require to be checked to demonstrate that the structure can accommodate these second-round effects, and so on. At the same time, it is common for large gates to be required to be able to become buoyant during installation or maintenance, if not during actual operational use, and the mass and its distribution within the gate will have an influence on its buoyancy and floating stability, which generally will have tight limits. This stability requirement also interacts with the mass part of the load effect/mass/stiffness design cycle. The design of gates in a seismic environment can lead to an indeterminate cycle of design and checking; this should be avoided by seeking a balanced practicable and pragmatic solution rather than over-optimising the design.

4.5 MEICA Equipment

Gates require Mechanical, Electrical, Instrumentation, Controls, Automation (MEICA) plant to provide their motive power and their control. This equipment may also require to be capable of providing the required performance after an operational basis seismic event. The input motions for equipment located on the gate will be the accelerations of the gate components to which they are attached; these are known as secondary response spectra. Similarly, the input motions for equipment sitting on the lockside or dockside will be modified from the general input spectra supplied to the gate design, normally provided at rockhead level, and may be expected to be magnified with elevation.

5. ADDITIONAL CONSIDERATIONS

5.1 Loading

When considering seismic loading at a detailed and rigorous level, certain complications arise. For example, angle stiffeners to skinplates will play their part in the overall global action of the gate structure as well as being subject to local actions in stiffening and supporting the plate between frames. The global seismic action is primarily driven by the fundamental natural frequency whereas the local effects due to spanning between frames will be related to the structural response of the local member, which will occur at a higher frequency. However, the web and flange of a stiffener subjected to horizontal and vertical accelerations will experience local hydrodynamic loading perpendicular to the stiffener surfaces as they are accelerated with trapped water mass. This causes additional and concurrent force actions in these elements, setting up unusual stress fields that require to be added to those induced by the global and local effects. It should be noted that the acceleration of components in any direction is determined by their individual response in that direction; these may exceed the initial motion input to the gate.

Figure 4 shows a typical example, where the stiffener and its associated skinplate will act as part of the global load resistance to the combined horizontal hydrostatic and hydrodynamic effects of the gate. As the gate spans the opening between the supporting walls, this results in largely axial stresses, whereas the coexistent local effect of these stiffeners and effective skinplate spanning between gate frames sets up bending induced stresses in the same longitudinal plane. At the same time, the local out-of-plane vertical effects cause the flange to try and span between the frames, setting up a vertical bending action which induces longitudinal bending induced stresses in

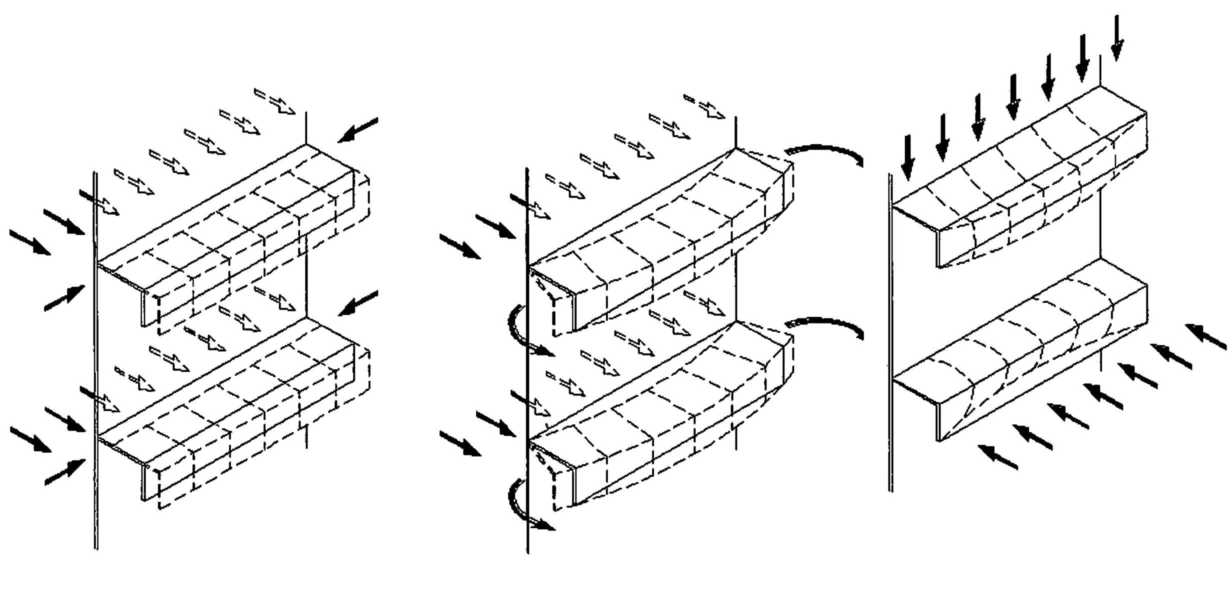


Figure 4 : Illustration of global, local and element loading effects

the stiffener flange. Simultaneously, the angle will provide some resistance to the out-of-plane vertical effects by cantilevering from the skinplate, setting up bending stress effects in the stiffener web. The angle may resist the out-of-plane vertical effects by simply spanning between the frames or as a fixed end effect; this will be influenced by the component frequencies. During this, the stiffener flange is also being accelerated with the water mass between the skinplates, resulting in it flexing and twisting along its length, setting up stresses in the flange and its supporting web. This simple example is typical of the multiple and simultaneous duty that is placed on components of a hydraulic gate structure under earthquake loads, and more complicated structural arrangements, such as the vertical web frames, are subject to the same complex loadings.

5.2 Ductility

For a design where damage is anticipated under higher seismic loading, detailing must be such as to achieve the required plastic deformations without total structural failure and collapse. The objective becomes therefore to ensure that ductile modes occur at lower loads than brittle modes of behaviour. Brittle modes would include for example buckling of elements, fracture of welds and lamellar tearing. Tensile yielding is a ductile mode if the steel used complies with normal minimum requirements for elongation and notch ductility. Buckling can be controlled by careful detailing, avoidance of slender stiffener sections and compliance with design guidance on the proportioning of outstand to thickness ratios. Likewise, attention should be paid to load path details to avoid stress concentrations and the potential for excessive demand on plastic strain in zones where damage is expected under the seismic loading. Where trusswork or bracing members are used in the design of the gate, these elements also require careful consideration.

An appreciation of global and local modes of failure and the sequence in which they occur provides a very useful means of determining where detailing effort should be focussed. Non-linear modelling accounting for material and geometric effects can be used if significant plastic behaviour is required to achieve the design aims. This need not be through a seismic time history approach, but can be examined under a quasi-static pushover analysis.

6. CONCLUSION

The design of hydraulic gates requires a systematic approach with a clear understanding of how the demands of functional and operational requirements, structural form, mass and stiffness distribution and the various loading regimes all interact in order to arrive at an optimally balanced solution. Seismic loading and hydrodynamic effects in particular require a deeper level of knowledge in order to understand the implications on the design. In particular, care needs to be exerted to proportion elements not only to achieve minimum strength requirements but also to achieve an optimal seismic response by control of stiffness and mass and in zones where plastic deformation is likely to occur under extreme events. In these zones, careful consideration of the detailing is required in order to maintain structural stability and provide for the required plastic deformations in order to prevent overall structural failure or collapse.

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SUMMARY

The paper describes a systematic approach to the seismic design of hydraulic gate structures in accordance with current state of the art. The approach is formulated around the definition of two performance levels, one defining an operating or minimal damage level and the other a survival event. The nature of seismic loading and hydrodynamic effects are described, analytical routes are outlined and the selection of design codes and detailing practice discussed. In addition, some of the complications inherent in a rigorous approach are explained.

RÉSUMÉ

L'article décrit une approche pour la conception sismique des structures de portes hydrauliques conformément à l'état de l'art actuel. Elle est basée sur deux niveaux de performance : le premier définissant un état limite de service et le second un état limite ultime. L'article présente la nature du chargement sismique, les effets hydrodynamiques, les routines analytiques, le choix des codes de calcul et des applications détaillées. En complément, quelques-unes des difficultés inhérentes à la méthode sont expliquées.

ZUSAMMENFASSUNG

Der Artikel beschreibt einen systematischen Ansatz für die seismische Gestaltung von Konstruktionen hydraulischer Tore nach dem gegenwärtigen Stand der Technik. Der Ansatz wird nach der Definition zweier Leistungsniveaus formuliert, eines, welches ein Betriebs- oder Minimalschadensniveau definiert, und das andere, welches einen Überlebensfall definiert. Die Art der seismischen Belastung und der hydrodynamischen Effekte werden beschrieben, analytische Wege werden aufgezeigt und die Auswahl von Normen und praktische Details werden diskutiert. Zusätzlich werden einige Komplikationen, die einem strengen Ansatz eigen sind, erklärt.

LIVERPOOL CANAL LINK – SUMMARY OF COMPLETED WORKS

by

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KEY WORDS

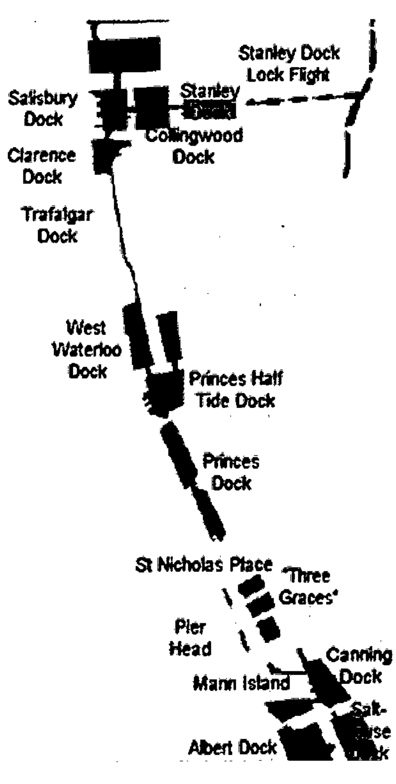
Canal, regeneration, heritage, planning, funding

MOTS-CLEFS

Canal, reconstruction, patrimoine, planification, financement

1. BACKGROUND

1.1 What is the Liverpool Canal Link ?



The Liverpool Canal Link is a 2.2 km new section of waterway that opened in to full navigation in 2009 and which connects the end of the Leeds & Liverpool Canal in north Liverpool into the South Docks commercial/leisure complex in the city centre, which includes Canning, Albert and Salt-house Docks. The link is not a conventional canal but is more a series of existing docks which are now interlinked via new sections of channel, including new basins, locks, tunnels and bridges.

1.2 Why and how was it built ?

In physical terms navigation is now possible for canal craft from Britain's national canal network, through Liverpool's waterfront UNESCO World Heritage Site and into the South Docks, which contain the UK's largest collection of Grade One Listed heritage buildings. An amount of £ 26 m of public and private funding was attracted to the project because of its value in further unlocking the tourism, leisure and commercial development potential of Liverpool's waterfront. Three main construction contracts were procured by the client British Waterways: the northern (docks) section built by Pierse, the central (Pier Head) section built by Balfour Beatty and the southern (Mann Island basin) section built by BAM Nuttall. Most of the new structures are reinforced concrete with a granite cladding. Arup were the main designer and, along with JR Knowles, they also assisted British Waterways in site supervision and contract administration.

1.3 What were the main challenges?

Assembling the funding, the land and the planning consents through this city centre site took over four years of, at times, intensive negotiations with Liverpool City Council, the port authority Peel (the main landowner), four government agencies – Northwest Development Agency (NWDA), Government Office North West (GONW), English Partnerships (EP) and National Museums Liverpool – and private developers Countryside Neptune. In total twelve legal agreements were required for BW to be allowed to commence works and they were assisted in their negotiations by the city's regeneration agency Liverpool Vision. The £ 25 m funding was provided by GONW, NWDA, EP, BW and Peel.

During construction close co-ordination was required with landowners and developers to maintain access to existing land and more importantly to other developments that were ongoing through the life of the project: a new cruise liner facility, ferry terminal, museum and the major developments around Princes Dock and Mann Island.

2. SCHEME DESCRIPTION

2.1 Stanley Lock Flight to Salisbury Dock – existing locks and dock space

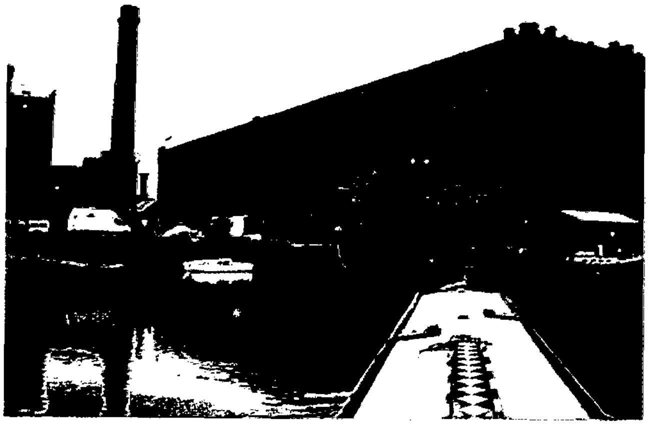


Fig. 1: Collingwood Dock looking towards Stanley Dock

The Leeds & Liverpool canal drops through a set of locks, the Stanley Dock Lock Flight, into Stanley Dock which is linked to Collingwood and Salisbury Dock. These docks had ceased commercial shipping operation in the 1970s and are therefore only used for commercial and leisure boats.

The port operator Peel identified the need to protect the water levels in their North Docks; these docks are a commercial operation and the water levels needed to be within Peel's control at all times. An isolation structure was designed and constructed across the old lock gate location between Nelson and Bramley-Moore docks; sheet piled cofferdam was installed tied together with tie rods and backfilled to provide an access over the lock passage. A set of balancing pipes installed across the isolation structure controlled by automated valves maintains the level of the water in the docks either side of the isolation structure. The pipes will also allow a continuation of the mixing of impounded salt water from the north docks with fresh water from the lock flight to maintain water quality and salinity.

2.2 Central Docks – new channel with a bridge then use existing dock space

From Salisbury Dock the new canal route runs south into Trafalgar Dock where a large length of the dock had been backfilled. The route through this section took the canal through both backfilled dock and through a section of existing dock structure.

The section of new channel through the backfilled dock was constructed utilising the existing dock wall on the east side and an excavated sloping side on the other. The bed and side of the canal are lined with an impermeable plastic membrane; the canal bed has a mass concrete slab to protect the liner and the slope is protected with precast concrete 'dycel' units.

The section of new canal which passes across an existing infilled dock passage between Trafalgar and West Waterloo Docks is constructed as a reinforced concrete U-shaped channel. The canal through this section isolated the area to the west so a new fixed access bridge has been built over the new canal and this was built off piled abutments with precast concrete beams.

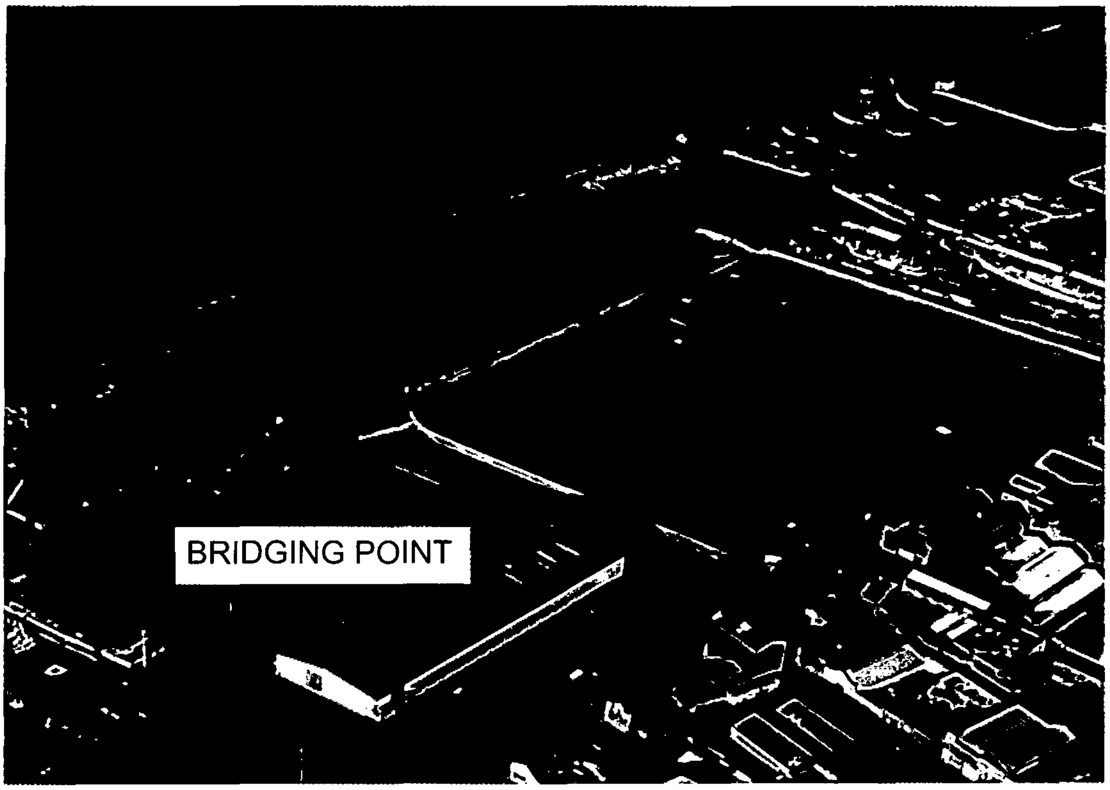


Fig. 2: Aerial photograph showing the route in-filled Trafalgar Dock

The route of the new canal link continues south through West Waterloo Dock into Princes Half Tide Dock; the water level in these areas was lowered during construction. The dock bed level has been raised over the last ten years and along the line of the canal the bed was re-profiled in places to ensure the minimum draft for canal boats was provided.

2.3 Princes Dock – existing dock space, change to existing bridges and a new lock

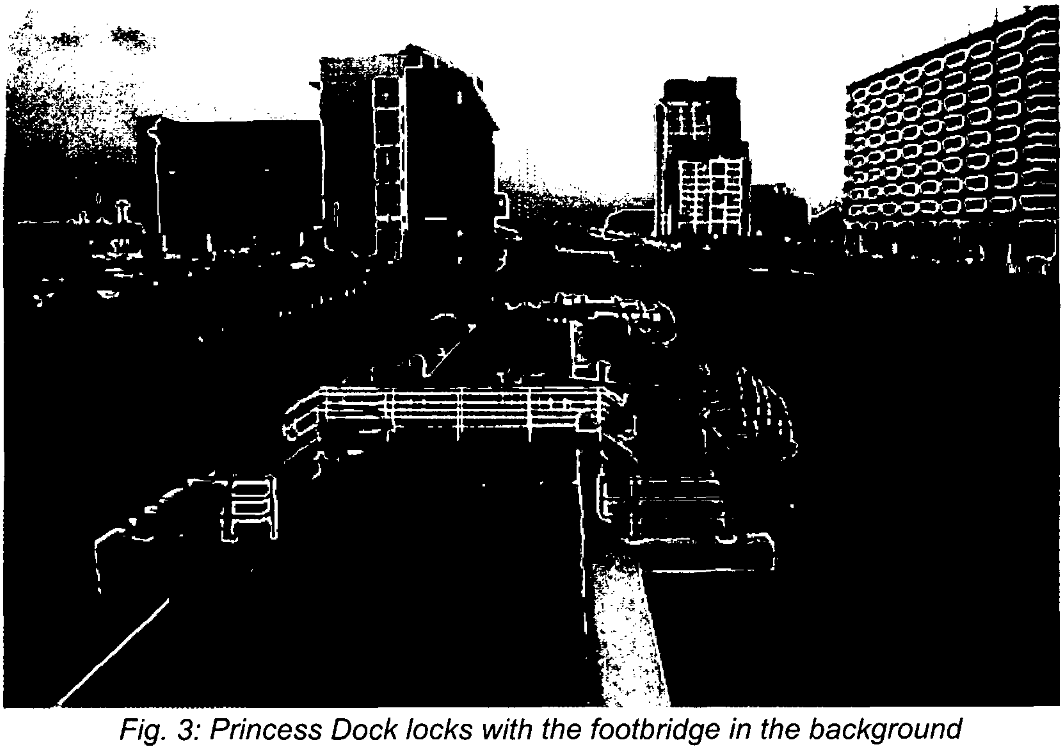


Fig. 3: Princess Dock locks with the footbridge in the background

The dock passage between Princes Half Tide Dock and Princes Dock was filled in with a sheet piled causeway; opening this passage to navigation required an in situ concrete box culvert to be installed and the road profile over the causeway lifted to accommodate the culvert.

The route south through Princes Dock goes under the Princes Dock footbridge and the water level dictated that the level the bridge had to be lifted to accommodate canal boats. The option to lift the bridge the desired height was not feasible due to the levels of access to adjacent buildings on the west side of the bridge. A compromise was chosen with a lift of 1.375 m and the structural hoops on the underside modified in three locations allowing clearance under a designated section of the bridge.

At the south end of Princes Dock the first change in operational water level was required and this entailed building a lock to lower the boats. The in situ reinforced concrete structure was supported on precast concrete piles driven through the filled in dock bed to rock head; conventional timber lock gates were used.

2.4 New Tunnel into Pier Head

The canal tunnel section between Princes Dock Lock and Pier Head was constructed in three sections under different contracts. The first section completed was the section under the vehicular marshalling area and access route to the new Cruise Liner Facility. This was procured by Liverpool City Council as part of design and build contract for the Cruise Liner Facility.

The second element constructed was the section to north linking into Princes Dock through a development site. This section of culvert is on a curve as a constraint was imposed by the landowner to keep the canal to the edge of the adjacent development site. At design stage modelling of boat manoeuvrability was undertaken to ensure narrow boats of up to 24 metres in length could navigate the radius. The last piece of this section of culverted tunnel at the south end links the canal into the Pier Head section. Here the canal has been widened to facilitate boats navigating through a change in alignment into the Pier Head.

2.5 New construction at Pier Head

– two basins with a short tunnel between

Fig. 4: South Basin at Pier Head with the short tunnel through to the north basin in the background

The canal at Pier Head has two open basins with a tunnel section linking them. This section of canal was designed in coordination with a new public realm scheme procured by Liverpool City Council, where an area 2.5 times the size of Trafalgar Square is re-profiled and re-surfaced. The effect has been to link the two projects using similar materials and integrating it within the World Heritage site. The canal is an in situ reinforced concrete structure clad in granite with a pineapple textured finish; lighting is incorporated in the canal walls and portals to provide animation at night. Adjacent to the open basins the publish realm has carved a huge dish profile to enable people to get closer to the waters edge with the added benefit of providing protection from the prevailing winds.

Advance works were required to maintain services to the Ferry Terminal Building on the river front. A service corridor below the canal was identified for water, gas and electric services which allowed them to be diverted prior to main works starting.

The Mersey Estuary Pollution Alleviation Scheme (MEPAS) drainage system picks up most of the surface water drainage from the city but there were two main drainage systems outfalling into the River Mersey passing through the Pier Head area. One was still functioning and, to negate an expensive diversion underneath the new canal structure, a diversion to the MEPAS drainage system was carried out. The other one outfall was supposedly sealed at the river front but this was proven not to be the case resulting in a flooded excavation and additional works required to seal the drain.

The ground water level through this area was around the excavation level and with the variation caused by the River Mersey tidal influence additional works had to be taken to deal with ever changing water levels. Notably there would be a time lag between high tide and the effect on the local ground water level even with such a local proximity to the river.

2.6 New construction at Mann Island

– tunnel into a basin, then a lock into the existing south docks waterspace

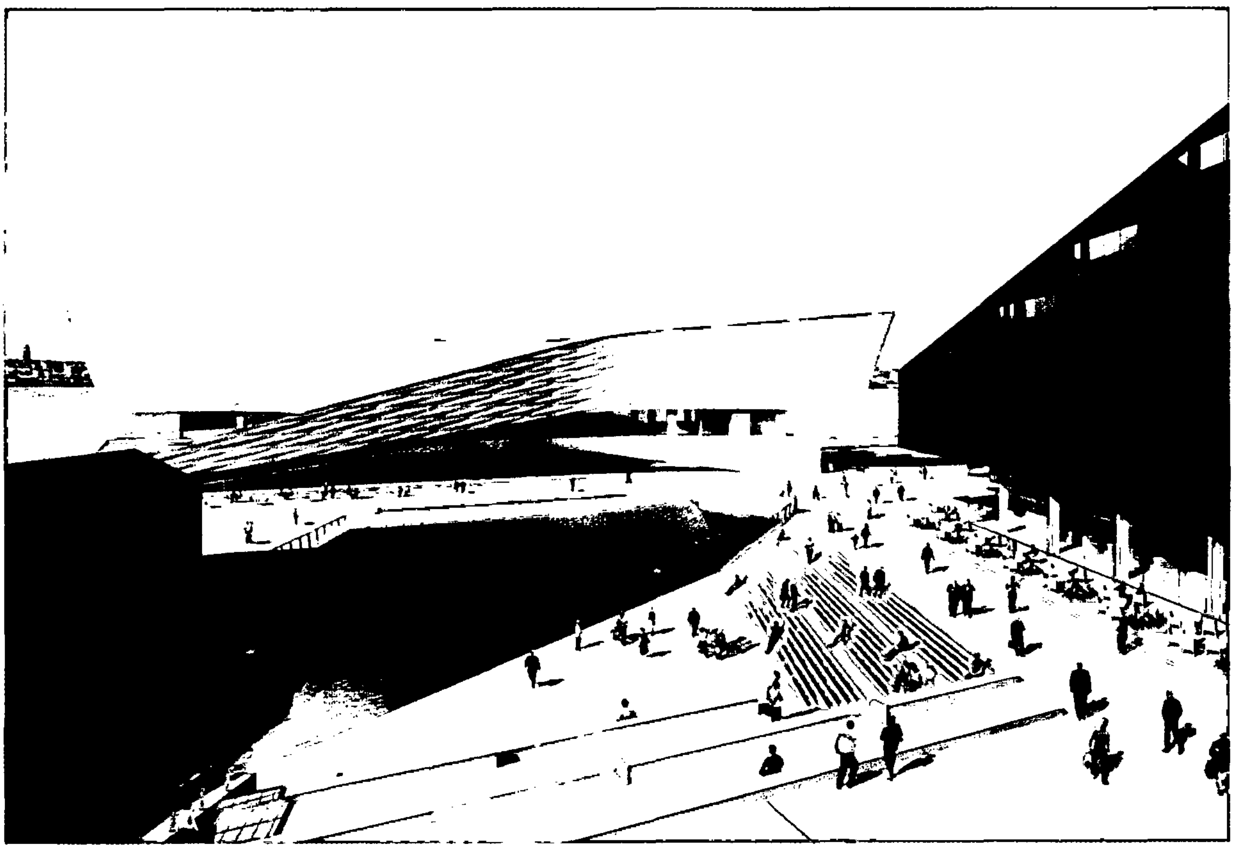


Fig. 5: An image of Mann Island basin with the new Museum of Liverpool in the background and the new development (still under construction) to the right

The canal carries on south through a tunnel over which is the access to the new Museum of Liverpool. This leads into the Mann Island basin with the Countryside/Neptune Properties development on the north east side and the New Museum of Liverpool on the west side. This section of canal is also in situ reinforced concrete structure clad in granite. On the south west side the canal runs parallel to one of the walls to Manchester Dock, which was previously infilled from the arisings from the Kingsway road tunnel that passes under the Mersey. The stability of this existing dock wall was unknown so the construction sequence was developed to minimise the area of this wall exposed at any one time. The proximity of the new Museum of Liverpool site limited the working space available and resulted in the need for a temporary sheet pile wall to carry out the excavation and construction of the canal. The interface with the foundation construction for the new museum required detailed contractor coordination as the wall to the new canal and the face of the museum massive raft foundations are less that 500 mm apart!

The Mann Island Lock lowers the canal boats down to Canning Dock. The break through into Canning Dock required approval from English Heritage as the dock wall is a listed structure and is the oldest dock wall in operation in the city. A temporary cofferdam was constructed around the entrance before the existing wall masonry was carefully dismounted and skilled masonry workers were required to ensure the new canal entrance was seamless in appearance.

The lock gates are steel due to the height of the gates and the potential for timber to warp over time. The lock also contains flood gates to prevent flooding of Pier Head and Mann Island canal and public realm in the event of failure of the Canning river entrance further south.

3. CONCLUSION

The planning, land assembly, funding, design and construction of Liverpool Canal Link represents a significant achievement by British Waterways and its partners and other stakeholders.

Weaving a new navigation through several development sites and across the city's most important area of public realm presented at times seemingly insurmountable risks and challenges. Throughout all of this there was a steadfast commitment to engineering and architectural design quality and it is now enjoyed by the many thousands of visitors who can visit the wonderfully regenerated waterfront. I'm sure everyone who worked on the project are as proud as I am and the lasting legacy we have left for the city.

SUMMARY

This paper is a shortened version of the Liverpool Canal Link paper to be presented at the PIANC MMX World Congress in Liverpool in May 2010. This paper describes the key features of the canal link, including brief design and construction considerations. The description runs from north to *south*, *i.e.* from Stanley Dock lock flight to Canning Dock, which is the journey a boat would make when first navigating the link.

The author was the senior manager responsible for the project delivery for the client British Waterways, following completion of the project he left to work for the consultant Jacobs.

RÉSUMÉ

Cet article est une version courte d'une publication sur la liaison canal de Liverpool qui doit être présentée au congrès international 2010 de l'AIPCN, à Liverpool, au mois de mai prochain. Elle décrit les principales caractéristiques de la liaison et aborde brièvement les aspects de dimensionnement et de construction. La liaison est présentée du Nord vers le Sud, c'est à dire depuis le passage de l'écluse de Stanley Dock jusqu'à Canning Dock, ce qui représente le trajet qu'un bateau pourrait faire lorsqu'il naviguera pour la première fois sur cette liaison.

L'auteur a été le premier directeur responsable du projet pour le client British Waterways, après l'achèvement de ce projet il a commencé à travailler pour le consultant Jacobs.

ZUSAMMENFASSUNG

Dieser Artikel stellt eine verkürzte Fassung des "Liverpool Canal Link" Artikels dar, der auf dem MMX. PIANC Weltkongress in Liverpool im Mai 2010 präsentiert wird. Er beschreibt die Hauptbestandteile der Kanalverbindung und enthält einige Überlegungen zur Gestaltung und zur Konstruktion. Die Beschreibung geht von Nord nach Süd, also von der Stanley Dock Schleuse zum Canning Dock, was der Fahrt entspricht, die ein Boot machen würde, wenn es die Verbindung zu befahren beginnt.

Der Autor war der Senior Manager, der gegenüber dem Kunden British Waterways für dieses Projekt verantwortlich war; nach der Beendigung dieses Projekts begann er für den Berater „Jacobs" zu arbeiten.

CRUISING BACK TO LIVERPOOL

by

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KEY WORDS

Cruise, floating facilities, design, construction

MOTS-CLEFS

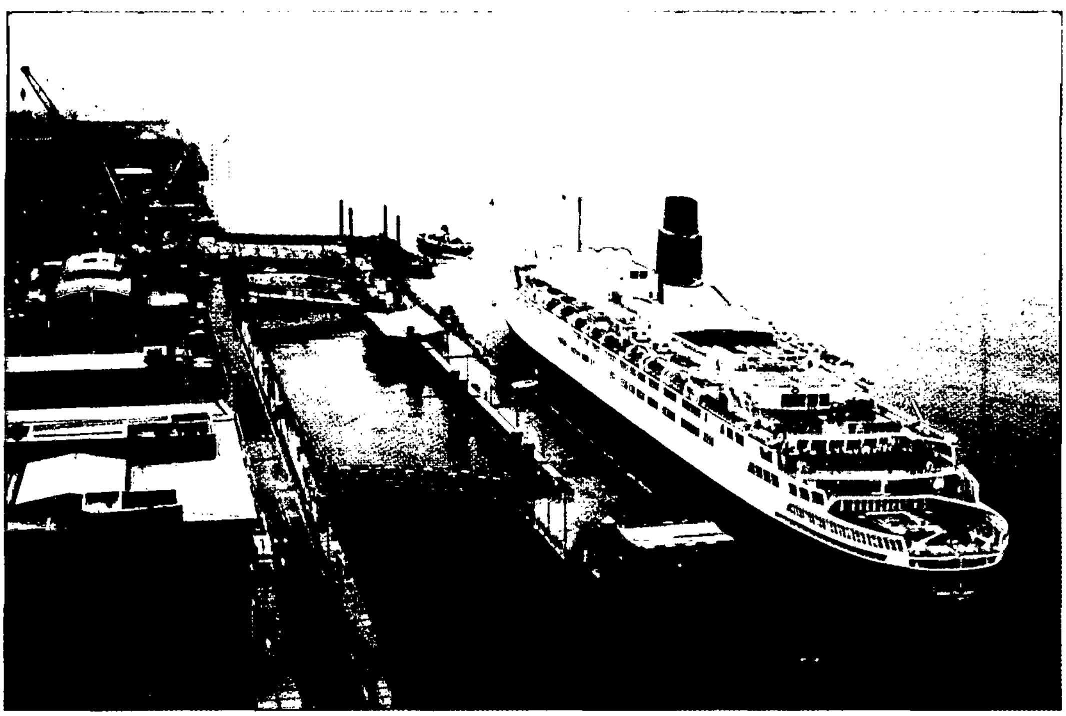
Croisière, équipements flottants, conception, construction

NEW CRUISE LINER FACILITY

Liverpool was once one of the world's largest passenger ports. White Star Lines and Cunard, *Lusitania* and *Mauritania,* are names synonymous with the City's glorious maritime past.

Maybe for a while luxury liners went out of fashion. But cruising the ocean waves is once again a fast-growing pastime and big business for ports. However, come the new Millennium, the city had no dedicated berth for cruise liners. Passengers had to be ferried back and forth from the pierheads.

Which is why Liverpool City Council and the regeneration body Liverpool Vision were anxious to build a new state-of-the-art cruise liner facility to attract the world's biggest cruise ships and their high spending passengers back to Liverpool and the north west region.



Gifford was appointed civil engineering and building structures engineering consultant to the project with a design that would see four huge pontoons fabricated offsite and positioned into a 258 metre long landing stage supporting reception facilities and pilot's buildings.

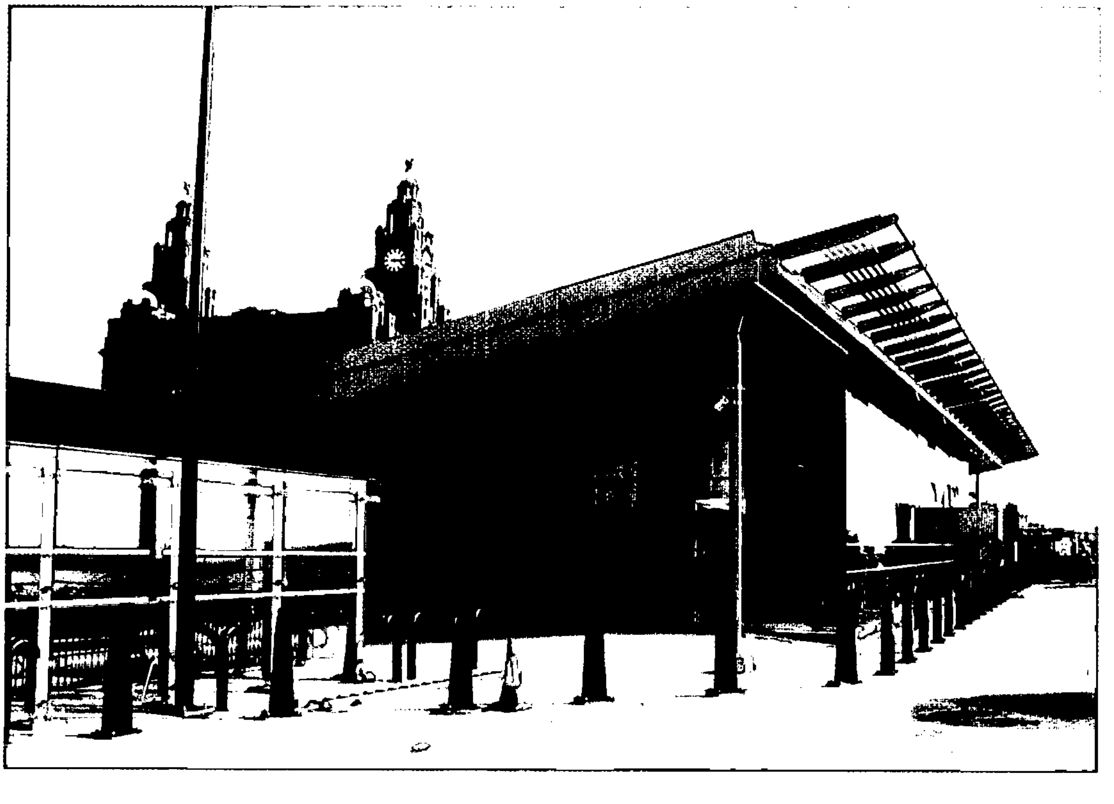
Our engineering team was convinced a floating facility would be preferable to a fixed structure in order to cope with as much as 13 metres of variation in tidal depth, one of the largest tidal ranges in the world. A floating facility has the benefits of maintaining a constant access level for ship-to-shore connection and passenger transit.

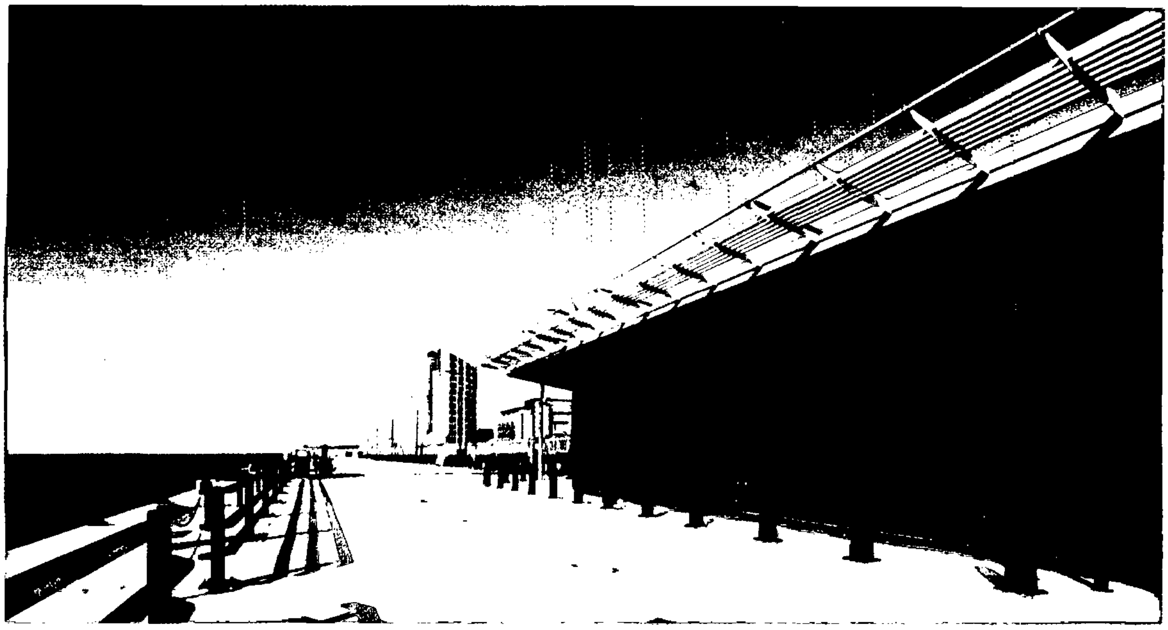
Although the original plans specified a steel floating structure, the volatility of world steel prices from 2003 onwards led us to recommend using concrete as the principal construction material, both from a cost point of view and for its performance. Concrete is a superior material for structures permanently submerged in water. It would also suit Lloyds of London for insurance purposes and passengers would still be greeted in glass and steel receptions built on the landing stage.

Tourists would be disembarking close by the iconic Liver building and its near neighbours that make up the famous waterfront silhouette know collectively as "The Three Graces". The facility needed to provide a high-class gateway for Liverpool and therefore the buildings on the facility had the design challenges of combining glass fronted structures typically found onshore but exposed to the constant movement of the platform – something which could be considerable during the berthing of a ship.

We also had in mind the need to minimise the environmental impact of the new structure and to avoid disturbing the historic quay wall which is within the World Heritage Site. Hence the facility is placed some 30 m from the quay wall out in the Mersey with separate vehicular and pedestrian linkspans to access it.

It was crucial to achieve the short project programme that the design and planning of the pontoons took place in parallel with the design of the buildings and superstructure that would eventually be built on them. However, this creates a need for careful weight control and risk management as the pontoons, when in position as a complete landing stage at the pierhead, must float at the correct level but the flotation level would be determined by the downforces of the superstructures built on it.





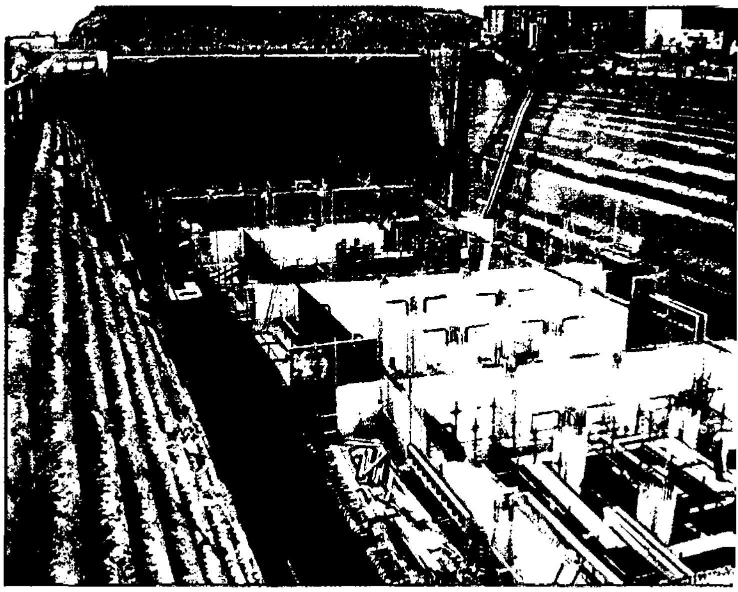
Just to complicate matters further, the options of where to build the pontoons began to narrow alarmingly. They would be very big – 64 metres long, up to 25 metres wide and 5 metres deep. It was decided that once built launching them over water or down slipways was too risky. Although there are plenty of nearby dry docks that weren't big enough, and building the pontoons at separate sites would not be economic.

The one possibility was to build them in the enormous Canada Graving Dock. Although in use for over 100 years, it hadn't been operational for some time due to the decline of the shipping industry. It needed some serious renovation work carried out to its pumping systems and the dock gates. But once that was carried out, the dock proved to be serviceable.

Many of the services and fittings for the landing stage were installed in the controlled environment of the dock. But the buildings superstructures could only be constructed once the pontoons were towed out into position and secured fast which meant building on a moving surface. And as the buildings grew vertically so the landing stage submerged further.

Whilst this stage of the project probably caused our engineering team the most sleepless nights, the careful calculations made during the parallel design process paid off and the landing stage "settled", so to speak, at the correct level as the buildings were completed.

Now Liverpool has its much-needed modern cruise liner facility which can take cruise ships as large as the Queen Mary 2 and once again the City is witness to the marvellous spectacle of giant ships docking in the Mersey just downstream of its famous ferries.



SUMMARY

Liverpool was once one of the world's largest passenger ports, which is why Liverpool City Council and the regeneration body Liverpool Vision were anxious to build a new state-of-the-art cruise liner facility to attract the world's biggest cruise ships and their high spending passengers back to Liverpool and its surrounding area. The new 250 m long floating concrete facility supports high quality glass buildings, and in its prime position within the World Heritage Site of the historic Liverpool waterfront and the Three Graces, it now provides a key marine facility to assist Liverpool in reinvigorating its maritime links.

RÉSUMÉ

Liverpool était autrefois l'un des ports à passagers les plus importants du monde, ce qui explique que le conseil municipal de Liverpool et l'organe de rénovation de la ville « Liverpool Vision » aient souhaité construire un nouvel équipement de pointe pour les lignes de croisière afin d'attirer, de nouveau, les plus gros bateaux du monde et leurs passagers à fort pouvoir d'achat à Liverpool et dans ses environs. Le nouvel équipement flottant en béton de 250 m de long supporte des immeubles en verre de grande qualité et sa position, au cœur du site historique de la rive de Liverpool classé au patrimoine mondial et des « Trois Grâces », offre à la ville un équipement clé pour revigorer ses liaisons maritimes.

ZUSAMMENFASSUNG

Einst war Liverpool einer der weltgrößten Passagierhäfen; deshalb war der Stadtrat von Liverpool sowie das Erneuerungs-Gremium „Liverpool Vision" darauf bedacht, eine neue Anlegevorrichtung zum Bau von Kreuzfahrtschiffen nach dem neuesten Stand der Technik zu bauen, um die weltgrößten Kreuzfahrtschiffe und ihre wohlhabenden Passagiere zurück nach Liverpool und seine Umgebung zu ziehen. Die neue 250 m lange, schwimmende Vorrichtung aus Beton trägt hoch qualitative Glasgebäude und in seiner erstklassigen Lage innerhalb der Weltkulturstätte des historischen Liverpooler Hafengebiets und der „Three Graces" stellt es nun eine maritime Schlüsselvorrichtung dar, um Liverpool zu helfen, seine maritimen Verbindungen wieder zu stärken.

CLIMATE CHANGE MITIGATION AND ADAPTATION MEASURES FOR INLAND WATERWAYS IN ENGLAND AND WALES

by

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KEY WORDS

Climate change, mitigation, adaptation, inland waterways, United Kingdom

MOTS-CLEFS

Changement climatique, atténuation, adaptation, voies navigables, Royaume-Uni

1. BACKGROUND

2.2 Design process

In early 2009, the Inland Waterways Advisory Council (IWAC) received a grant from the Department of Environment, Food and Rural Affairs to research and to publish evidence of how inland waterways in England and Wales can assist in mitigating and adapting to the effects of climate change. The IWAC is an independent statutory body created to advise the UK government, navigation authorities and other interested persons on matters relevant to Britain's inland waterways.

There is now no serious doubt that climate change is happening. If the worst effects of global warming are to be avoided, it is vital for all sectors to take steps to reduce their greenhouse gas emissions. Measures which reduce a sector's contribution to the climate change problem are referred to as mitigation measures.

However, whilst mitigation measures might help to lessen the scale of the problem, some impacts of global warming are now inevitable. Adaptation will therefore also be essential. Adaptation measures help society prepare for and adapt to the anticipated effects of climate change by reducing vulnerability and increasing long-term resilience.

This article summarises some of the findings of the IWAC research report. Based on the 'most likely' impacts of climate change, it highlights the anticipated consequences for inland waterways in England and Wales and explores the range of potentially appropriate climate change mitigation and adaptation measures.

2. CLIMATE CHANGE PROJECTIONS

Under a 'low emissions' scenario, the UK Climate Impacts Programme UKCIP02 suggests that by 2080, England and Wales might expect:

- an increase in precipitation, mainly in winter, of around 15 %;
- a decrease in summer precipitation of up to 30 %; and
- an increase of some 2°-3° C in average annual temperature.

These changes are likely be accompanied by an increase in water temperature, and changes in sedimentation; sea levels will rise and there may be a greater frequency of extreme events. Adaptation measures may thus be required to enable inland waterways to cope with an increased frequency of both Strong Stream and low flow events; associated changes in sedimentation; and the wider implications of increases in both air and water temperatures.

Beyond 2080, there is the potential for more fundamental changes, notably associated with predicted sea level rise. The report to IWAC did not explore climate change scenarios beyond 2080. Rather, both the report and this paper focus on what the inland navigation sector may need to do in the short to medium term.

3. REDUCING EMISSIONS FROM THE INLAND WATERWAYS SECTOR

England and Wales have approximately 4500 km of inland waterways, the vast majority of which are used only for recreation. By length, around 60 % is river based, the remainder being canals.

The waterways network is owned and managed by some twenty navigation authorities comprising a mixture of public corporations, agencies or national parks, voluntary organisations and trusts, and some private sector companies. There is a similar variety in the waterways themselves – including the Manchester Ship Canal and a few other commercial freight waterways (mainly canals); the extensive narrow canal network predominately of the Midlands and the North West; the rivers and lakes of the Norfolk Broads; and several river navigation systems, many in the South and East. Some waterway areas are heavily used and are in fact currently over subscribed by boating users, whereas others are underutilised. Several restoration projects are currently in hand and many more are in the pipeline.

Whilst the contribution of the England and Wales inland waterways sector to the overall problem of global warming is very small, urgent action is required across all sectors to mitigate the effects of climate change. The recent UK Climate Change Act requires a 26 % cut in Britain's carbon dioxide emissions by 2020, and an 80 % cut in all greenhouse gas emissions by 2050 (both relative to 1990 total emissions).

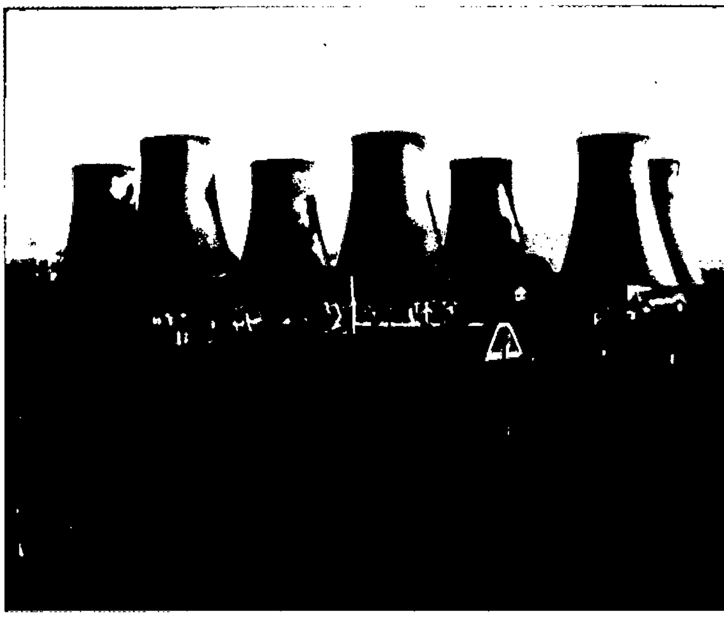

Fig. 1: All sectors need to take action to reduce their greenhouse gas emissions

For the UK inland waterways sector, there is no panacea. Individually, many of the measures identified in the IWAC report will make only a small difference. A combination of measures will therefore need to be implemented if the sector is to achieve a meaningful reduction in greenhouse gas emissions.

The report identified many different measures for reducing emissions from vessels. Some, such as engine use/speed, depend for their effectiveness on the behaviour of individuals. Others would require action by Government or by navigation authorities (eg. new standards for marine engines, or the provision of electricity hook-ups using energy from a renewable source). Many measures could be promoted using incentives - for example, licence fees might be reduced for vessels meeting certain emissions or design criteria. Freight Facility Grants might similarly be made conditional on meeting emissions targets. Potential incentives need further investigation.

Many of the measures identified by the report rely directly or indirectly on changes in behaviour or perception. An education and awareness-raising campaign, undertaken in partnership with a range of user groups, could thus be a useful 'no regrets' measure - particularly if this exercise could also cover some of the adaptation requirements discussed later in this paper. New and ongoing research and development initiatives will also be important, both to further develop alternative energy sources and to improve the efficiency of engines and vessel design.

Insofar as emissions associated with inland waterways infrastructure are concerned, many navigation authorities have already started to move towards general 'good housekeeping' measures. However, the IWAC report identified a number of options whereby authorities might both contribute to a reduction in emissions, and save money. In addition to generating energy locally or using energy from renewable sources, it may be possible for some authorities to exploit opportunities for using water bodies as a source of heating or cooling; to develop low-head hydropower facilities; or to install wind turbines on waterway land. Such opportunities require investigation at a site-specific level.

Finally, moving more freight onto the principal inland freight waterways of England and Wales has the potential to result in a significant reduction of CO_2 emissions. This shift from road to water should therefore continue to be actively promoted.

The report concluded that a combination of different, often local or small-scale, mitigation measures will be required. Inland navigation authorities in England and Wales, supported by the Association of Inland Navigation Authorities (AINA) where necessary, should play a role. AINA was formed in 1996 to provide a single voice on waterway management issues. The broad purpose of AINA is to facilitate the management and development of the inland waterways as an economic, environmental, recreational and social resource. Collectively inland navigation authorities in England and Wales and, when necessarily AINA, should therefore start now to:

- review the range of available mitigation measures and opportunities;
- determine which measures/opportunities are potentially most appropriate; and
- commence a programme of implementation of such measures.

Navigation authorities should also consider how best to influence or assist both their users and other stakeholder organisations in taking action to reduce emissions across the wider sector. Possible priority joint initiatives in this respect might include:

- working with IWAC, UK Government and industry as appropriate to develop and promote new emissions standards; to explore the possibility of introducing incentives; to promote freight movement by water; and
- working with AINA and a range of user and stakeholder groups to develop and promote a climate change education and awareness raising campaign to cover both mitigation and adaptation measures.

4. CLIMATE CHANGE ADAPTATION

The report also identified a number of different types of adaptation measures (see IWAC, 2009). Such measures will contribute to improving resilience and thus make inland waterways better prepared to deal with the effects of climate change:

- 'no regrets' measures, which would provide benefits irrespective of the particular climate change scenario and which may also contribute to meeting other environmental objectives
- adaptive management, which uses data and risk-based assessments to inform decisions on existing or new operations and management activities, enabling them to evolve to take account of climate change effects
- 'win-win' opportunities, measures which meet dual objectives and may, for example, allow costs to be shared between benefiting organisations.

Longer term measures designed to provide efficient and cost-effective solutions to climate-induced problems were also identified but these often require further research or investigations before implementation.

'Regrets' measures, meanwhile, are often irreversible measures which could prove counterproductive and should be avoided.

Amongst the 'no regrets' measures identified by the scoping report, arguably the most essential action for inland navigation authorities is to establish an appropriate monitoring regime. Navigation authorities in England and Wales (supported by IWAC and AINA as appropriate) should therefore begin, at a proportionate level, to:

- investigate and install or improve telemetry, SCADA or other systems for monitoring, data collection and information management;
- build capacity within their organisation to understand and be prepared to respond to the effects of climate change;
- undertake risk-based assessments; set thresholds for action; identify effective and reliable means of communicating changes, restrictions and warnings to users.

Navigation authorities and others intending either to modify or replace assets, or to undertake new development or restoration projects, should future-proof such initiatives to improve their resilience to the effects of projected climate change.

Where inland waterways depend for their operation on a reliable water resource, the responsible authorities should take early steps to:

- identify and implement a suite of appropriate water conservation measures; and
- where appropriate, develop a water resources, conservation and use strategy.

Fig. 2: Action can be taken to reduce water leakage from locks

In all of the above, synergies with the Water Framework Directive should be explored and promoted.

Many of the 'no regrets' and 'win-win' measures identified in the report depend on (or would benefit from the involvement of) other organisations. Measures most likely to benefit from early attention include:

- working with AINA and user groups to develop and promote a climate change education and awareness raising campaign (see above);
- working with the England and Wales Environment Agency and others to optimise data collection and management; and
- where appropriate, preparing integrated water and/or land management plans.

Fig. 3: Buffer strips can both trap sediment and prevent contaminants entering the watercourse

5. CONCLUSIONS

Some degree of climate change now appears inevitable, with associated increases in winter precipitation, reductions in summer rainfall, changes in sediment regimes, and increased air and water temperatures. The extent and speed of such changes, and hence the magnitude of associated impacts, will depend in part on the success of mitigation measures to reduce greenhouse gas emissions. Action on mitigation is urgently needed.

Adaptation measures to increase resilience and make inland waterways better prepared to deal with the effects of climate change, will also become necessary. Whilst consideration may need to be given to modifying or replacing certain operations, assets and infrastructure, etc. some such decisions will not have to be taken for several years. In the meantime, however, measures to collect, retain and manage high quality, locally relevant data; to monitor change; and to improve understanding are required in order to provide vital information to inform decision-making.

Such data will also be needed to enable navigation authorities and others to future-proof ongoing operations and new developments so that they can withstand the projected changes in precipitation, temperature and sedimentation.

Many of the mitigation and adaptation measures described in the IWAC report could most effectively be delivered by encouraging behavioural changes. Educating users both about the implications of their actions, and how modifying their behaviour can help to save both money and the planet, can be an effective way of achieving shared objectives. Such awareness raising initiatives would best be undertaken through a coordinated approach involving a number of partner organisations (eg. British Marine Federation, Royal Yachting Association, Inland Waterways Association, British Canoe Union and others).

Another important method of delivering climate change adaptation will be through strategic planning. The requirements of inland waterways under a scenario of climate change can be highlighted in or delivered through the preparation of a water strategy or via participation in a third party strategic planning exercise, for example the Environment Agency's Water Framework Directive river basin management plans. The opportunities for additional recreational use of both water areas and towpaths arising from increased air and water temperatures can similarly be included in more local integrated planning and management initiatives, prepared in partnership with stakeholders as appropriate.

The IWAC scoping report identified a number of other potential opportunities for inland waterways to help mitigate or adapt to the effects of climate change. These include options for the generation of renewable energy; the promotion of freight movement by water; and the identification of 'win-win' measures which meet not only navigation but also flood risk management, nature conservation or agricultural objectives.

Finally, there are several areas where ongoing or new research is required. The UK Government, IWAC, navigation authorities, AINA and other relevant partner organisations as appropriate should therefore support measures that seek to:

- develop alternative fuels/sources of energy, including bio-fuels, alternative energies, hybrid engines, fuel cell technology; low energy hull design;
- explore options for improving the resilience of assets and infrastructure including use of (drought-tolerant) vegetation in engineering;
- investigate alternatives or improvements to avoid or minimise the adverse effects of dredging;
- improve innovation in water conservation;
- identify new water resources and storage opportunities;
- research and promote additional measures to reduce sediment contained in run-off from reaching water bodies;
- improve understanding of the carrying capacity of natural systems, and of water-ecology interrelationships;
- improve understanding of vectors for transfer of alien species; and methods for the management or eradication of alien species; and
- explore and exploit 'win-win' options for habitat creation or restoration schemes.

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SUMMARY

In early 2009, the Inland Waterways Advisory Council (IWAC) received a grant from the Department of Environment, Food and Rural Affairs to research and to publish evidence of how inland waterways in England and Wales can assist in mitigating and adapting to the effects of climate change. The IWAC is an independent statutory body created to advise the UK government, navigation authorities and other interested persons on matters relevant to Britain's inland waterways.

There is now little doubt that climate change is happening. If the worst effects of global warming are to be avoided, it is vital for all sectors to take steps to reduce their greenhouse gas emissions. Measures which reduce a sector's contribution to the climate change problem are referred to as mitigation measures.

However, whilst mitigation measures might help to lessen the scale of the problem, some impacts of global warming are now inevitable. Adaptation will therefore also be essential. Adaptation measures help society prepare for and adapt to the anticipated effects of climate change by reducing vulnerability and increasing long-term resilience.

This article summarises some of the findings of the IWAC research report. Based on the 'most likely' impacts of climate change, it highlights the anticipated consequences for inland waterways in England and Wales and explores the range of potentially appropriate climate change mitigation and adaptation measures.

RÉSUMÉ

Début 2009, l'« Inland Waterways Advisory Council (IWAC ») (Conseil consultatif des voies navigables intérieures) a reçu un financement du DEFRA (ministère de l'environnement, de l'alimentation et de la ruralité) pour la recherche et la diffusion des éléments probants de la contribution des voies navigables anglaises et galloises à l'atténuation du changement climatique et à l'adaptation à ces effets. L'IWAC est un organisme officiel indépendant créé pour conseiller le gouvernement du Royaume Uni, les services de navigation et les partenaires concernés par les questions relevant des voies navigables britanniques.

Il n'est plus guère douteux que le climat soit en cours de changement. Pour éviter les pires conséquences d'un réchauffement global, il est vital que tous les secteurs s'efforcent de réduire leurs émissions de gaz à effet de serre. Les dispositions qui diminuent les contributions d'un secteur au changement climatique sont dites mesures d'atténuation.

Toutefois même si les mesures d'atténuation peuvent réduire l'étendue du problème, certains effets du réchauffement global resteront inévitables. Il est donc essentiel de s'y adapter également. Les mesures d'adaptation aident la société à anticiper et à se préparer aux conséquences prévues du changement climatique par la réduction de la vulnérabilité et l'augmentation de la résilience à long terme.

Cet article récapitule quelques unes des contributions du rapport de recherche de l'IWAC. A partir des effets les plus probables dus au changement climatique, il en met en lumière les conséquences pour les voies navigables anglaises et galloises et balaye les mesures potentielles appropriées d'atténuation ou d'adaptation.

ZUSAMMENFASSUNG

Anfang des Jahres 2009 bekam das Inland Waterways Advisory Council (IWAC) den Auftrag des Amtes für Environment, Food and Rural Affairs (Umwelt, Ernährung und Landwirtschaft), nach Beweisen zu forschen und zu veröffentlichen, wie Binnenwasser-straßen in England und Wales dazu beitragen können, Effekte des Klimawandels zu mäßigen und sich daran anzupassen. Das IWAC ist eine unabhängige Körperschaft des öffentlichen Rechts, die eingerichtet wurde, um die Regierung des Vereinigten Königreichs, Schifffahrtsbehörden und interessierte Dritte in Angelegenheiten, die die Britischen Binnenwasserstraßen betreffen, zu beraten.

Es gibt kaum Zweifel daran, dass es einen Klimawandel geben gibt. Wenn die schlimmsten Auswirkungen der globalen Erwärmung verhindert werden sollen, ist es für alle Industriezweige lebenswichtig, Maßnahmen zu ergreifen, um ihre Abgas-Emissionen, die den Treibhauseffekt fördern, zu reduzieren. Maßnahmen, die den Beitrag eines Industriezweiges zu den Klimaveränderungen reduzieren, werden als Linderungsmaßnahmen bezeichnet.

Obwohl Linderungsmaßnahmen helfen können, das Gesamtproblem zu verkleinern, sind jedoch einige Auswirkungen der globalen Erwärmung unvermeidbar. Eine Anpassung ist daher erforderlich. Anpassungsmaßnahmen helfen der Gesellschaft, sich auf die angenommenen Effekte des Klimawandels vorzubereiten und sich daran anzupassen, indem die Verletzbarkeit reduziert und die langfristige Widerstandsfähigkeit erhöht wird.

Dieser Artikel fasst einige Ergebnisse des IWAC Forschungsberichts zusammen. Basierend auf den „wahrscheinlichsten" Einflüssen des Klimawandels werden die angenommenen Auswirkungen für die Binnenwasserstraßen in England und Wales hervorgehoben und die Bandbreite der potenziellen, angemessenen Linderungsmaßnahmen des Klimawandels und die Anpassungsmaßnahmen werden untersucht.

CLIMATE CHANGE AND NAVIGATION: WATERBORNE TRANSPORT, PORTS AND WATERWAYS: A REVIEW OF CLIMATE CHANGE DRIVERS, IMPACTS RESPONSES AND MITIGATION

by

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KEY WORDS

Climate change, navigation, waterways

MOTS-CLEFS

Changement climatique, navigation, voies navigables

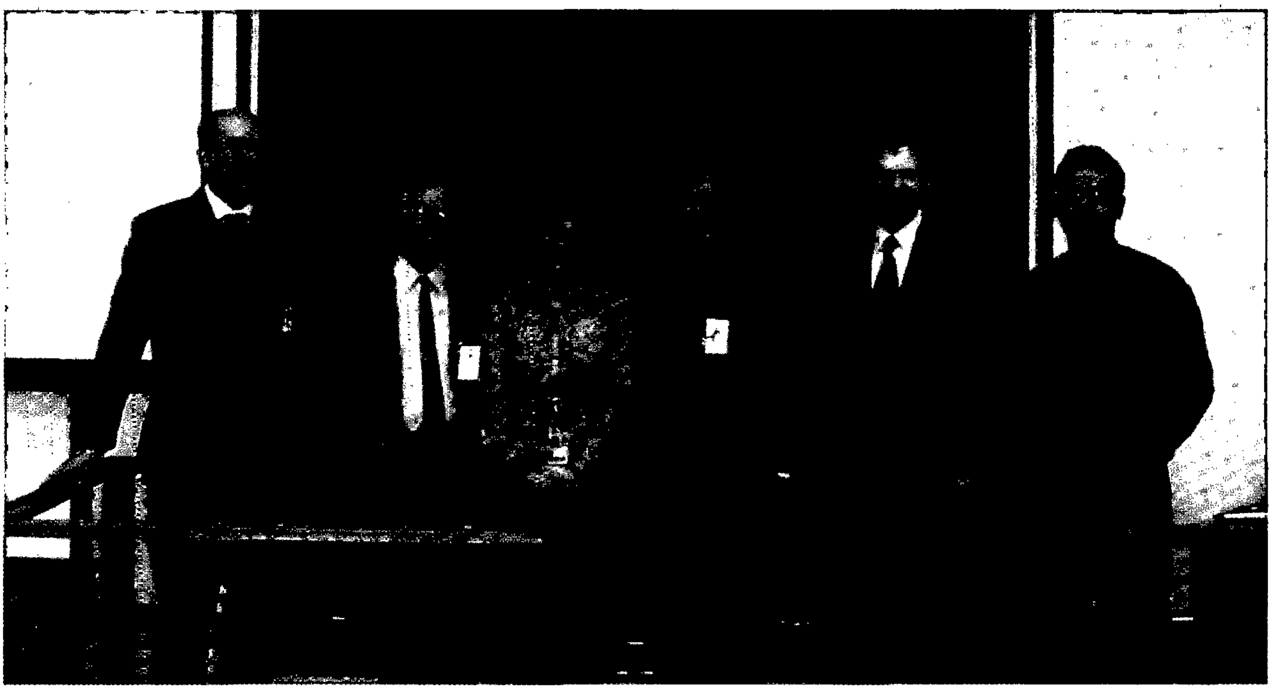

Figure 1: PIANC EnviCom Task Group 3: Stephan Mai (Federal Institute of Hydrology, Germany), Peter Hawkes (HR Wallingford, England), Kate White (US Army Corps of Engineers), Øivind Arntsen (University of Science and Technology, Norway), Hans Moser, (Federal Institute of Hydrology, Germany, and Group Chairman), Pierre Gaufres (National Centre for Maritime and River Studies, France), at the Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire; Gernot Pauli (Central Commission for Navigation of the Rhine) is missing from this photograph.

1. TOPICAL MOTIVATION TO REVIEW CLIMATE CHANGE AND NAVIGATION

The Intergovernmental Panel on Climate Change updated its reports and recommendations during 2007. Its assumptions, definitions and findings represent a peer-reviewed body of knowledge that identifies changes in climate and projected future changes. It was timely for PIANC to update its position and recommendations regarding climate change.

The main purpose of PIANC EnviCom Task Group 3: *Climate change and navigation* was to take a broad look at all aspects of climate change of potential interest to navigation and ports, and recommend specialist Working Groups to prepare detailed guidance on aspects of greatest interest to the industry. The Task Group 3 report informs PIANC on how navigation may be affected by climate change and where actions might be taken to develop adaptation strategies, mitigation measures and investments in a pro-active way. The report provides a common and basic platform for all PIANC commissions to build up their work plans regarding climate change in the fields of infrastructure, vessels, and transport management.

PIANC has recently established a *Permanent Task Group on Climate Change*, with chairman Kate White and members representing PIANC's main permanent committees.

2. CONTENT OF THE PIANC REPORT ON CLIMATE CHANGE AND NAVIGATION

The Task Group 3 report (PIANC, 2008) reviews climate change impacts on maritime and inland navigation including sea level rise, wind conditions, wave action, tidal and surge propagation and range, ocean circulation, storms, coastal hydrodynamics, sea chemistry, environmentally protected areas, ice conditions, icing, water supply and quality in inland rivers, extreme hydrological conditions, and coastal, estuarine and river morphology. Figure 2 illustrates the range of potential climate change impacts upon navigation. The report includes:

1. Identification of the relevance of climate change for maritime and inland navigation and a summary of the realistic impact scenarios (e.g. environmental, technical, economic, political).
2. Summary of examples where climate change already creates problems for navigation.
3. Discussion on how the navigation sector could contribute to reduce climate change impacts, e.g. through reduction of CO_2 emissions, and taking cargo off roads and air.
4. Discussion of climate impacts and responses to prepare the navigation sector for the projected climate scenarios, with the aim of adapting navigation infrastructure, equipment and daily practice for future sustainability.

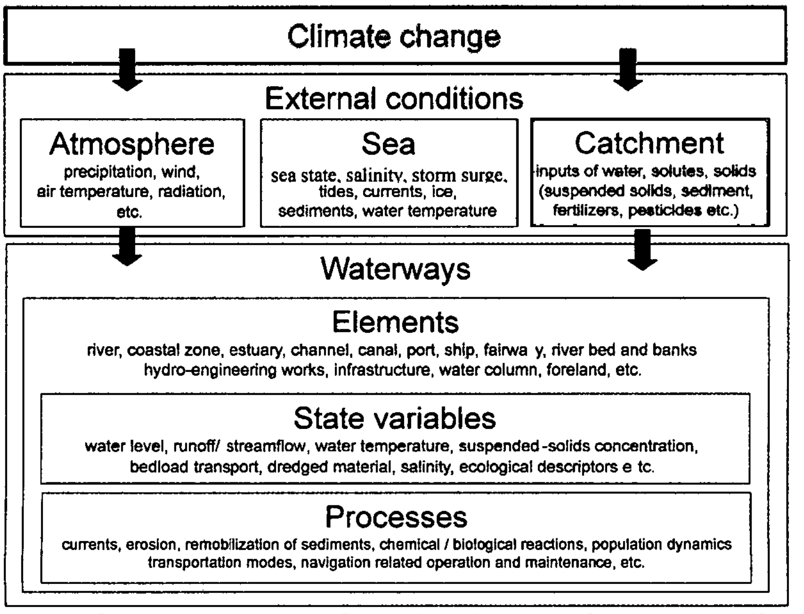

Figure 2: Illustration of climate change influencing the use of waterways (from PIANC, 2008)

3. EXAMPLE DETRIMENTAL EFFECTS OF CLIMATE CHANGE

Potential climate change impacts on maritime navigation include sea level rise, allowing higher depth limiting wave conditions to reach exposed port structures, perhaps reducing the effectiveness of breakwaters and harbours. Changes in wave and wind climate may affect downtime and shipping routes; changes in ice extent and icing of vessels may also affect navigation.

Potential climate change impacts on inland navigation mostly arise from changes in water supply to navigable river sections (Moser *et al,* 2008). These include increased or decreased water level and velocity, and resultant changes in sedimentation processes such as bank failure, local scour, and locations of accretion and erosion. More frequent low water level conditions during summer, particularly in natural rivers, may disrupt navigation through increased downtime. Warming would tend to reduce periods of ice cover in waterways in cold areas.

4. EXAMPLE OPPORTUNITIES ARISING FROM CLIMATE CHANGE

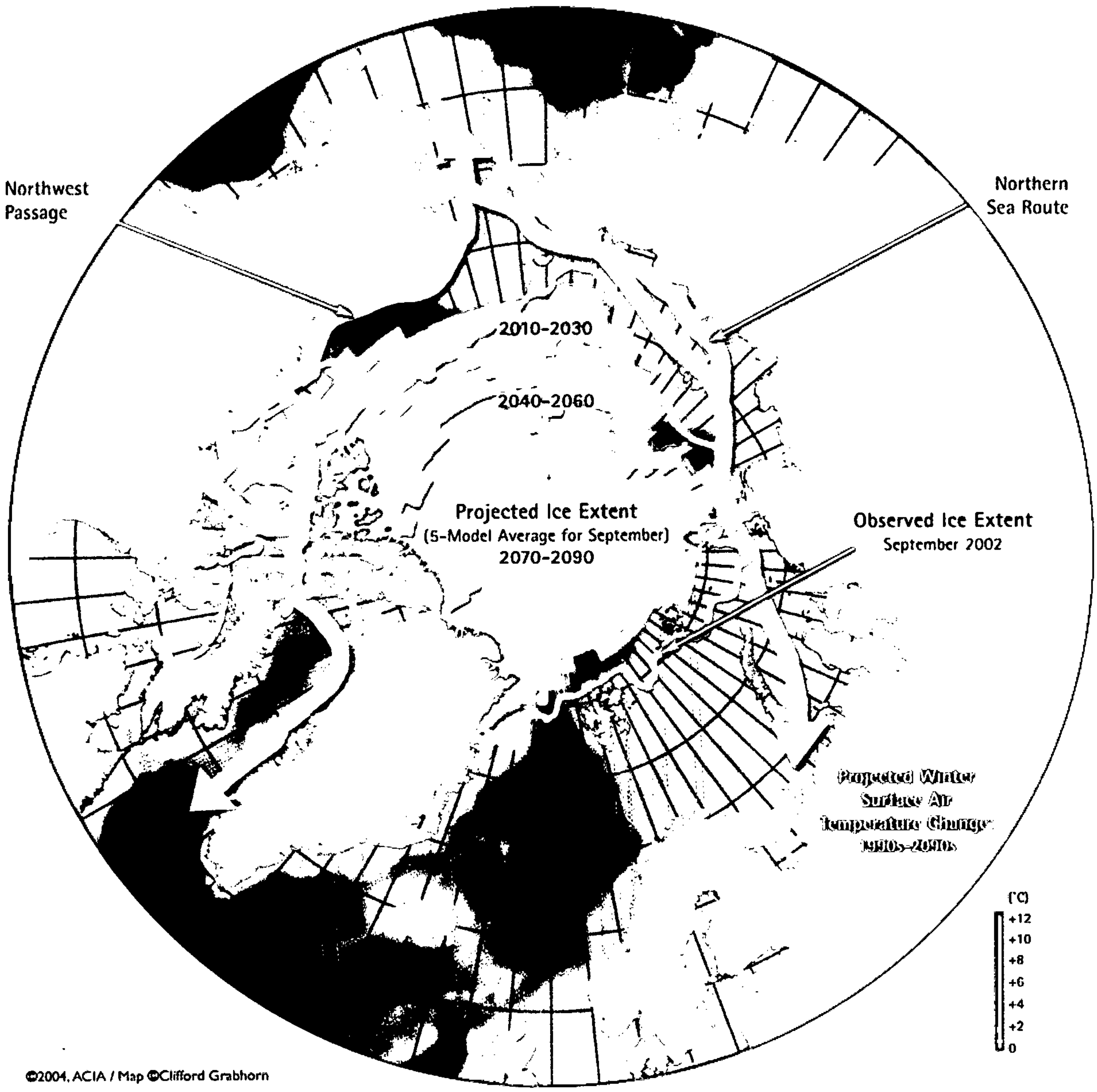

Figure 3: Observed and projected Arctic sea ice extent (reproduced, with minor changes to the annotation, from ACIA, 2004)

Reduced ice cover would permit better access to Arctic Regions, as illustrated in Figure 3 on the previous page. If the Northwest Passage were open as a shipping route all year, there would be potential for reduced fuel consumption in shipping between Europe and Asia.

Buhaug *et al.* (2008) show that transport's share of overall CO_2 emissions was 27 % in 2005, with navigation accounting for about 12 % of transport CO_2 emissions (Figure 4).

PIANC (2008) concludes, that "Navigation may well be one of the winners of climate change, most likely due to regulatory measures for climate change mitigation. Navigation is characterised by low energy consumption and therefore a small carbon footprint; in addition it has a good potential for reducing it even further. Its climate-friendly image makes it attractive for shippers of cargo. Carbon pricing or other regulatory measures will make it even more so and will give it a competitive edge over other modes of transport, especially road transport and aviation. Thus, being itself relatively climate-friendly and becoming a tool for mitigation of Greenhouse Gas (GHG) emissions in tomorrow's world economy, navigation may even be a double winner from climate change."

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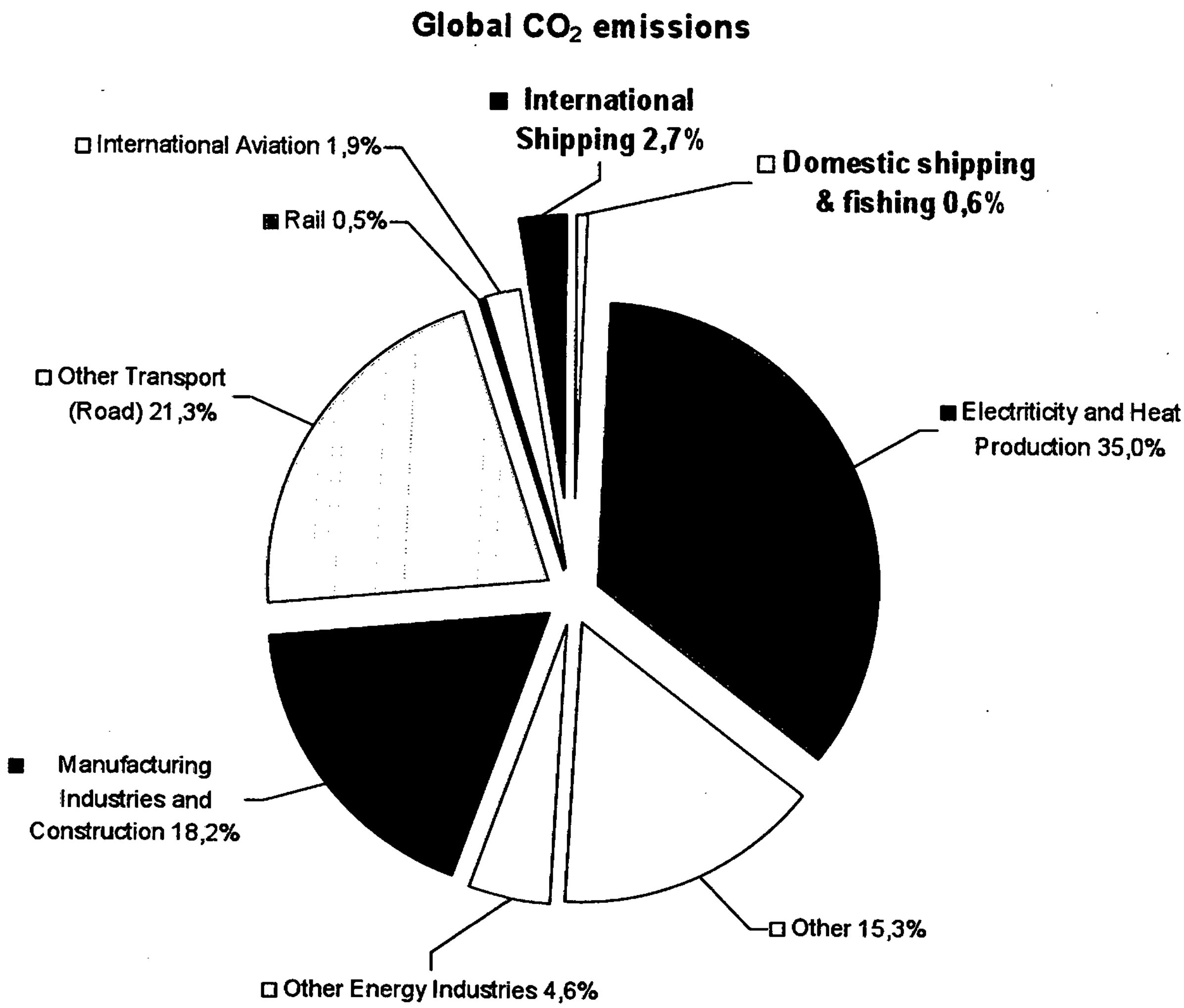

Figure 4: CO_2 emissions from shipping compared with global total emissions (reproduced from Buhaug et al., 2008)

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SUMMARY

PIANC EnviCom Task Group 3, *Climate change and navigation,* met in Brussels (Belgium) in March 2007, in Wallingford (England) in August 2007, and in Hanover (USA, see Figure 1) in February 2008. Its purpose was to take a broad look at ways in which future climate change might affect maritime, inland and arctic navigation, so that PIANC could direct its continuing climate change assessments accordingly. The Group's report (PIANC, 2008) was issued in May 2008 and is freely available from PIANC. This article and an accompanying PIANC MMX Congress paper (Hawkes et al, 2010) present some of the main points from the report.

RÉSUMÉ

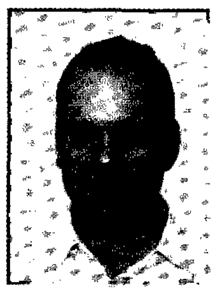
Le groupe de travail n°3, *Changement climatique et navigation*, s'est réuni à Bruxelles (Belgique) en Mars 2007, à Wallingford (Angleterre) en Août 2007 et Hanovre (USA, voir Figure 1) en Février 2008. L'objectif principal était d'explorer globalement les domaines dans lesquels le réchauffement climatique pourrait impacter la navigation maritime, fluviale et arctique afin que l'AIPCN puisse orienter des investigations spécifiques en conséquence. Le rapport publié en mai 2008 est téléchargeable gratuitement sur le site de l'AIPCN. Le présent article ainsi qu'une communication conjointe au congrès AIPCN MMX (Hawkes et al, 2010) exposent les points principaux du rapport.

ZUSAMMENFASSUNG

PIANC EnviCom Task Group 3, *Climate change and navigation* (Klimawandel und Schifffahrt) hat in Brüssel (Belgien) im März 2007, in Wallingford (England) im August 2007 und in Hannover (USA, s. Abb. 1) im Februar 2008 getagt. Die Aufgabe war, einen umfassenden Einblick zu bekommen, inwieweit zukünftige Klimaveränderungen sich auf die See-, Binnen- und arktische Schifffahrt auswirken können, sodass PIANC seine bestehenden Bewertungen des Klimawandels entsprechend lenken kann. Der Bericht der Gruppe (PIANC 2008) ist im Mai 2008 erschienen und kann kostenfrei von PIANC bezogen werden. Dieser Artikel sowie ein begleitender Artikel zum PIANC MMX Kongress (Hawkes et al, 2010) präsentieren einige der wichtigsten Aspekte des Berichts.

DREDGING AND SEDIMENT MANAGEMENT: WORKING WITH NATURE?

by



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KEY WORDS

Capital dredging, sediment management, mitigation, European sites, beneficial use

MOTS-CLEFS

Dragage d'investissement, gestion des sédiments, mesures d'atténuation, sites européens, valorisation

1. INTRODUCTION

Dredging can either be maintenance dredging (routine dredging that is needed to maintain navigation channels and berths at a declared depth) or capital dredging (to deepen, widen or create a new navigation channel) which is often proposed as part of new port development, such as quay extensions. Depending on the type of port and its location, capital and maintenance dredging are important activities in the continued successful operation of the port.

Many ports in the UK are situated in estuarine areas that are designated under European and international legislation for their importance for various habitats and species that they support. Key habitats within these designated areas include sedimentary habitats such as mudflats, sandflats and saltmarsh which can be potentially impacted by dredging, for example by affecting sediment transport which can result in erosion. Such habitats are often designated in their own right (e.g. part of a Special Area of Conservation (SAC)), or are fundamental to supporting wader and wildfowl populations that are interest features of Special Protection Areas (SPA).

In addition to designated sedimentary habitats and the waterbird species they support, estuarine areas are typically important for fish populations and a number of UK estuaries are important for migratory fish, such as salmon. Dredging inevitably increases the suspended sediment concentration in the water column which can have an impact on fish. Such effects can be physical (e.g. clogging of gills) or chemical (e.g. affecting dissolved oxygen levels).

Given the sensitive nature of the sedimentary habitats and the high level of protection provided by legislation, the assessment of the potential impacts of both capital and maintenance dredging is often central to environmental impact studies. Where it is predicted that an adverse effect on habitats would arise, the assessment proposes mitigation and/or compensation measures to minimise, avoid or compensate for the predicted effects. Such assessments are part of the consideration as to whether or not a proposed port development project (or maintenance dredging programme) is environmentally acceptable and should be granted to consent.

Through case studies, this article examines the approach taken to sediment management as part of mitigation and compensation packages for port development and dredging projects. These case studies are considered to represent examples of 'good practice' in the management of the estuarine environment where port development has occurred or is proposed.

2. CAPITAL DREDGING PROTOCOL (NORTHERN GATEWAY CONTAINER TERMINAL PROJECT)

2.1 Overview of the proposed dredging

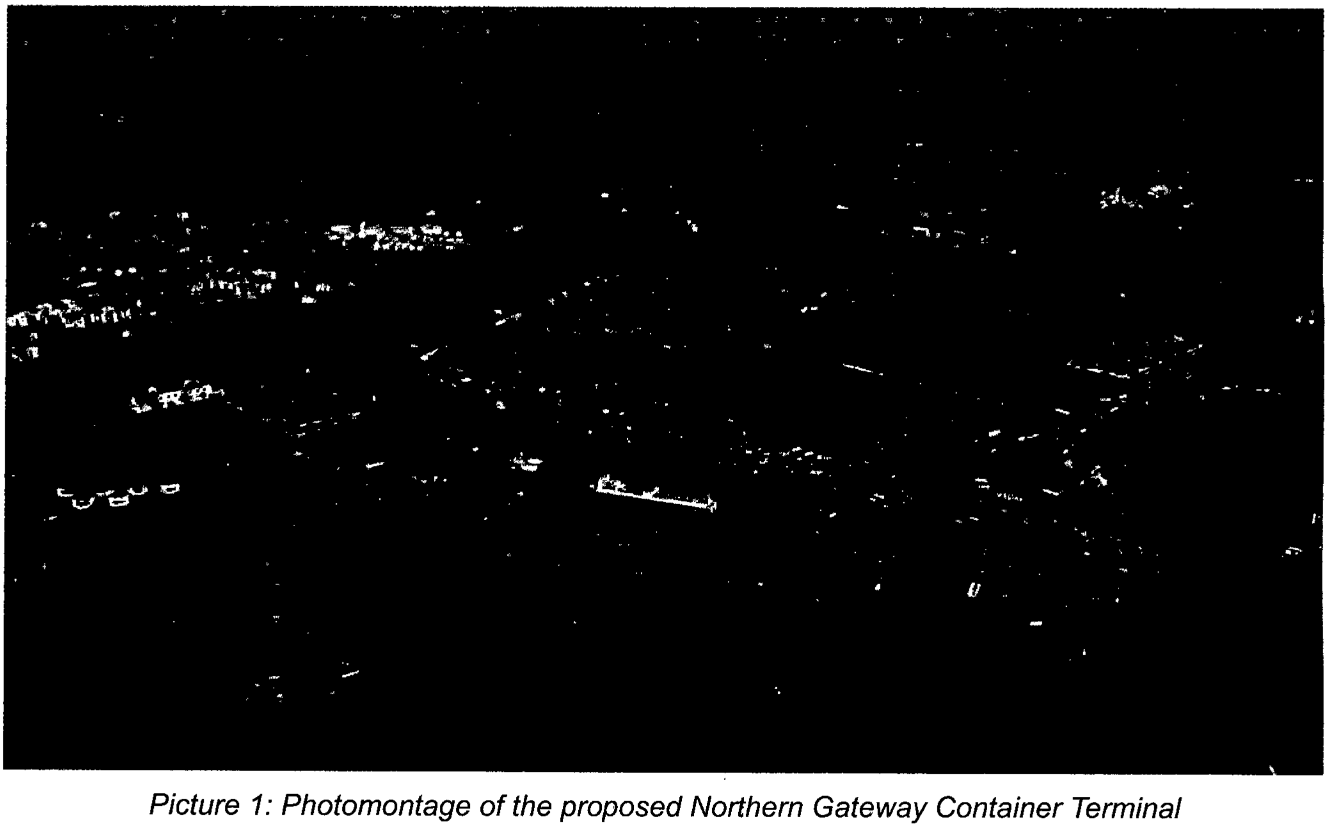
The NGCT project includes the development of a container terminal of approximately 54 ha at Teesport (Photograph 1). As part of the project, it is necessary to undertake capital dredging of the approach channel which will comprise dredging of approximately 4.5 million m^3 of silts and soft alluvial deposits, Mercia mudstone and granular material. The project received all permissions and consents in 2008, but has yet to be implemented.

There are essentially two techniques which could be used during the capital dredge; mechanical dredging using a backhoe and hydraulic dredging using either a cutter suction dredger (CSD) or a trailing suction hopper dredger (TSHD). The type of dredger used will depend on the material being dredged and location in the estuary. It is likely that the use of the CSD will be limited to small areas for short periods of time, for example, where there is either insufficient water depth or working space to operate a large TSHD.

2.2 Environmental concerns

Through the consultation that was undertaken during the environmental impact assessment (EIA), a number of issues of concern related to the impacts of dredging were raised by the regulators and statutory bodies. The impacts generally fit into two categories; those relating to raising levels of suspended sediment, particularly in relation to water quality, and those relating to the deposition of material on sensitive receptors. The key concerns can be summarised as follows:

- Water quality
  Specific concerns were raised regarding the potential impact associated with re-suspending silt, which can have a high biological oxygen demand and, therefore, could potentially deplete oxygen from the water column. This can be a particular problem during the summer months when river flows are lower and the potential for dilution is reduced.



Picture 1: Photomontage of the proposed Northern Gateway Container Terminal

- Migratory fish (salmon) and sprat
  Salmon move upstream in the river from May onwards through the summer period, with peak movements occurring in September-October. The downstream smolt run peaks in May. Sprat also occur in significant numbers in parts of the Tees estuary (Seaton Channel) during the period May to August. Impacts on water quality during these periods could, therefore, potentially disrupt migration routes and impact on sprat.

- Deposition of material on designated intertidal areas
  The ES predicted that some of the sediment re-suspended during the dredging would be deposited on designated intertidal areas (specifically, Seal Sands which is part of the Teesmouth and Cleveland Coast SPA and Ramsar site). This potential impact is of concern as it could affect the food resource for waterbird populations.

2.3 Details of the capital dredging protocol

Dredging protocols can be developed to define how the dredging work will be undertaken in order to minimise or avoid potential impacts that have been predicted to occur on, for example, water quality, fish populations and designated habitats. Such a protocol was developed for the Northern Gateway Container Terminal (NGCT) project at Teesport in the Tees estuary, UK (Royal Haskoning, 2007) following consultation with regulators on the Environmental Statement (Royal Haskoning, 2006).

2.3.1 Minimising potential impact on water quality and fish

To reduce the impact of dredging with the TSHD on suspended sediment concentration in the water column and, potentially, dissolved oxygen concentration, the capital dredging protocol proposed that dredging would be undertaken in long strips along the axis of the estuary, rather than dredging across the width of the river. Work undertaken by HR Wallingford to inform the ES had predicted that any sediment plume generated by dredging would remain on the same side of the river as the dredging operation. This measure would, therefore, avoid increased suspended sediment concentrations across the width of the river.

The dredging protocol proposed that capital dredging should be completed on one side of the river before dredging was undertaken on the other side of the river. Water quality would, therefore, only be impacted on one side of the river at a time and, should dredging be undertaken during the months when migratory fish (salmon) are present in the river, one side of the river would remain relatively unaffected. This would form a passage through which migratory fish would be able to move past the dredging activity.

To minimise the potential for an impact on sprat, the dredging protocol proposed that no dredging would be undertaken in the Seaton Channel area over the period May to August.

When dredging with a CSD, the dredger loads material onto a barge and the most significant impact in terms of producing suspended sediments is the overflow from the barge loading equipment. To reduce the potential risk to water quality, and therefore to migratory fish, the dredging protocol proposed that the barge will be located either on the eastern or western side of the estuary. As described above for the TSHD, the sediment plume from the barge loading operations will remain on one side of the river.

2.3.2 Minimising deposition of sediment on Seal Sands

In order to reduce the potential impact on water quality and migratory fish during dredging with the CSD, the dredging protocol proposed that the barge for the CSD would be located on either the eastern or western side of the river. The sediment plume modelling undertaken for the ES indicated that placement of the barge on the eastern side of the estuary would reduce the potential for material to be transported to Seal Sands. The dredging protocol recommended that the barge would, therefore, be preferentially placed on this side of the estuary for the duration of the capital dredging to reduce the potential for impact on designated habitats.

3. SEDIMENT REPLACEMENT (HARWICH HAVEN APPROACH CHANNEL DEEPENING)

3.1 Description of the dredging project

The Harwich Haven is formed by the confluence of the estuaries of the River Orwell (Suffolk) and River Stour (Essex) and the major ports of Felixstowe and Harwich are located in the Haven.

The Harwich Haven Approach Channel Deepening project commenced in 1998 and involved deepening the navigation channel from 12.5 m below Chart Datum (CD) to 14.5 m below CD. The capital dredging would give rise to approximately 18 M m^3 of sediments, comprising a mixture of mud, sand and gravel and clay, most of which was unusable (clay) and was disposed of offshore in a designated disposal ground. Royal Haskoning, in association with HR Wallingford, undertook an EIA for the proposed channel deepening.

3.2 Predicted impacts on designated intertidal habitats

One of the key areas of concern with respect to the environmental impact of the proposed scheme was the potential for effect on the hydraulic and sedimentary regime of the Stour and Orwell estuary system. The potential for such effects were studied through undertaking extensive numerical modelling studies as part of the EIA process.

The EIA predicted that the rate of intertidal erosion within the estuary system would increase by approximately 2.5 ha per annum. This effect was predicted to arise as a result of the trapping of muddy material in the deepened channel which would previously have been transported further into the estuary system and been deposited onto the intertidal areas. The trapped material would then be dredged during routine maintenance dredging campaigns (undertaken on an approximately 12 week basis by the Harwich Haven Authority) and disposed at a designated site offshore. The maintenance dredging would, therefore, represent a mechanism by which fine material is lost from the estuary system.

3.3 Details of the sediment replacement programme

A range of different approaches to sediment management were explored in order to mitigate the predicted increase in the rate of intertidal erosion. These approaches aimed to return some of the material that would be dredged during maintenance dredging to the estuary system and comprised:

- Subtidal placement of fine material;
- Increased overflow during maintenance dredging; and,
- Water column recharge at various locations.

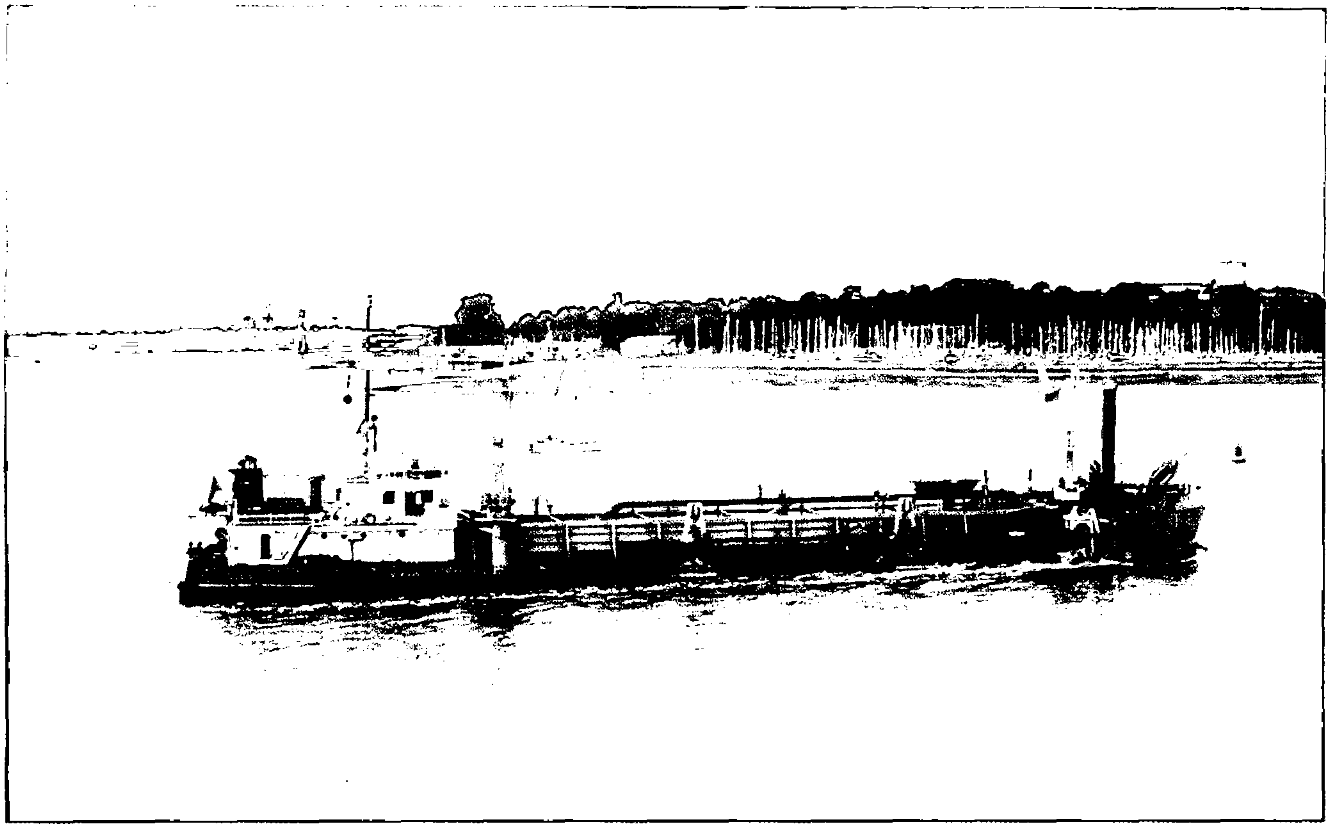
Over time, and based on the results of trial placements of sediment and monitoring, the overall mitigation strategy has evolved into an approach that is considered to be the most effective (relying substantially on water column recharge). In addition, the locations and methodology for the water column recharge have been modified in response to the findings of monitoring and concerns from the fishing industry that too much sediment was being replaced into the system.

The sediment replacement programme currently involves vessels disposing of fine material along tracks; as the dredgers move along the tracks they pump sediment into the water (Photograph 2 on the next page). This sediment replacement occurs on rising tides to encourage material onto the intertidal areas. In addition, the dredgers place material through the drag pipe of the dredger onto the bed in the harbour entrance for subsequent dispersal by the tidal currents.

4. HABITAT ENHANCEMENT SCHEMES (TRINITY III TERMINAL EXTENSION)

4.1 Description of the Trinity III Terminal Extension project

In 2003 construction commenced on a 270 m extension to the Trinity III Terminal at the northern end of the Port of Felixstowe to create additional deep-water berthing facilities. Capital dredging of approximately 900,000m^3 of material was associated with this extension. This construction work was completed in late 2004 (Photograph 3 on the next page).



Picture 2: The dredger used for the sediment replacement programme in the Stour and Orwell Estuaries

Picture 3: The extension to the Trinity III Terminal at the Port of Felixstowe (left of photograph)

4.2 Effect on intertidal erosion

The EIA studies concluded that the extension of the Trinity III Terminal would increase the rate of intertidal erosion throughout the Stour and Orwell estuary system and proposed that this could be mitigated through modification of the sediment replacement programme described above.

The studies also predicted that the project would increase wave energy over intertidal areas in the lower Orwell estuary. This effect arises due to wave reflection from the quay face and was predicted to result in localised erosion over these intertidal areas which, although already suffered from high erosion rates, would further reduce the ecological interest of the foreshore. In addition, increased erosion of the foreshore would further threaten the seawall that is present behind the intertidal area and which protects an area that is designated for its freshwater habitats.

Picture 4: Bunds formed by the placement of dredged clay and gravel, backfilled with mud from maintenance dredging (Shotley foreshore, west bank of the lower Orwell estuary)

4.3 Beneficial use of dredged material in intertidal areas

In light of the above predicted effects, specific measures were proposed for the beneficial use of dredged material arising from the dredging associated with the Trinity III Terminal Extension project. The schemes (referred to as 'habitat enhancement schemes') were developed on the east (Trimley) and west (Shotley) foreshores in the lower Orwell estuary and serve a number of functions, namely:

- To mitigate for the predicted effects of the scheme on localised erosion of intertidal areas in the lower Orwell estuary;
- To improve the existing ecological quality of intertidal mudflat and saltmarsh habitat (e.g. to increase the abundance and diversity of benthic invertebrate communities and, therefore, food resource for waterbirds and fish);
- To increase the stability of the flood defences in the lower estuary.

Picture 5: Bund formed by the placement of dredged clay and gravel, backfilled with mud from maintenance dredging (Trimley foreshore, east bank of the lower Orwell estuary)

The habitat enhancement schemes comprised the placement of dredged clay and gravel on the intertidal area to form bunds (Photographs 4 and 5) which were backfilled within mud derived from maintenance dredging undertaken in the navigation channel and berths in the Harwich Haven. An important feature of the schemes which was crucial in gaining their acceptance from the regulatory bodies, was that they were recognised by the regulators as not necessarily being permanent structures and they would erode and evolve over time. This was considered desirable as the habitat enhancement schemes would not constrain future options for the sustainable management of flood defences and habitats in the estuarine system.

5. CONCLUSION: WORKING WITH NATURE?

The three project case studies discussed in this article highlight contrasting ways in which sediment arising from capital and maintenance dredging projects can be used and managed in a beneficial way. One of the key drivers for seeking novel or innovative methods for managing dredged sediment is often the need to identify means whereby the predicted adverse impacts of a project, identified through environmental impact assessment studies, can be mitigated, as required by conservation legislation such as the Habitats Directive. The sediment management measures discussed in this article were important components of the environmental impact assessment process for each of the projects and often central to ensuring that the projects did not result in unacceptable impacts on important estuarine habitats. As a result, the development of these measures, and their acceptance by regulatory bodies, was instrumental in enabling permission for the schemes to be granted.

The three case studies discussed in this article highlight different approaches to sediment management, and it can be argued that each approach does 'work with nature'. The capital dredging protocol developed for the Northern Gateway Container Terminal project represents a different form of sediment management from the other case studies in that it prescribes a way in which the dredging activity (or method) itself can be undertaken to avoid or minimise a predicted impact. The case studies describing water column recharge and direct placement of material on intertidal areas are examples of active management and use of sediment in mitigation techniques once it has been dredged.

As discussed in this article, the direct placement of dredged material on intertidal areas was intended to serve a number of different functions, with each function fulfilling the important role as beneficial use of dredged material. This use of dredged material demonstrates working with nature in two respects. First, the placement of fine material from maintenance dredging on an area of eroded foreshore provided a better habitat for colonisation by benthic invertebrate communities, which benefitted estuarine fish and birds. Second, in providing a coastal defence function, the intertidal placements were not intended to try to stop or reverse erosion on the area (and therefore be a 'hard' defence protecting the existing seawall); they were designed to erode and evolve over the medium term (15 to 20 years). In this way, the placements would not constrain future coastal defence options in the lower Orwell estuary, but would provide protection to a coastal defence that was considered to be a risk through erosion of the foreshore fronting the defence.

The sediment replacement programme aims to replicate the natural movement of fine sediment throughout the estuary system by placing a proportion of maintenance dredged material that accumulates in the approaches and berths to the ports in the Harwich Haven back into the estuary system rather than removing it from the system to a disposal ground. In this way, the programme is designed to work with the hydrodynamic processes of the estuary system.

The programme has evolved over time to identify the most appropriate locations for placement of sediment in to the water column and on the bed of the estuary. The locations have been defined taking into account the ecological and fisheries implications of the placements and how effectively fine sediment could disperse onto intertidal areas (and thereby offset the predicted increases in intertidal erosion rate). In addition, the volume of dredged material that is placed has been refined (based on the results of environmental monitoring) to ensure that the appropriate volume of material is placed at each location.

6. REFERENCES

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SUMMARY

Many UK ports are situated in estuarine areas that are designated under European and international legislation for their nature conservation importance. Ports often have to undertake maintenance dredging to maintain navigation channels and berths at a declared depth and capital dredging as part of the new developments (approach channel deepening and creation of new berths).

Capital and maintenance dredging has the potential to impact on designated intertidal areas and the waterbird populations they support, for example through increasing the rate of intertidal erosion. In addition, increasing suspended sediment concentrations in the water column can impact on fish species (e.g. migration through estuarine areas).

Given the sensitive nature of estuarine habitats and the high level of protection afforded to them by legislation, the assessment of the potential impacts of both capital and maintenance dredging is often central to environmental impact studies, together with mitigation and/or compensation measures to minimise, avoid or compensate for the predicted effects.

This article examines the approach taken to sediment management as part of mitigation and compensation packages for port development and dredging projects through a number of case studies. These case studies are considered to represent examples of 'good practice' in the management of the estuarine environment where port development has occurred or is proposed. The approaches that are discussed comprise:

- Capital dredging protocols;
- Sediment replacement; and,
- Direct intertidal placement of dredged sediments.

The article concludes by highlighting ways in which the sediment management techniques can be considered to be 'working with nature?'.

RÉSUMÉ

Au Royaume-Uni, de nombreux ports sont situés dans des zones estuariennes répertoriées en tant que zones naturelles d'intérêt par la législation européenne et internationale. Les ports doivent souvent engager des travaux de dragage d'entretien des chenaux de navigation et des bassins portuaires pour maintenir une profondeur suffisante, ainsi que des dragages d'investissement (travaux neufs) pour permettre de nouveaux aménagements (approfondissement de chenaux, création de nouveaux postes à quai).

Les dragages d'entretien et d'investissement peuvent avoir un impact sur les zones intertidales et les populations d'oiseaux marins qui en dépendent, par exemple en augmentant l'érosion de cette zone. De plus, l'augmentation des concentrations en matières en suspension dans la colonne d'eau peut impacter différentes espèces de poissons (par exemple leur migration via les zones estuariennes).

Compte tenu de la sensibilité des habitats estuariens et du haut niveau de protection réglementaire qui leur est associé, l'évaluation des impacts potentiels des dragages d'entretien et d'investissement, ainsi que les mesures d'atténuation ou de compensation de ces effets, sont souvent centrales dans les études d'impacts.

Cet article analyse, à travers de nombreuses études de cas, les différentes approches liées à la gestion des sédiments, et plus particulièrement les mesures de mitigation et de compensation associées à des projets de développement portuaire ou de dragage. Ces études de cas sont considérées comme des exemples de « bonnes pratiques » de gestion des zones estuariennes concernées par des développements portuaires existants ou projetés.

Les approches considérées comprennent :

- les protocoles des dragages d'investissement ;
- les déplacements de sédiments ;
- les stockages directs des sédiments dragués dans la zone intertidale.

Cet article conclut en mettant en évidence des mesures de gestion des sédiments qui peuvent être considérées comme « Oeuvrant avec la nature?».

ZUSAMMENFASSUNG

Viele Häfen des Vereinigten Königreichs liegen in Ästuargebieten, die hinsichtlich ihrer Bedeutung als Naturschutzgebiete der europäischen und internationalen Gesetzgebung unterliegen. Oft müssen in diesen Häfen Unterhaltungsbaggerungen durchgeführt werden, um eine festgelegte Tiefe für die Fahrrinne und die Anlegestellen vorhalten zu können; außerdem werden infolge der neuen Entwicklungen Großbaggerungen durchgeführt (Vertiefung der Hafenzufahrt und Schaffung neuer Anlegeplätze).

Groß- und Unterhaltungsbaggerungen beinhalten das Potenzial, ausgewiesene Wattgebiete und von ihnen geschützte Wasservogel-Populationen zu beeinflussen, z. B. durch eine steigende Erosion in den Wattgebieten. Zusätzlich kann eine steigende Konzentration an gelösten Sedimenten im Wasser Einfluss auf Fischarten haben (z. B. Wanderung durch die Ästuargebiete).

Die sensible Natur des ästuaren Lebensraums und den hohen Schutzgrad, der ihnen durch die Gesetzgebung gewährt wird, vorausgesetzt, erfolgt die Abschätzung möglicher Einflüsse, sowohl der Groß- als auch der Unterhaltungsbaggerungen, oft durch zentrale Studien zum Einfluss auf die Umwelt, zusammen mit Linderungs- und/oder Kompensationsmaßnahmen, um die vorhergesagten Einflüsse zu minimieren, zu vermeiden oder zu kompensieren.

Dieser Artikel untersucht den Ansatz, Sedimentmanagement mittels einer Reihe von Fallstudien als Teil eines Linderungs- und Kompensationspaketes für die Hafenentwicklung und für Baggerprojekte zu sehen. Es wird davon ausgegangen, dass diese Fallstudien Beispiele für „good practice" beim Management der ästuaren Umgebung darstellen, wo Hafenentwicklung vorkommt oder vorgeschlagen ist. Die Ansätze, die diskutiert werden, umfassen:

- Protokolle von Großbaggerungen,
- Sedimentersatz und
- Direkte Platzierung von ausgebaggerten Sedimenten im Watt.

Der Artikel schließt mit der Hervorhebung von Wegen, wie die Sedimentmanagement-Techniken als „Arbeiten mit der Natur?" betrachtet werden können.

TECHNICAL INNOVATIONS FOR REMOTE AND EXPOSED LOCATIONS: EXPERIENCES FROM THE ISLE OF SCILLY HARBOUR IMPROVEMENTS PROJECT

by

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Harbour facilities, island community, concrete blockwork, wave loading

MOTS-CLEFS

Installations portuaires, communautés insulaires, blocs en béton préfabriqués, efforts dus à la houle

1. INTRODUCTION

The Isles of Scilly are located South West of Cornwall, are home to approximately 2100 residents and are a popular tourist destination. The islands are reliant upon goods imported by sea on the Gry Maritha (cargo vessel) and the Scillonian III (passenger vessel) which operate regular services between Penzance, Cornwall and St Marys, Isles of Scilly (figure 1). The economy of the Isles of Scilly is reliant on tourists, with 85 % of the economy being tourism based. Both vessels are more than 30 years old and will require replacement within the next few years in order to continue the service. A multi modal study into the ongoing operation of the link has concluded that a single vessel capable of carrying both cargo and passengers is more efficient than two separate vessels when combined with improvement to the berthing and passenger and freight handling facilities at Penzance and St Mary's harbours.

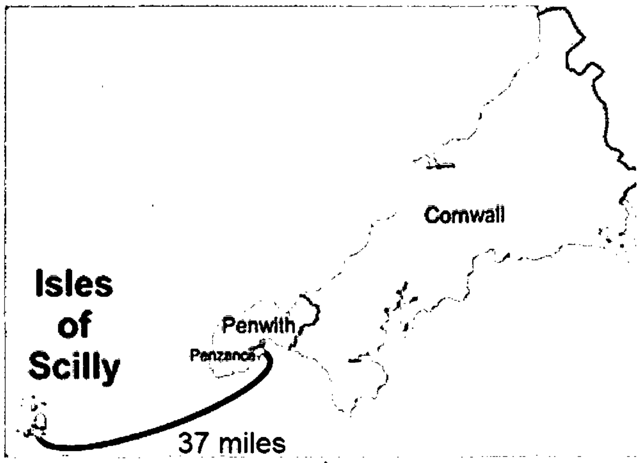

Figure 1: Isles of Scilly Link route

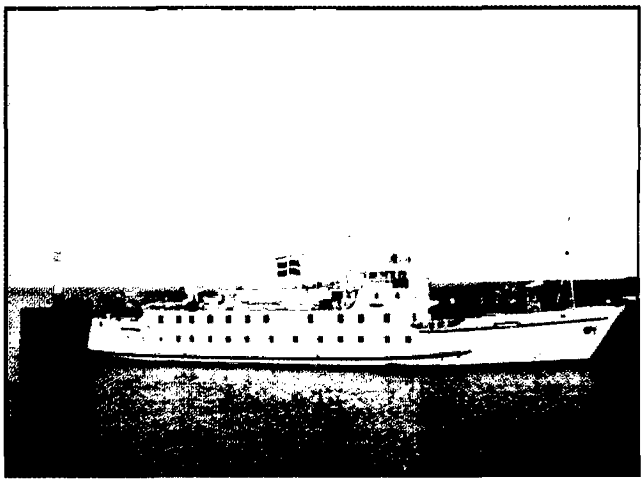

Figure 2: Current passenger vessel (Scillonion III)

The proposed vessel will provide a capacity for freight and passengers in line with the current service demands. The freight handling space must be flexible to allow for a variety of different materials that are transported to the islands. The service regularly conveys food, household goods, fuel, livestock, building materials and vehicles. Once a year the islands host a world gig racing championship and 'gigs' are transported to and from the islands. The capacity for freight will be equivalent to 113 pallets although the vessel will be able to carry a combination of pallets and 10' containers. There will also be designated spaces for up to 6. 'reefers' (refrigerated containers). The vessel will be fitted with 450 internal seats and 150 external seats hence the maximum passenger capacity will be 600 but this is only anticipated to be used at times of extreme demand. The normal operating regime will focus upon a capacity of 450.

Cornwall Council are currently undertaking three separate projects that will enable the sea service to continue in a sustainable manner, namely the procurement of the new combined freight and passenger vessel; appointment of an operator to run the service; and, the construction of improvements to the harbours at Penzance and at St Marys to accommodate the new vessel, to improve the facilities for passengers and freight and to bring the service up to an acceptable standard.

This paper will provide details of the proposed harbour improvement works.

2. SCHEME BACKGROUND

In 2002, the Council of the Isles of Scilly commissioned a report entitled "Moving On - A Transport Strategy for the Isles of Scilly". This report recommended that a Route Partnership should be formed to address current transport issues between the Isles of Scilly and the mainland. Accordingly, a Route Partnership was formed in 2003, with its main aims being those of addressing the issues that faced the transport links between the Isles of Scilly and the mainland in a co-ordinated manner and to bring together the relevant local authorities and key landowners. The Route Partnership currently consists of Cornwall Council, the Council of the Isles of Scilly and the Duchy of Cornwall.

In 2003, the former Penwith District Council[1], as the owner and operator of Penzance Harbour, commissioned a technical investigation of the harbour, whilst the Council of the Isles of Scilly commissioned a technical investigation of St Mary's Harbour, which is owned and operated by the Duchy of Cornwall. These investigations fed into a multi-modal study of transport links from the UK mainland to the Isles of Scilly, commissioned by the former Cornwall County Council[2]. The purpose of the study was to develop a preferred solution and submit a Major Scheme Bid to seek Government funding.

These reports proposed 3 shortlisted options for each harbour, which, together with alternative proposals for replacement vessel(s), were taken into a 'route' analysis. The different scheme options were compared using a Benefit Cost Ratio (BCR), in line with the requirements for funding applications from the Department for Transport (DfT). The scheme with the highest BCR was given conditional funding approval by the DfT in May 2007.

The preferred schemes were developed to concept design stage for the submission of Harbour Revision Orders (HRO) to the Secretary of State in 2005. St Marys HRO was approved in 2007. Penzance HRO was approved in September 2009.

In 2007 Cornwall Council, invited tenders from interested contractors for the design and construction of the harbour improvements at both Penzance and St Marys. The contractor would be appointed under an Early Contractor Involvement (ECI) type arrangement to enable the harbour designs to be developed in partnership with the Route Partners to ensure that the final designs deliver the optimal solution in terms of delivering the Route Partnerships overall objectives within the available budget.

Birse Coastal together with their design consultant Halcrow Group Ltd and architects Trewin Design Partnership were appointed to the ECI phase works in spring 2008.

2.1 Penzance Proposals

Penzance harbour is located to the west of Mounts Bay. The location and the alignment of the harbour

[1] As of 1st April 2009 Penwith District Council and Cornwall County Council ceased to exist and were replaced with a single unitary authority namely Cornwall Council

[2] ditto

walls mean that it is relatively sheltered from the predominant south westerly wave direction. Despite this the exposure conditions are relatively severe with a spring tidal range of 4.6 m and predicted heights of 1 in 200 year nearshore waves of up to 3.25 m

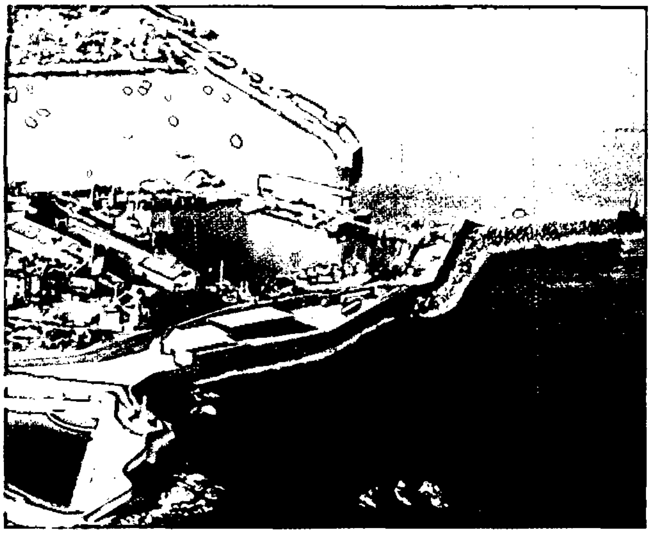

Figure 3: Proposed layout of Penzance Harbour

The proposed works at Penzance consist of the following:

- Extension of the existing Lighthouse Pier to enable the larger boat to berth, and to provide improved protection to the berth from waves. An 18 m long extension has been selected to provide protection to the longer vessel, the alignment of the extension matches the existing quay in order to keep a similar approach for the new vessel as the existing. The length and alignment of the quay have been tested using a Boussinesq wave model that has demonstrated an adequate reduction in wave heights at the berth and in the adjacent inner harbour that is used as a marina;
- Rock armour protection to the existing Lighthouse Pier to reduce overtopping of the quay into the berth area. The rock armour will also provide protection to the existing structure and quay extension from wave loading; and
- Reclamation between Battery Rocks and South Pier to contain a new passenger building and freight handling facilities. The reclamation is protected by a vertical wall as the use of rock armour was deemed at the concept design stage to take too great an amount of the adjacent intertidal foreshore. The proposed wall height has been optimised with the highest wall in the areas that will protect buildings, and a lower wall in areas that are backed by parking and turning areas, and that are more resilient to overtopping.

2.2 St Marys Proposals

St Marys Harbour is located to the west of Hugh Town in a location sheltered from most wave directions, but exposed to waves from the west of the islands. The spring tidal range at the harbour is 5 m and a 1 in 200 yr nearshore wave is predicted to have a height up to 3.55 m.

The proposed works at St Marys harbour on the Isles of Scilly consist of the following:

- Extension of the existing quay to enable the larger boat to berth, the extended berth would continue to be weather and tide dependant as the existing quay as the form of construction of the existing quay together with the hard bedrock seabed would make dredging to improve access times cost prohibitive;

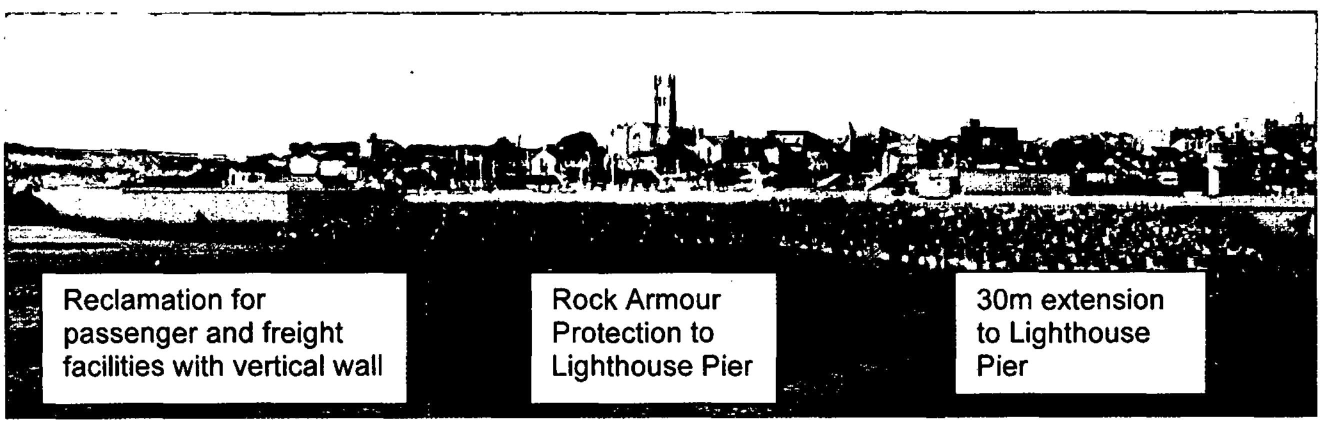

Figure 4: Penzance Proposals

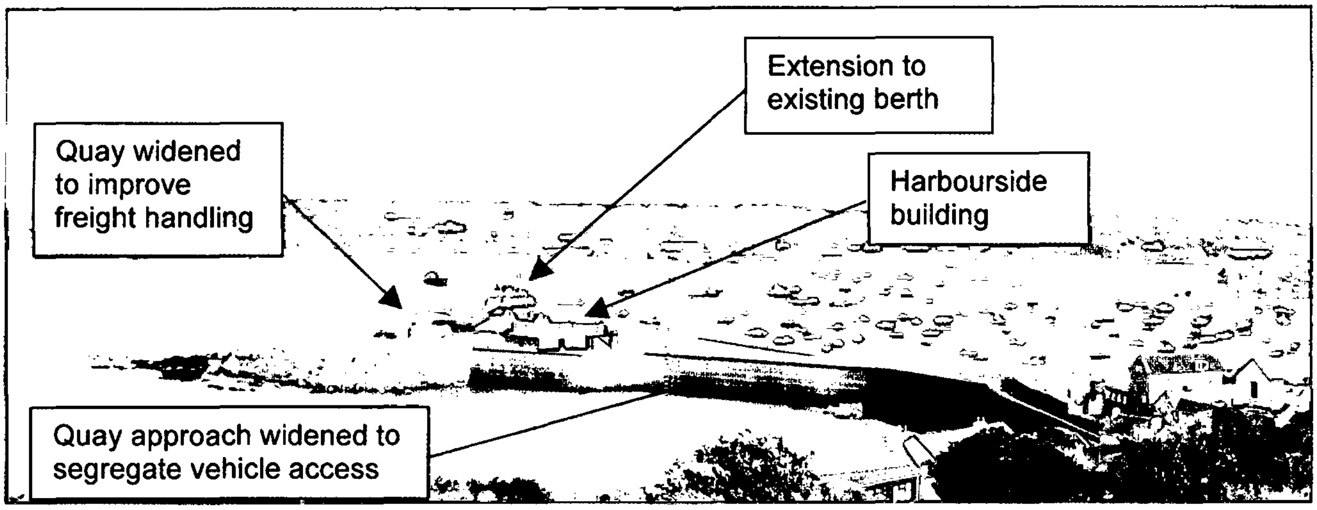

Figure 5: St Marys Proposed Works

- Widening of existing quay to provide improved freight handling area, the widened quay will be protected by a vertical wall, as the feasibility study concluded that an armoured revetment would use too much of the sensitive foreshore. The wall heights have been varied to provide differing levels of protection to suit the uses of the areas adjacent to the walls, the wall next to the freight building having a higher crest to control overtopping;
- Widening of existing quay approach to allow segregation of vehicles from pedestrians, the widened approach is again protected by a vertical wall. In order to keep construction costs down the wall height has been limited to provide safe access during lower period events (1 in 1 year), with emergency access provided along the existing quay during higher return period events;
- Conversion of an existing Harbourside Building to provide passenger facilities, including check in, passenger waiting areas and baggage handling facilities; and
- Construction of a new freight storage building.

3. PRECAST CONCRETE WALLS

Both sites have made use of blockwork quay wall construction techniques. This form of construction was selected due to its simplicity and robustness, and is similar to the original construction of the quays.

The remote location of both sites has lead to the development of some innovative design solutions that seek to improve construction rates, whilst minimising the delivery weights of the precast blockwork. The sections that face the open sea though are subject to significant wave action and need to be a significant size to withstand the design wave forces.

The site at Penzance is constrained in area and because it is located in the heart of the community, there is no space for setting up an on-site pre-casting facility. The size of the construction works would also mean that the creation of such a facility would not necessarily make economic sense. Therefore, the design has had to consider the limitations of transport links to the sites, and specifically, the limits on road transportation.

The works at St Marys will be reliant on deliveries arriving by sea. It is expected that the precast blockwork will be delivered by barge. Whilst this opens up different opportunities for the sourcing of the units, the limitations on available access for unloading of the blocks has also put limits on the viable weight of the units.

Therefore, an innovative design solution was developed at the tender design stage and further developed through the ECI works. This utilises hollow precast concrete blockwork which is filled with in situ concrete on-site, to provide the required structure mass. A typical block detail and a developed cross section are shown in Figures 6 and 7 on the next page.

The design of the wall has the following benefits over conventional solid blocks:

- Weight of blocks is kept low, enabling transportation by road and lifting using relatively small equipment;
- Faster wall construction, allowing works to "get out of the water" faster;
- Concrete plug between units will provide a good shear key between units;
- Where taller units are used, some of the concrete can be replaced with bulk fill material reducing concrete volumes; and
- Where high spec concrete with additives, such as pigments, are used for architectural purposes, the amount of the more expensive coloured mix is reduced.

However, the use of these blocks has caused some design challenges, such as:

- To avoid the use of steel reinforcement and maintain the traditional durability benefits of mass concrete blockwork construction, a lifting frame is required to allow the lifting to be controlled and keep stresses down on the blocks;
- The precast blockwork has become more complex, increasing the cost of the units due to the more complex formwork and casting operations; and
- Concern over potential catastrophic failure during lifting without reinforcement has lead to the inclusion of polymer macro-fibres to give some post crack strength.

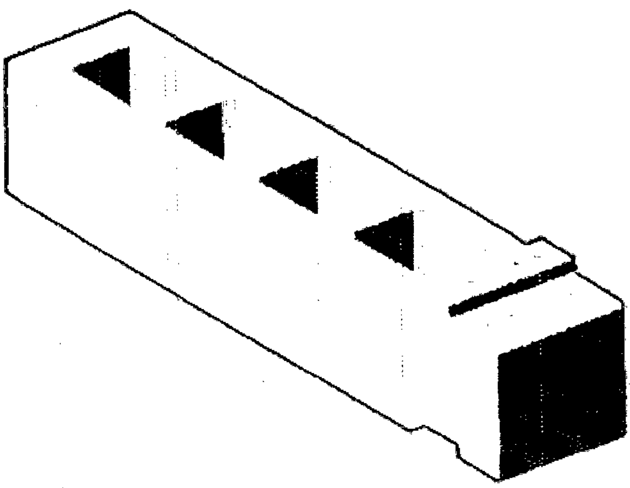

Figure 6: Typical hollow block detail

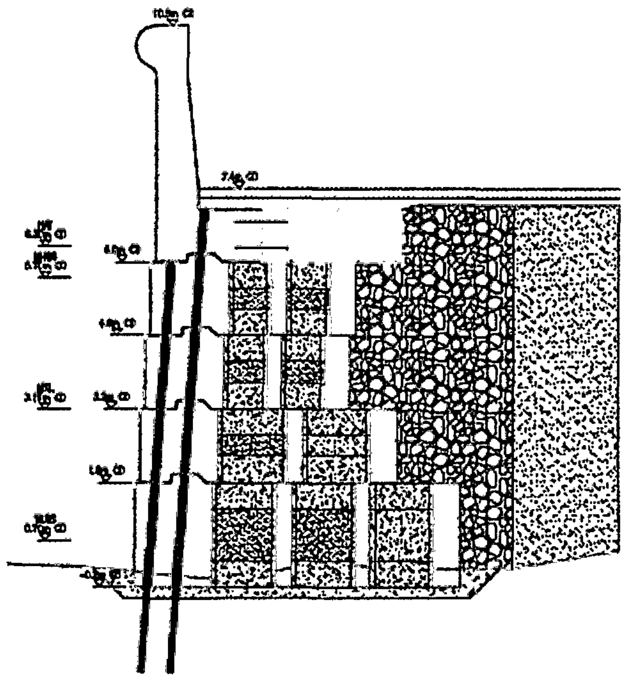

Figure 7: Typical wall cross section

4. RESISTING IMPULSIVE WAVE PRESSURES

Both harbours are located in exposed locations, and the harbours are subject to significant wave conditions. The Figures 8 and 9 (page 68) show the modelled bathymetry of both harbours, together with wave roses showing the dominant wave directions.

Both harbours have limitations placed on their construction meaning that the structures are limited to vertical walls for some or all of their length. At St Marys the environmental sensitivity of the foreshore and seabed meant that the construction along the whole length has been limited to a vertical structure. At Penzance the importance of the foreshore and adjacent Battery Rocks formation meant the landward end of the structure was limited to a vertical wall, whilst rock armour was allowed along the seaward end to help absorb the wave energy.

The high wave energy coupled with the bed profile and vertical quay walls means that both harbours will be subjected to impulsive wave conditions.

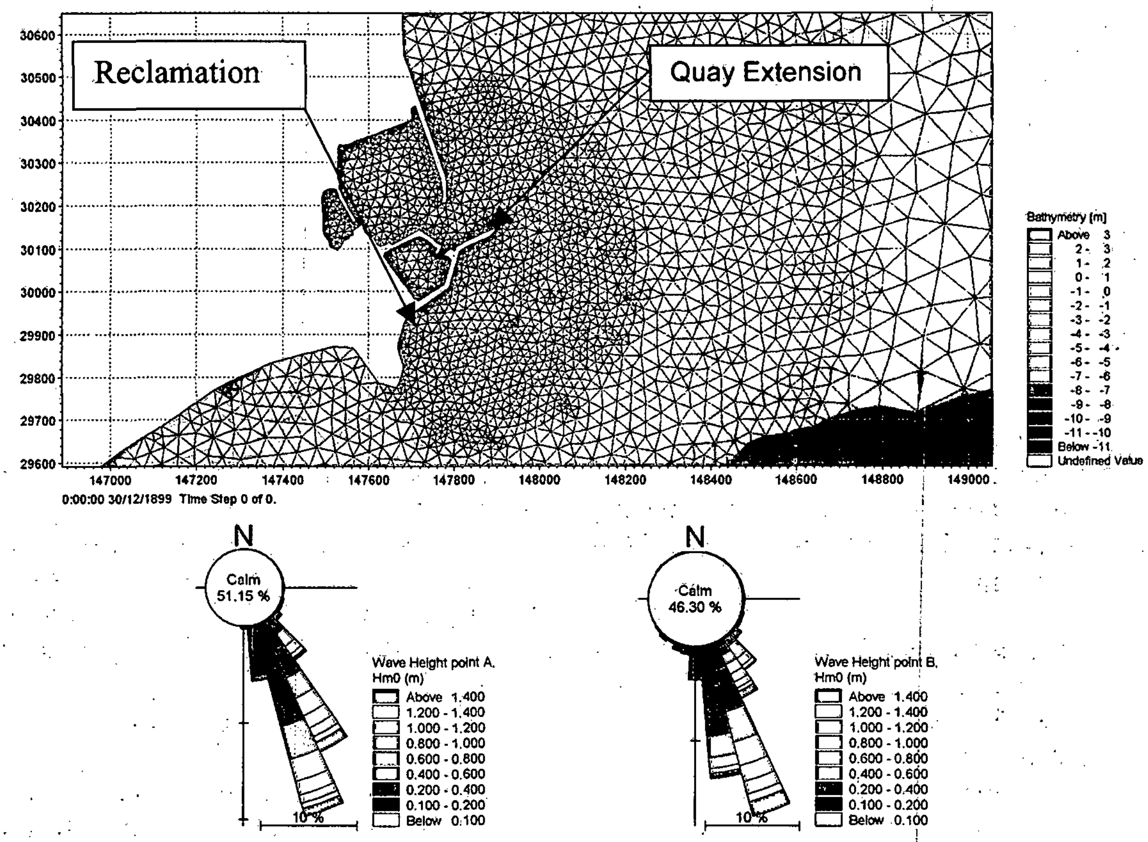

Figure 8: Bathymetry and Wave Rose for Penzance Harbour

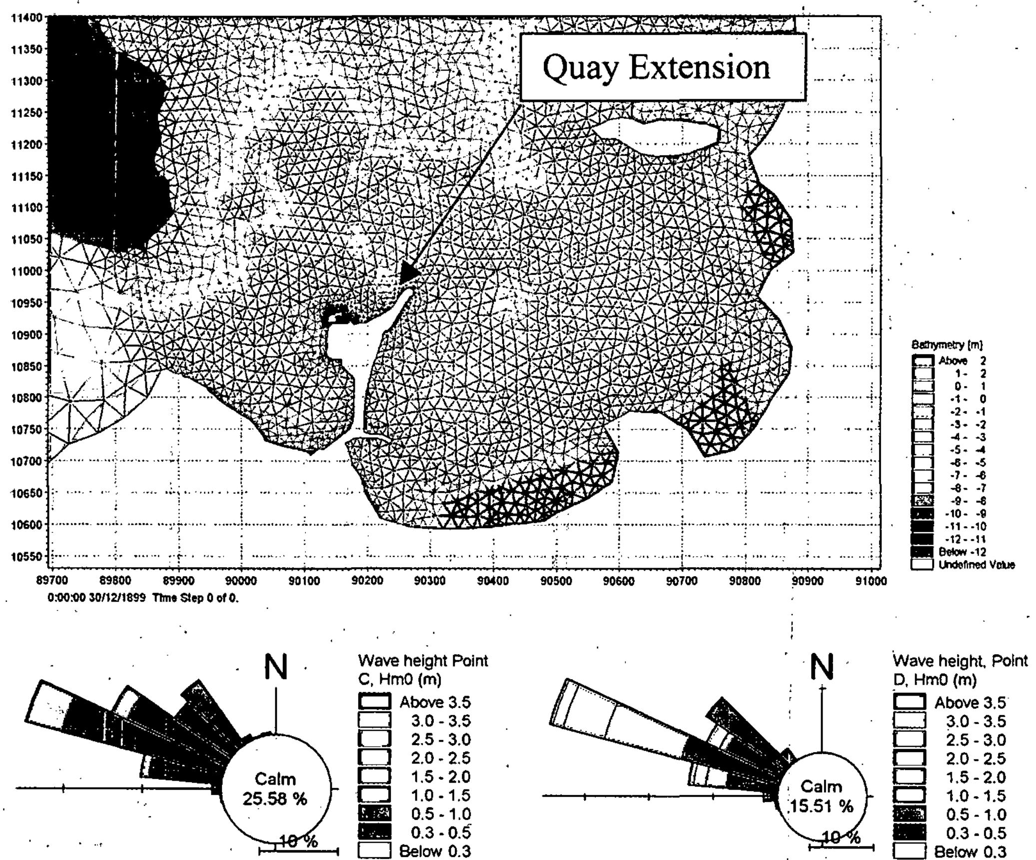

Figure 9: Bathymetry and Wave Rose for St Marys Harbour

The impulsive wave loads have been calculated using methods proposed by Kortenhaus and Oumeraci, and presented in the PROVERBS text. The peak impulsive forces have been calculated to exceed 700 kN/m^2.

The overturning forces due to the high impact forces were significant and dominated the wall design leading to significantly larger precast units than the other load cases, such as quay deck loads and pulsating wave pressures.

In order to reduce the block sizes to improve economy of the works it was decided to utilise the strength of the underlying bedrock by introducing ties into the material. This has lead to a novel approach to the design.

It is proposed to use Glass Fibre Reinforced Polymer (GFRP) reinforcement bars to provide tension piles into cores drilled into the rock. The selection of GFRP for this application has made use of and considered the following:

- GFRP has a high yield modulus (around 1000 N/mm^2), reducing the diameter of socket through the precast required.
- GFRP does not suffer from corrosion in the same manner as traditional steel reinforcements.
- The low elastic modulus of GFRP is not a significant issue as the loads are short term and elastic movement of the wall will help to dissipate the high peak pressures.
- The issue of long term relaxation under load associated with GFRP should not be an issue as the bars are not stressed under normal application. This means the application can make use of the full yield modulus of the material.

5. CONSTRUCTION IN A SENSITIVE COMMUNITY

The island community is reliant on the sea link to Penzance for the importation of basic commodities, including food and fuel (oil and diesel). The temporary loss of the link would have a significant effect on the community.

In early 2008, a failure of the Gry Maritha freight vessel, lead to a reduction in freight capacity to the islands for several weeks. The problems for the islands were acute as this occurred during the peak tourist season around the World Pilot Gig Racing Championships that are held annually on the islands. Even though freight was still able to be carried on the Scillonian III, the reduced capacity had a significant effect on the ability of the islands to support the tourist trade.

This short term loss of the link demonstrated to the project team the effect that an unplanned and prolonged loss of the cargo service would have on the local community. Although this supported the overall need for the improvements to the service that this scheme is promoting, it is also clear that any proposed works to upgrade the harbours must be carried out in as sensitive manner as possible with any closures of either harbour facility having to be planned and of a very limited duration.

5.1 Construction at Penzance

The proposed works at Penzance will take over a year to complete, and will therefore be ongoing throughout the tourist seasons. Additionally the works carried out to extend the quay will be programmed for summer to make the best use of the good weather and long days for tidal working. There is therefore considerable potential for disruption to the service during the construction of the works.

Proposals developed by Birse Coastal during the tender stage, and through the design development have focussed on working away from the existing quay wherever possible. The intention is to form a temporary access causeway formed along a part completed section of rock revetment to the seaward face of the existing quay. This route will be formed above mean sea level to give the maximum working window possible.

Working from on the temporary causeway the quay extension will be constructed using land based plant sat on a platform at the end of the causeway, or from a jack-up barge sat adjacent to the end of the quay. The blockwork will be delivered using tractor trailer units running along the causeway. Upon completion of the extension the rock revetment will then be completed by working backwards using land based plant to place the final armour stones onto the causeway.

5.2 Construction at St Marys

Construction at St Marys will be especially difficult due to the lack of available working space in and around the harbour. This together with a need to maintain as much as possible the ongoing use of the quays, both for the mainland sailings, but also significantly the multitude of off-island boats that take people between the many small island communities that make up the Isles of Scilly.

Here the proposed method of construction involves creating a working platform in a sheltered corner of the bay adjacent to Rat Island, and then working out from here to construct the landward section of reclamation. This will form a good, sheltered working area for the pier extension works, and act as storage for the delivery of units to the site. Space for storage is important to allow a stock of units to be kept on site to avoid delays due to the anticipated problems achieving delivery to site in bad weather.

Delivery of equipment and materials will either utilise landing craft for smaller quantities, or barges that can be brought in and beached onto the foreshore for offloading at low tide. These methods should enable the equipment and materials to be delivered to the non-active side of the existing quays.

Construction of the extension to the quay will utilise end over end construction to work out to the end, when the rear wall is partially complete it will form shelter for the construction of the forward quay walls in a more controlled manner. It will therefore be important that the construction of the rear wave wall is complete within the summer months to avoid winter working on this exposed face. This will need careful management of the supply chain to ensure that deliveries are made to meet programme.

A further sensitivity of the islands is to the sudden ingress of a sizeable construction workforce. This can affect the availability of accommodation for tourists, and have an effect on the social dynamics of the community. Birse Coastal are proposing to utilise local labour wherever possible, and introduce training to bring the available labour up to standard, where they do not have the available skills. The situation is even more acute as a new primary and secondary school is planned to be under construction on St Mary's at the same time as the harbours project. This will lead to a greater demand for resources.

6. ACKNOWLEDGEMENTS

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SUMMARY

In summary, the Isles of Scilly Link proposals are unique due to the remote locations of both harbours and the sensitive communities that surround the works.

Working within the communities has lead to innovation in the design, delivering a unique overall solution that achieves the benefits of a traditional mass concrete blockwork wall with improved construction rates in the specific local circumstances.

The contractor has also had to focus on his construction methods and logistics to minimise the impact on the communities and the effect on the life-line link that currently operates through the two harbours.

High impulsive wave pressures have lead to design challenges, and innovative solutions including a novel use of GFRP reinforcement.

RÉSUMÉ

Le contexte des travaux aux îles Scilly est unique en raison de la situation des ports et des communautés sensibles qui y vivent.

Travailler au sein de ces communautés a conduit à des innovations dans la conception, aboutissant à une solution globale unique qui intègre les bénéfices d'un quai en blocs bétons préfabriqués et une construction adaptée aux conditions locales particulières. L'entrepreneur a aussi du adapter ses méthodes de construction et de logistique pour réduire l'impact sur les communautés insulaires et sur le lien essentiel qui existe entre les deux ports.

Les fortes pressions dues à l'impact des vagues ont conduit à relever un défi et à proposer des solutions innovantes utilisant des renforcements à base de fibres de verre.

ZUSAMMENFASSUNG

Zusammengefasst sind die Vorschläge für das „Isles of Scilly Link"-Projekt einmalig wegen der räumlichen Lage der Häfen als auch wegen der betroffenen Gemeinden, die die Anlagen umgeben.

Das Arbeiten innerhalb der Gemeinden hat zu Innovationen im Design geführt, indem eine einmalige übergreifende Lösung geliefert wurde, die die Vorzüge von herkömmlichen Massenbeton-Hohlblockmauerwerk-Mauern mit einer verbesserten Konstruktion, die den lokalen Bedingungen Rechnung trägt, verbindet. Der Auftragnehmer musste auch auf seine Konstruktionsmethoden und die Logistik achten, um den Einfluss auf die Gemeinden und die Auswirkung auf die lebenswichtige Verbindung zu minimieren, die gegenwärtig beide Häfen verbindet.

Hoch-impulsiver Wellendruck hat zu Herausforderungen im Design geführt und zu innovativen Lösungen, einschließlich einer neuen Anwendung von GFRP-Verstärkungen.

REFURBISHMENT AND RECONSTRUCTION OF THE SOUTH HOOK LNG IMPORT TERMINAL JETTY

by

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KEY WORDS

Development of LNG terminal, renovation of infrastructure, jetty construction

MOTS-CLEFS

Développement d'un terminal gazier LNG, restauration des infrastructures, construction de la jetée

1. INTRODUCTION

The South Hook LNG Import Terminal, located in Milford Haven, Wales is a huge private investment that diversifies UK gas supplies. It is the largest of the terminals built in the UK to date and is now operational providing 20 % of the total UK gas requirement The terminal forms part of the Qatargas II project, which is a global project commissioned by Qatar Petroleum, ExxonMobil and Total to extract gas from the Arabian Gulf, liquefy it in Qatar, ship it to the UK and re-gasify it for introduction into the UK national grid. The terminal is capable of handling the largest LNG ships currently used in the world – up to 345 m long and 266,000 m^3 capacity Q-Max vessels.

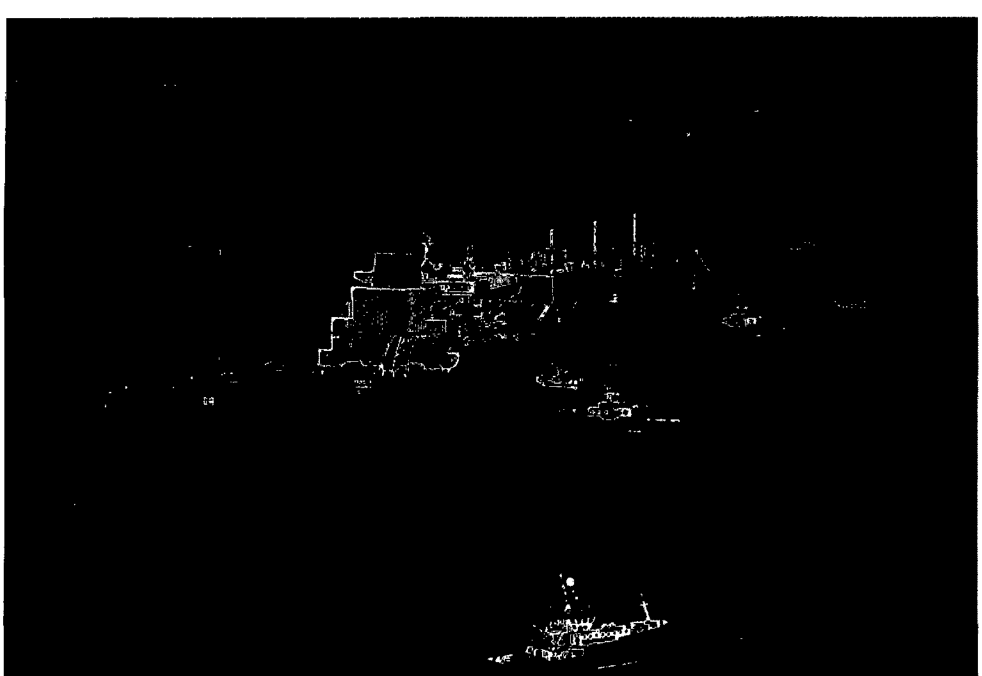


Fig. 1: Q-Flex LNG carrier on South Hook jetty

South Hook LNG Terminal Company Ltd, the client, placed an Engineer, Procure and Construct (EPC) contract with CB&I for the entire Milford Haven Terminal. CB&I in turn placed an EPC contract for the jetty structure with Besix Kier JV, a fully integrated joint venture between Besix, a Belgian construction company and Kier Construction Ltd of the UK. Besix Kier JV sublet two major elements of the work: heavy demolition to Herbosch Kiere Scaldis JV and the concrete repairs and cathodic protection to Freyssinet Ltd. Much of the jetty construction work outside these subcontracts was carried out directly by Besix Kier.

The aim of the works was to construct a world class importation facility by extending the life of the existing jetty (originally the Esso oil refinery jetty), and rebuilding it where necessary. The original jetty had been built between 1959 and 1961 and had been out of commission since the decommissioning of the Esso refinery in the 1980's. It consisted of a 1 km long approach trestle and a 1.25 km long berthing line incorporating 5 berths. The jetty is situated at the most westerly end of Milford Haven close to the Haven mouth.

Construction of the jetty was carried out between 2005 and 2007, requiring utilisation of skills encompassing refurbishment, demolition and new construction all in a marine environment. In order to achieve this, one of the largest marine construction fleets required in the UK in recent times was assembled. This paper describes how some of the challenges encountered during the works were overcome and the reasons why the selected methods were adopted. Following a nine month design and mobilisation period work on site took three years and was completed on programme.

2. REFURBISHMENT

2.1 Scope of the Refurbishment

The existing jetty structure is within a Special Area of Conservation incorporating several SSSI's. This is a highly protected categorisation falling under European law. Directly under the jetty approach trestle is an area of red maerl coral (Figure 2) – the only known bed in Wales. It is a form of calcified seaweed that takes thousands of years to grow.

Fig. 2: Red Maerl Coral

Through a series of initial pre-contract investigations it was determined that the landward 800 m of the approach trestle could be retained and refurbished. However the roadway over the trestles would have to be removed and replaced with new, due to its deteriorated condition.
The refurbishment works were required to 80 bents and consisted of the following operations:

- Bracing of the existing structure
- Removal of the existing concrete roadway
- Erection of enclosed work platforms to the piles and crossheads
- Removal of cracked and spalled concrete by hydro-demolition
- Replacement of rusted reinforcement and introduction of additional reinforcement where necessary to give required strength enhancements
- Sprayed concrete replacement of removed concrete
- Installation of impressed current cathodic protection including titanium mesh
- Sprayed concrete protective overlay
- Installation of new roadways, crash barriers, cable trays and lighting
- Removal of bracing
- Refurbishment of an adjacent steel trestle to act as a small boat collision barrier.

2.2 Protection of the Red Maerl

A detailed survey of the seabed was carried out by marine biologists. This determined areas of dense maerl and areas with little or no maerl (Figure 3). This meant that positions for spud legs and anchors could be determined for all operations prior to the commencement of works, a significant exercise when methodology was still being developed, allowing locations to be selected that would cause minimal or no damage.

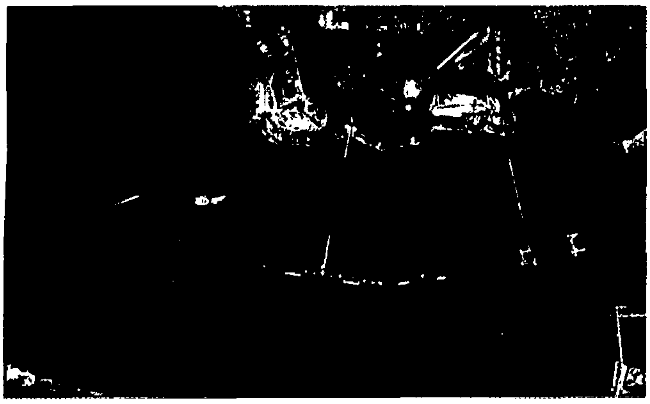


Fig. 3: Distribution of Red Maerl Coral shown by red circles

2.3 Temporary Works

The site was very exposed to wind and swells. This was particularly so for the approach trestle. Due to this it was decided that for the major lifting a self elevating platform (SEP), commonly known as a jack-up barge, would be required. An SEP with 37 m long legs and a crane capable of lifting the 40 T road elements at a radius of 30 m was brought to site.

A condition of the FEPA Licence was that nothing was to be dropped into the sea. This included the water from our hydro-demolition, dust from grit blasting, rebound from the sprayed concrete etc. Thus a fully enclosed safe working platform was required that would contain all of these, whilst at the same time providing suitable access to carry out the works. A series of 'houses' measuring 13 x 5 m by 6 m high were constructed to cater for this (Figure 4). The lower floor of each house was sealed using steel pans with a sheet rubber overlay. Debris skips were fitted to the ends of the houses to collect the demolished concrete and provided a sump for pumping the waste water onto an adjacent barge.

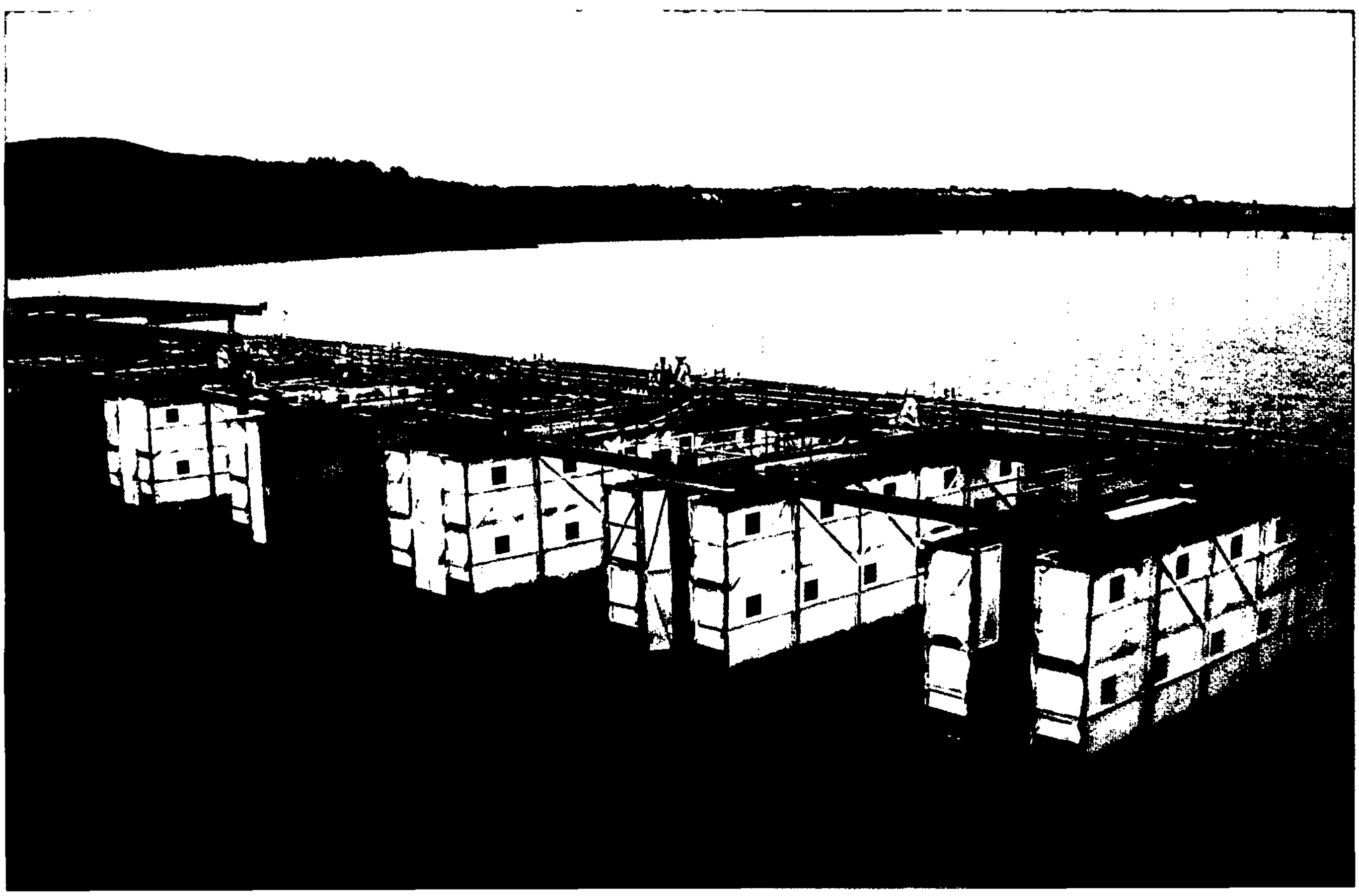


Fig. 4: Enclosures around pile bents

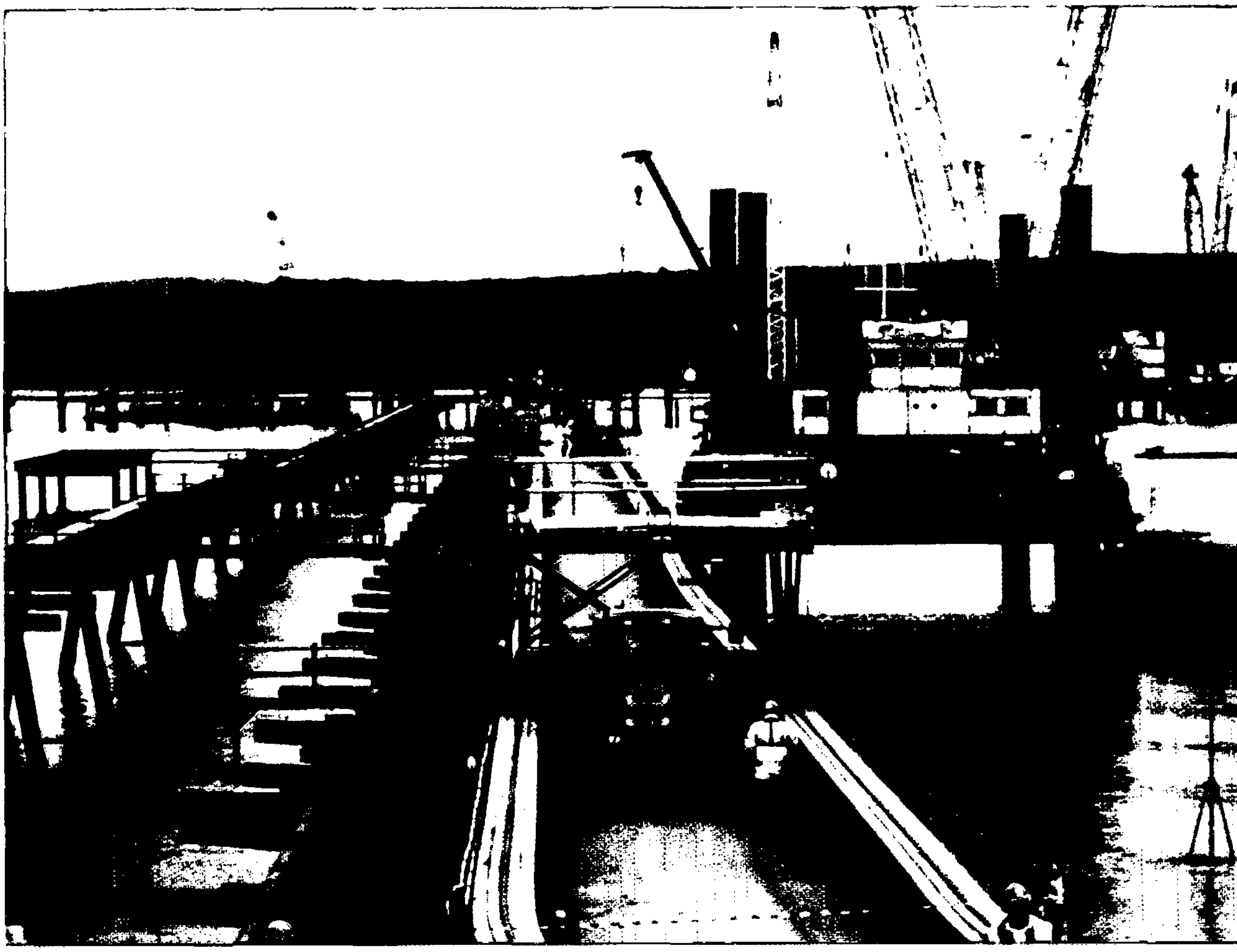


Fig. 5: Rail system for transporting road units

2.4 Approach Road Replacement

To reduce weight on the old structure the new road units were in the form of a composite concrete slab with steel truss sub-frame. The frame allowed a reduction in the quantity of concrete thus ensuring that the units were light enough to handle as a full width slab. The steel truss fulfilled the dual role as a pipe support for the under-slung service pipes. The road units were initially fabricated on the landward section of the site.

The adopted solution for transporting the deck units out to the barges was a rail system which was constructed from the site precast yard to and along the first 250 m of the jetty (Figure 5). This spanned from bent to bent on independent steel beams as no use could be made of the existing road slabs due to their deteriorated nature. A barge was permanently stationed at the seaward end of the rail system. This had a 250 T crane on board which allowed lifting of the 40 T road sections from the rail trolley onto materials barges. It also acted as a crew transfer platform giving easy transfer of personnel from the shore to barges.

3. DEMOLITION OF OLD BERTHS

The demolition works incorporated the removal of approximately 30,000 tonnes of concrete slabs, decks and pilecaps - this included the removal of three berths, 16 mooring dolphins and approximately 200 m of roadway. Also 850 piles had to be removed to 1 m below seabed level. The piles were a mix of prestressed hollow tubular concrete piles and steel piles, some of which were concrete filled. Demolition of these elements was necessary as the existing structures in these areas were no longer required, of insufficient strength, or of inappropriate layout to allow for their re-use within the new jetty facility.

3.1 Deck Removal

Information regarding the existing slab reinforcement was very limited. For thick pilecaps this did not matter as the width-to-depth ratio was low enough to allow the concrete alone to give sufficient strength for lifting. For the berth decks the width-to-depth ratio was such that either investigation of the reinforcement had to be carried out or steel beams could be fixed to the upper surface to act as reinforcement. The latter option was selected as it removed the need to carry out extensive investigations or to make significant assumptions.

The two main berths were cut into 14 pieces each, with a maximum weight of 1,410 tonnes per piece and size of 20 x 12 m. Cutting was carried out using diamond wire to make a single cut through the full width of the deck for each piece. Deck cutting could be carried out prior to fixing any of the reinforcement beams or connecting the heavy lift crane. Mooring dolphin caps did not require cutting as they weighed 400-900 tonnes which allowed them to be removed in a single piece (Figure 6).

In order to remove the concrete decks the piles were severed below deck level. This was achieved using diamond wire saws that clamped around the outside of the piles. This work had to be carried out whilst the concrete slab was secured to the heavy lift crane hook and so pile cutting was carried out on a 24 hour a day basis to minimise the crane time required. The cut level of piles often varied due to tidal constraints meaning that when the pile cap was delivered to the demolition barge further trimming of the piles was required to allow the pilecap to be positioned securely aiding safe demolition.

Once the piles were completely severed from a deck section the deck would be transported in the crane hook to the demolition barge. Two main heavy lift cranes were used for this operation; the self propelled 3,300 tonne capacity Rambiz (Figure 7 on the next page) and a 400 tonne capacity self propelled sheerlegs.

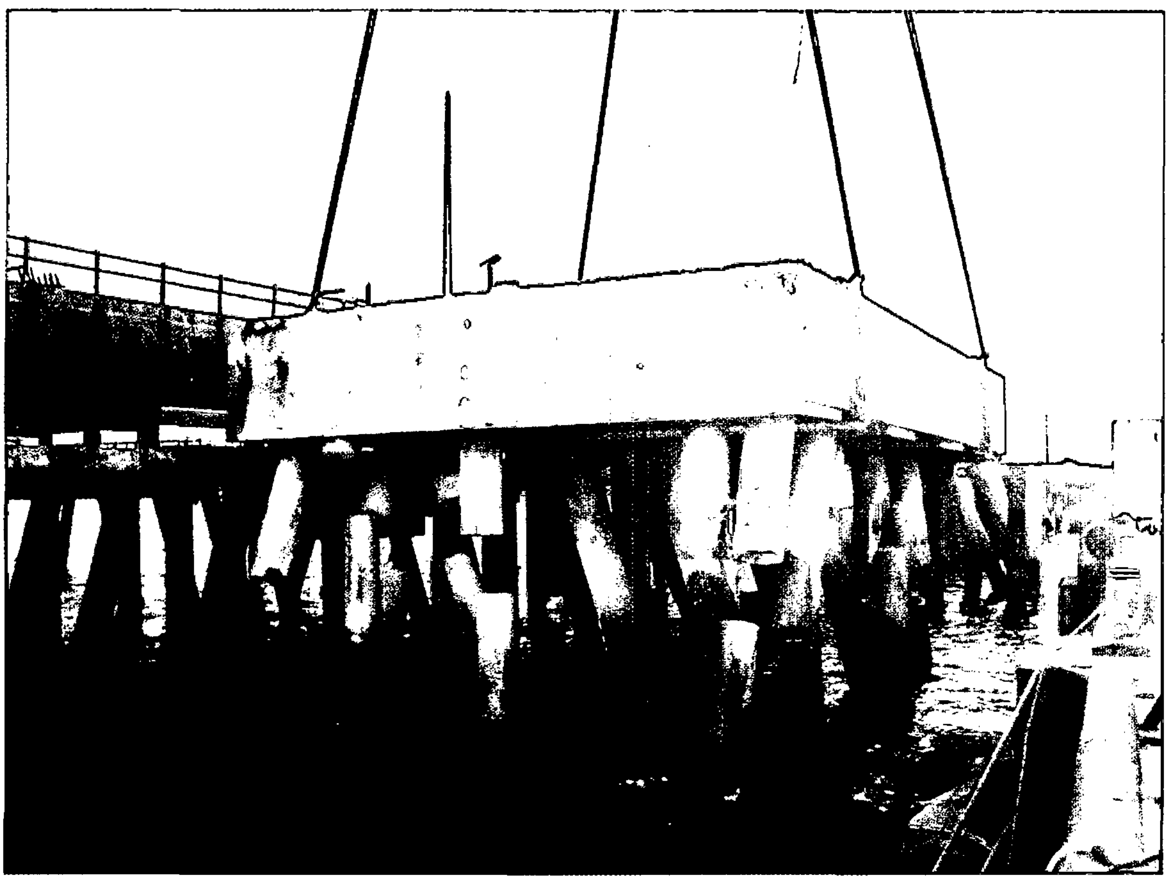


Fig. 6: Lifting of mooring dolphin pilecap after cutting piles

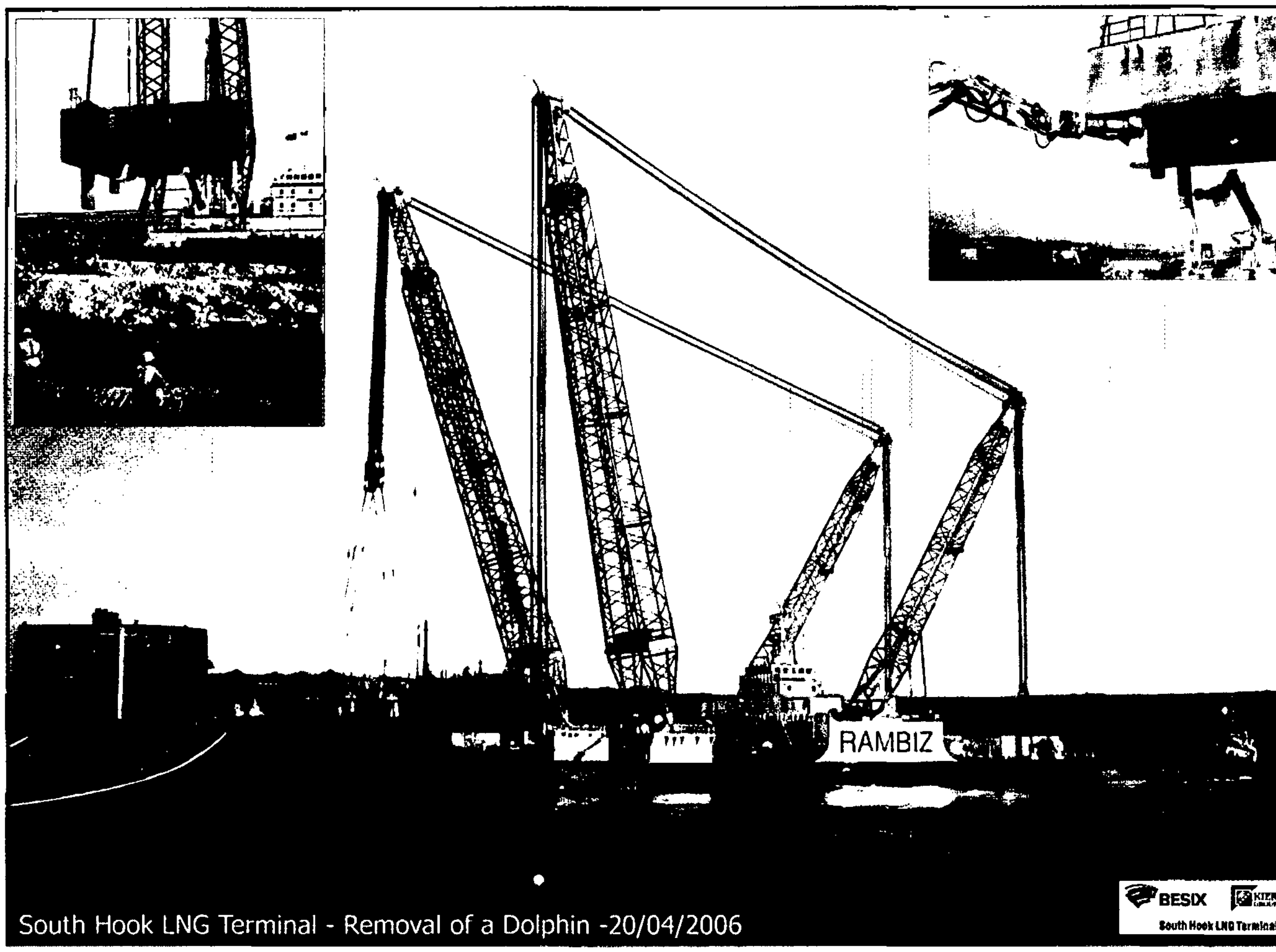


Fig. 7: Rambiz transporting concrete mooring dolphin cap

3.2 Pile Removal

Demolished piles had to be removed to 1 m below seabed level. As most piles had hollow cores a high pressure water cutter operating at 2500 bar with abrasive grit was specifically constructed for the project (Figure 8). This was lowered down the inside of the pile to the correct level where the cutter then made a single pass around the inner annulus of the pile cutting the concrete, reinforcement and pre-stressing wires. This was the most environmentally friendly way of removing the piles as there was minimal disturbance of the seabed. Where piles had been cut at a higher level due to tides a second cut was required to the pile head to cut below the plug to give an open annulus.

For piles that could not be cut internally (due to obstructions, concrete plugs etc) cutting had to be carried out externally. For this a hydraulic guillotine was used (Figure 9). This guillotine had water jets on the underside that were used to jet out the silt from around the pile allowing the guillotine to be lowered until it was able to cut 1m below seabed level. The hydraulic blade then closed severing the pile.

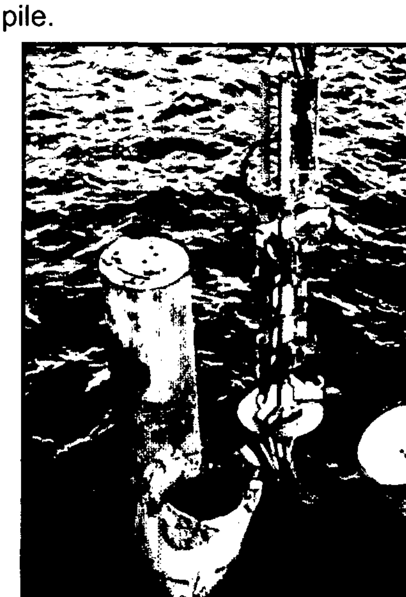


Fig. 8: Underwater internal pile cutting machine

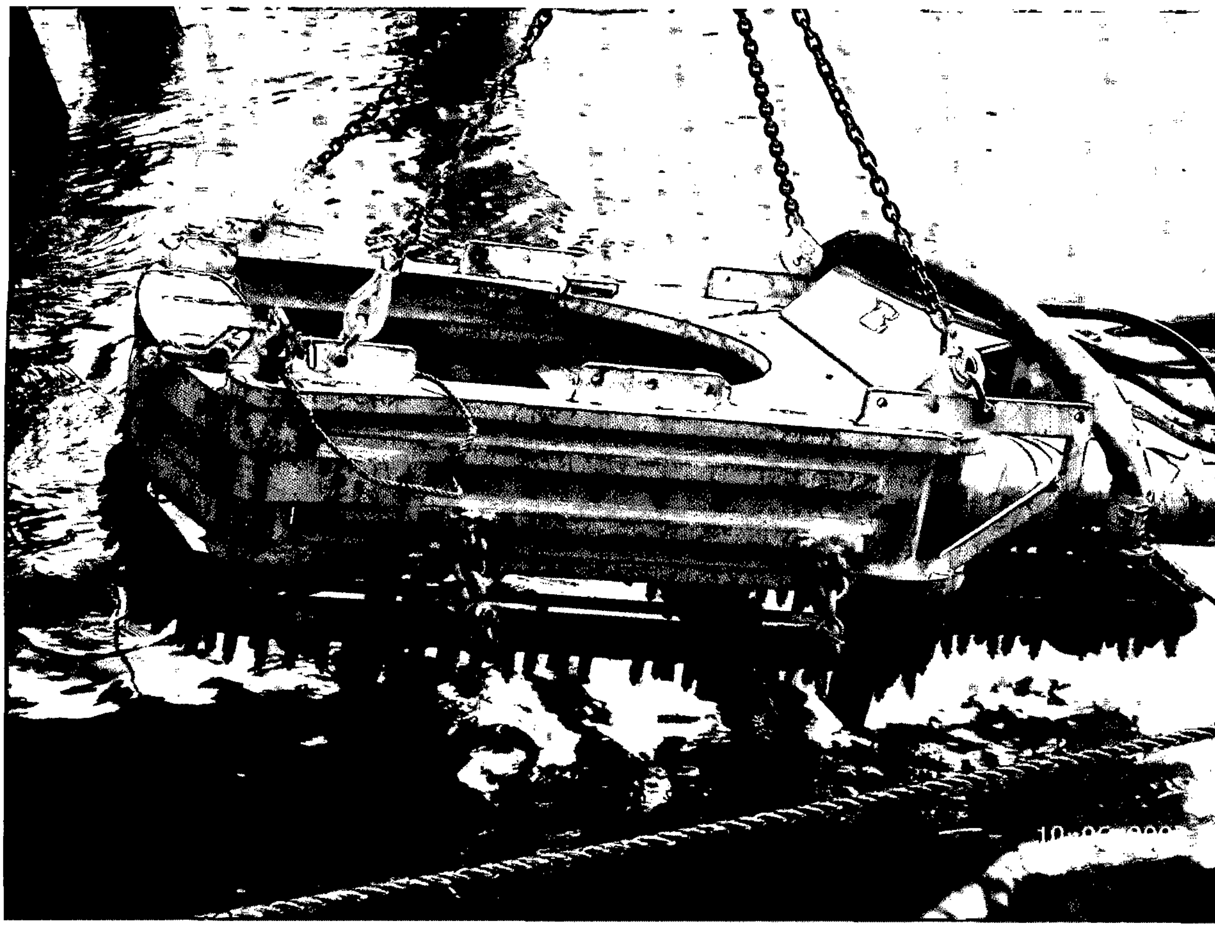


Fig. 9: Underwater external pile cutting machine

3.3 Disposal of demolished structures

A number of options were considered for disposal or re-use of the concrete slabs and piles. These included:

- The creation of a breakwater adjacent to a local island.
- Using the material to partially fill an area of the estuary that was likely to be infilled for future development.
- Onshore disposal, which was the favoured solution as it appeared to be the most straightforward and gave the greatest certainty of successful methodology. However as the detail was worked through it became apparent that it would not be possible to gain approval due to the number of additional trucks that would be placed on the local road network to remove the crushed concrete.
- The final option was to create a floating yard for receiving the elements, breaking the concrete, separation of reinforcement, crushing and removal for re-use. A suitable barge was located in Norway that would be large enough for all these operations. It measured 122 x 30 m and included a timber deck covering as well as timber rock-walls.

The plan was to land concrete elements weighing several hundred tonnes on the barge with loads onto the barge deck concentrated as point loads through a few pile stubs protruding from the bottom of the elements. Prevention of damage to the barge deck was a great concern. A protective layer of crushed concrete was placed over the entire area of the barge and then a mat of precast concrete road slabs was used to further spread the loads. This proved successful with no deck damage recorded at the off-hire survey.

Approval of this system was more problematic than anticipated. It became necessary to hold a joint meeting between all interested parties which included eight government bodies. Following descriptions of control measures, which included filtration of rainwater run-off, dust suppression, underwater and above water noise monitoring during crushing etc., approval was given just in time for works to commence on programme.

Fig. 10: Transfer of crushed concrete to coaster

The methodology worked very well as the concrete was then quickly broken up and crushed with a maximum weekly throughput of material of 6,000 tonnes. The crushed material was stockpiled on the barge and periodically transferred to a coastal vessel (Figure 10) which moored alongside for loading. This transported the material to south coast ports for re-use within the construction industry.

4. NEW CONSTRUCTION

New construction consisted of the following elements:

- Two new berths measuring 40 x 16 m
- 8 berthing dolphins and 16 mooring dolphins
- Control building and jetty head structures
- 250 m of roadway
- Fenders, bollards, quick release hooks, crash barriers, lighting and cable trays.

4.1 Piling

Works included the driving of 370 piles of 1066 mm diameter and 24 mm wall thickness. The piles were up to 53 m long and weighed up to 32 tonnes. Initially piles were brought to site by ship and stored on one of the redundant berths. This proved to take up too much critical SEP time in the off-loading and collection of piles and also resulted in damage to the pile coating during the additional handling operations.

Subsequent deliveries were transported by barge and remained on the barge until required. By standardising pile lengths this method became viable and allowed for the programme flexibility necessary with up to three SEPs piling at the same time and requiring piles from the same barge.

For pile driving the SEPs were positioned using real time kinematic GPS systems which allowed barge positioning to within +/- 0.5 m. All SEPs were fitted with fully hydraulic gates and, with legs up to 65 m long, were suitable for operating in the deep water of the Haven channel. The piles were driven to refusal through the overlying weak sandydeposits down to the siltstone rock using S150 hydraulic piling hammers. The piles were not self supporting and so required bracing either to one another or to the SEP until a stable group could be formed.

Tension piles anchors were drilled through the silt and generally 6 m into the rock using Wirth reverse circulation drilling rigs (Figure 11). Reinforcement cages of 12 m length were placed into the socket and underwater concrete was poured to complete the anchor.

During driving it was necessary to ensure that seals, dolphins and harbour porpoise would not be unduly affected by the noise. Underwater noise monitoring was carried out to measure noise levels. This determined that no piling could be carried out if they were within 600 m. A cetaceous biologist was employed as a marine mammal observer to carry out underwater listening and visual observations to ensure that this was the case during each pile driving operation. A soft start regime was also adopted lasting 20 minutes, giving time for any sea creatures so minded to vacate the area.

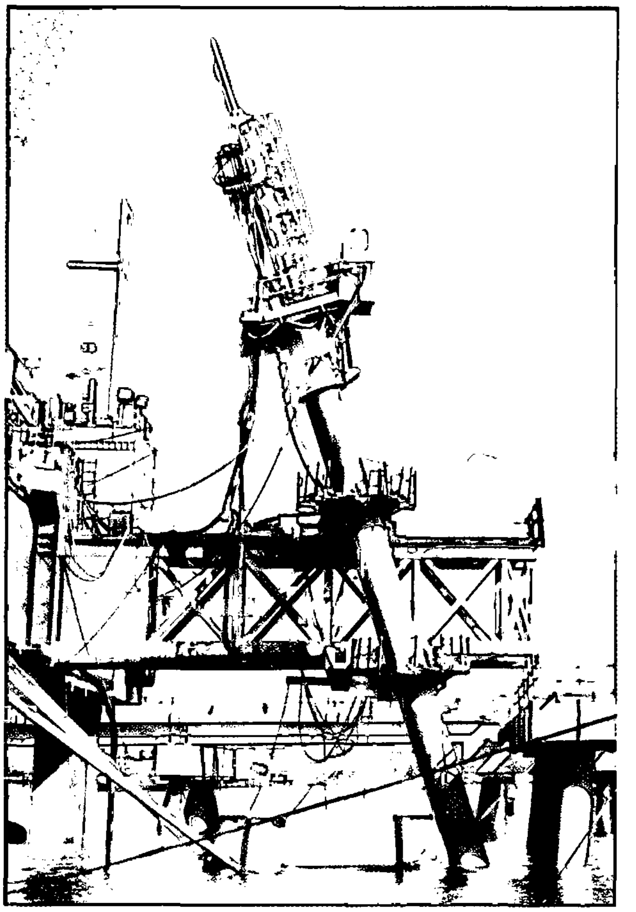


Fig. 11: Pile top drilling rig

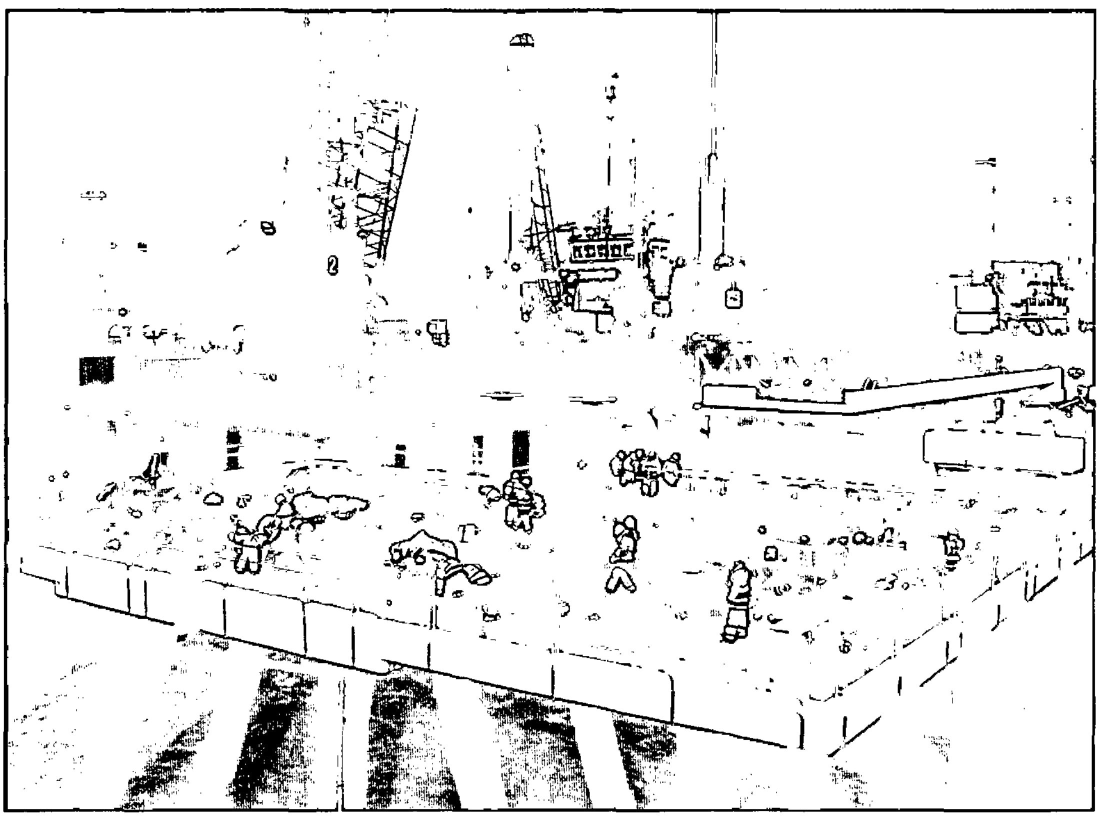


Fig. 12: Precast concrete soffit panels

4.2 Precast concrete

Precast concrete units were manufactured to give integral side and soffit sections to avoid the need for any formwork over the water (Figure 12 on the previous page). A fifth SEP was used to place precast elements and reinforcement. Wherever possible, reinforcement was prefabricated on-shore. Cages of up to 30 m length were prepared for the crossheads and full mooring and berthing dolphin cages were also assembled in advance (Figure 13).

Fig. 13: Pre-assembled reinforcement cages

4.3 In situ concrete

With no access from the shore to many of the structures concrete had to be delivered by sea. Four concrete shuttle barges were used two of these were built specifically for the project. Each had two 9 m^3 agitator drums on board. A tank was also included to allow drums and skips to be washed out without discharging any water into the Haven. Concrete was placed by skip either using one of the SEP's or a floating crane (Figure 14).

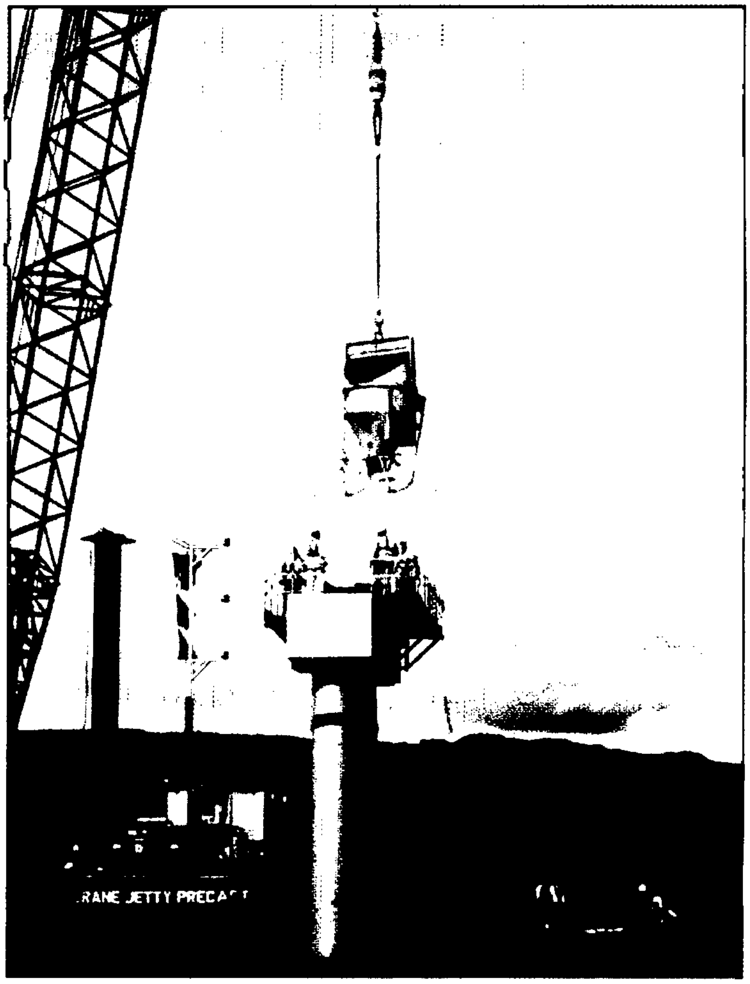


Fig. 14: In situ concreting of a crosshead

The quantity of concrete required at approx 15,000 m^3 did not justify the erection of a site batch plant and concrete supply therefore came from a local ready mix plant. It was difficult to plan the actual times of a pour as a small delay in a preparatory item could mean that an entire tidal cycle had to take place prior to the pour actually starting. The weather was also prone to change; this could impact on the duration of an activity. Tugs were required to move crane barges into position for pours and these might not be available at exactly the right time. These factors made it difficult for the ready mix plant, with its other commitments, to sequence concrete supply to the jetty, leading to further delays. A site based batch plant, whilst appearing more expensive, would perhaps have been better suited to this style of marine working.

5. GENERAL CHALLENGES

5.1 Safety

The project was large in scale, requiring careful planning in the following areas:

- Marine working
- Substantial amounts of diving (up to four dive teams at a time)
- Heavy demolition
- Hydro-demolition
- Heavy lifting
- Diverse nationalities (over 30 nationalities although a much more limited range of languages) with a variety of experience and expectations regarding safety standards.
- Environment (wind, swell, cold, rain, fog etc).

Safety was therefore always a priority and was approached in a robust manner. A wide range of safety training courses were organised throughout the project duration for staff and labour utilising both internal and external resources. These were aimed not only at the above topics but also covered more general responsibilities or specific duties.

A behavioural based safety scheme was introduced that showed significant improvements in the safety statistics as the work progressed. This was combined with an Injury & Incident Free programme introduced by the client that put the onus on each individual to commit to improve some aspect of safety within their control.

Monthly safety newsletters were produced to inform personnel of what was planned for the site, to give feedback on incidents and near misses and to address a specific topic each month. Some of the articles were written in Polish or Urdu rather than English so as to reach out to the entire workforce. Mr Five, our safety mascot, was also developed for the project to illustrate safety concepts (Figure 15).

The workforce was directly involved not only through a Safety Committee but also through the use of safety coaches. These were drawn from the workforce and were given the full-time role of speaking to the workforce about the work they were doing, how they had approached it and how they were considering the welfare of themselves and others. This proved a successful way of engaging the workforce and encouraging them to think and plan. The workforce was also more likely to confide in a safety coach as they found it easier to discuss in an open manner the work they had to carry out. The safety coaches had the back-up of trained safety advisors for any specific advice.

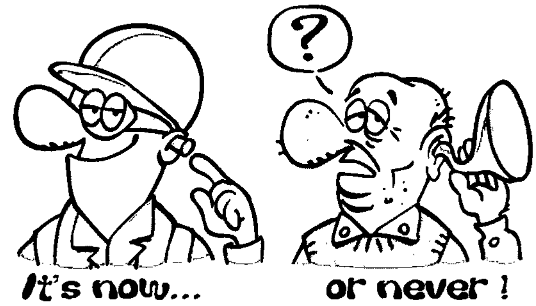


Fig. 15: Safety mascot for illustration of safety messages

5.2 Mobilisation

Mobilisation of marine equipment was a significant exercise. In total five SEPs, 11 floating cranes, two sheerlegs, eight materials barges and 18 workboats and tugs were mobilised as well as marine transportation of piles, structural steel and crushed concrete. Many of the tows were carried out in the winter and most had to travel around the point of Cornwall leading to significant uncertainties, delays and sometimes damage due to weather. Some of this equipment required mobilisation from other continents.

Long marine tows tend to be risky in time and cost. Consequently to ensure the programme could be met equipment from Equitorial Guinea was mobilised using a semi-submersible vessel (Figure 16 on the next page). This was one of the largest vessels to have ever entered the Haven but was able to use an area away from the main shipping channel to partially submerge and discharge the equipment on board.

Mobilisation of staff and labour also proved more difficult than anticipated. As the Project was located in the relatively remote southwest corner of Wales it only gave a 90° recruitment zone and it took several hours for most people in the UK to travel to the site. At peak over 100 staff and 500 labour were employed by Besix Kier JV.

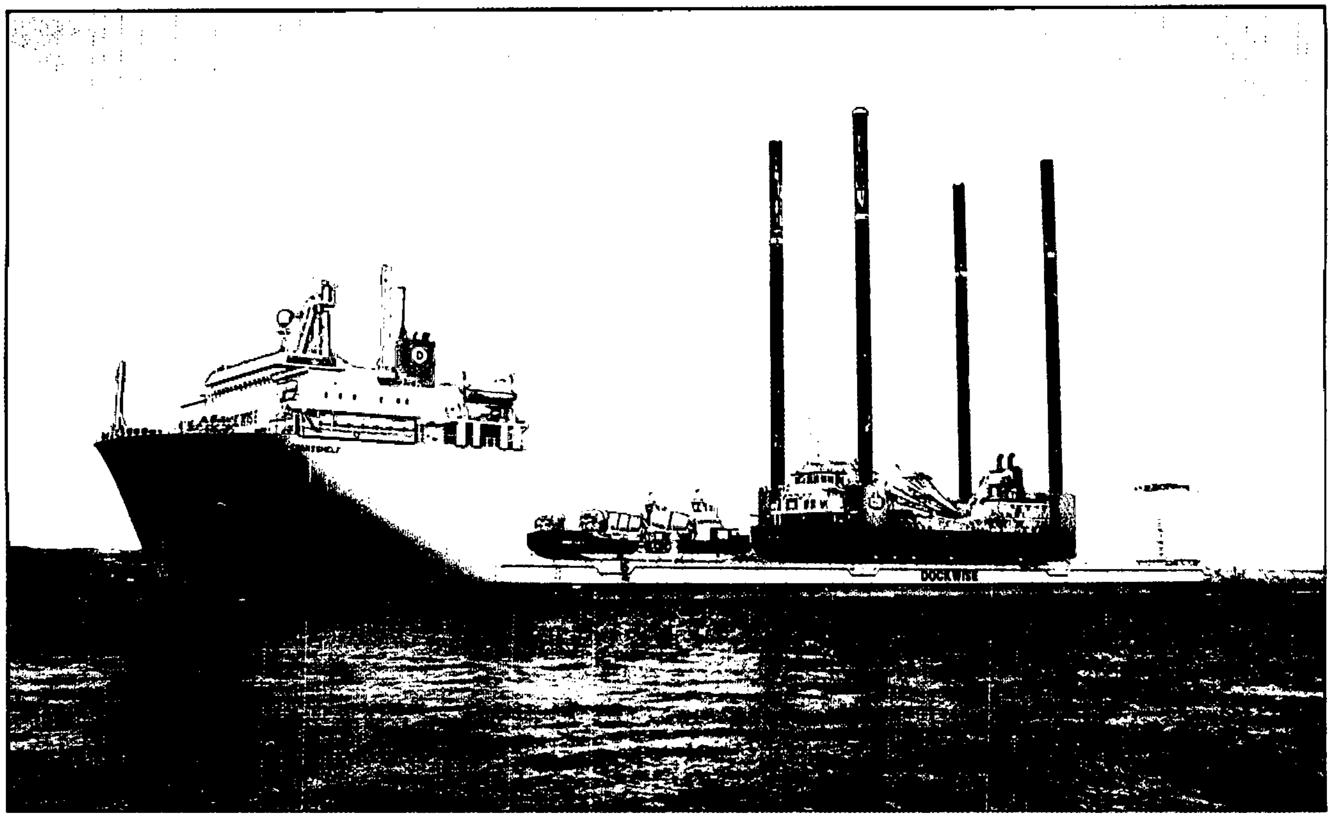


Fig. 16: Semi-submersible vessel used for equipment mobilization

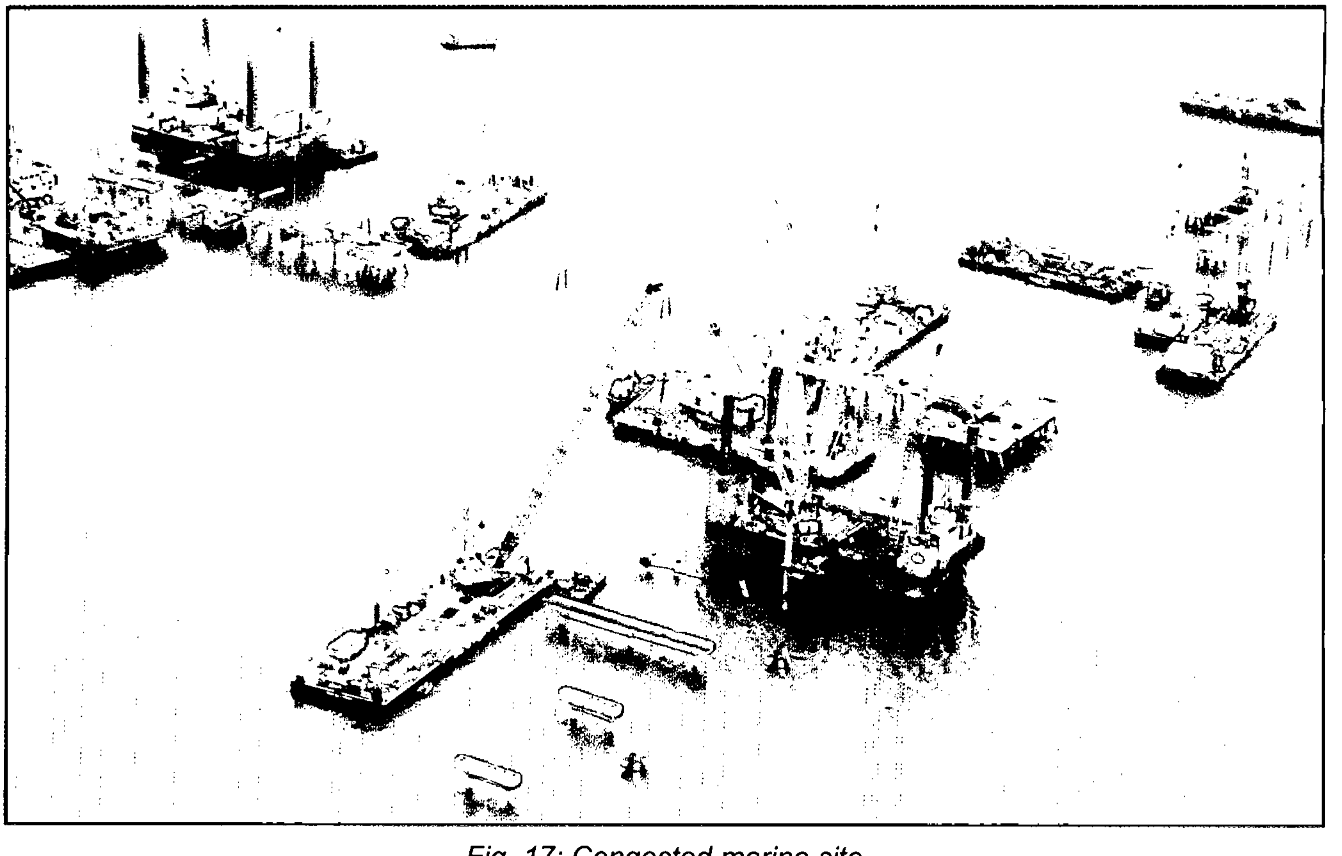


Fig. 17: Congested marine site

5.3 Logistics

The majority of the equipment listed above was on site throughout the peak period of production during 2006 - 7. All of this equipment required frequent movement as well as delivery of personnel and materials, and attendance from up to five patrolling safety boats per shift.

As can be seen from Figure 17 the equipment was working in a very restricted area. With most barges putting out four anchors to a distance of up to 200 m from the barge careful co-ordination of anchor positions to ensure barges could move when required was necessary. All anchor locations were pre-determined on location drawings and were dropped in position using GPS technology.

A dedicated marine co-ordination team was required to work 24 hours per day 7 days per week to manage the movement of all vessels on site, communicate with the harbour master, arrange pilots, schedule materials and fuel deliveries and ensure the timely movement of equipment and personnel.

5.4 Weather

During the winter frequent storms blew in from the Atlantic. For two months each winter very little progress was possible. During storms as much equipment as possible was moved to Pembroke Port. Thus production was lost prior to a storm and similarly after a storm as barges were re-mobilised to site. These conditions combined with an 8 m maximum tide significantly restricted periods during which movements of equipment could be carried out.

6. CONCLUSION

Construction of a complex jetty structure in a relatively remote location was possible whilst causing minimal impact on the environment. Many challenges were thrust upon the team but through the complimentary skills of Besix and Kier, which were well suited to the unique nature of the project, coupled with a dynamic and flexible relationship with the client and main contractor, it was possible to overcome these in a timely manner to allow the marine works to be completed on programme (Figure 18).

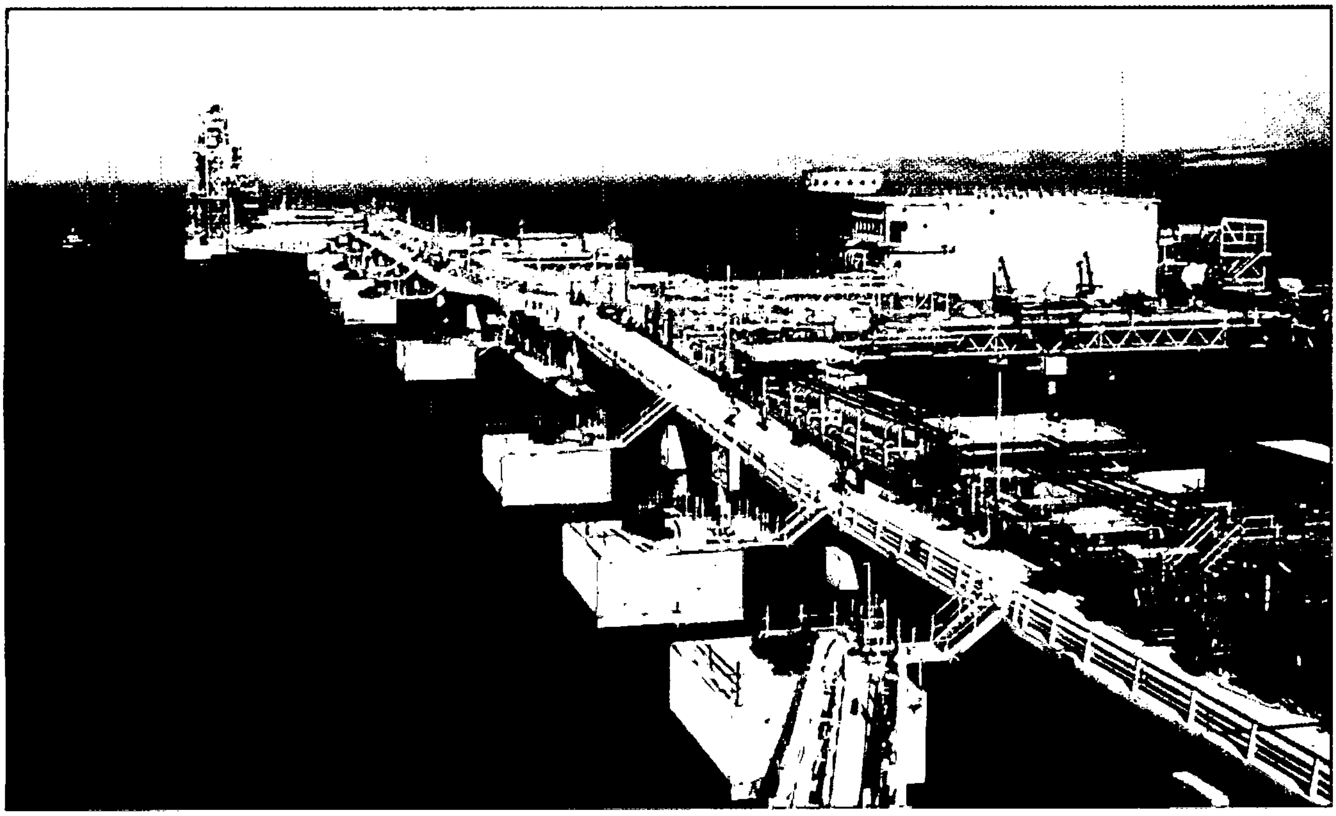


Fig. 18: Jetty structural works complete

SUMMARY

The jetty for the South Hook LNG Import Terminal was constructed between 2005 and 2007. Works included refurbishment of the approach trestle for re-use within the terminal, demolition of some of the structures that were no longer required, and new construction of the berthing line. This paper reviews the methods that were adopted and discusses how some of the challenges were overcome.

RÉSUMÉ

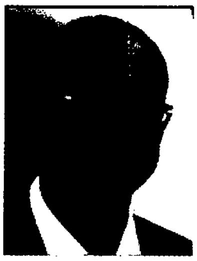
La jetée du terminal d'importation de gaz naturel liquéfié de South Hook a été restaurée et reconstruite entre 2005 et 2007. Les travaux comprenaient la restauration, pour réutilisation, d'une partie de la jetée d'accès, la démolition des structures obsolètes et la construction d'un nouveau poste d'accostage. Le présent article décrit les méthodes adoptées pour la réalisation de ces travaux et explique comment les principaux défis ont surmontés.

ZUSAMMENFASSUNG

Die Hafenmole für das South Hook LNG Import Terminal wurde zwischen 2005 und 2007 erbaut. Die Arbeiten beinhalteten die Aufarbeitung der Anfahrtsstütze für eine Wiederverwendung innerhalb des Terminals, den Abbruch einiger Bauwerke, die nicht länger benötigt wurden, und den Neubau einer Anlegestelle. Dieser Artikel bespricht die angewendeten Methoden und diskutiert, wie einige der Schwierigkeiten gelöst wurden.

STOURPORT BASINS RESTORATION – MAINTAINING AND BUILDING HERITAGE FOR THE FUTURE

by



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KEY WORDS

Canal, regeneration, restoration, partnership, contemporary

MOTS-CLEFS

Canal, rénovation, restauration, partenariat, contemporain

1. INTRODUCTION

"*The greatest of all canal-inspired towns is Stourport...*" [CROWE, N., 1994]

The built environment of the United Kingdom's inland waterways is a remarkable working heritage infrastructure. Its architecture and engineering features provide a valuable part of the national heritage as well as regional and local distinctiveness. The special identity for Stourport-on-Severn can be seen in its canal basins placed at the central part of the town. Figure 1 shows a view across the main canal basin and the restored Clock Warehouse.

Many English market towns now are seeking to adapt to the needs of the 21st century. Some have recognized that turning to the historic environment can be a means of reinforcing their identity and individuality. However, there can be few places with such a strong association with a single determining feature - its canal basin infrastructure - as Stourport. The town's canal ancestry means there are precious features in its local, regional and national profile.

Fig. 1: Clock Warehouse and upper basin (2009)

Stourport is consequently Britain's premier canal town and an important national heritage asset. The loss of the original commercial role of the canal and basins at the town, alongside wider national economic and social changes, have nevertheless led to Stourport sharing twentieth century decline in economic and social well-being with many market towns.

Today it is acknowledged that safe, active and attractive waterfronts can provide distinctive places for people and improving the quality of life for all. Indeed, the UK waterways attract 270 million visits to the network each year and contribute up to £1.2 billion (€ 1.33bn) to the visitor economy [BRITISH WATERWAYS & ENGLISH HERITAGE, 2009]. Therefore after a careful assessment of the options to deliver a restoration project, British Waterways has worked with a range of interests to find how it can address its engineering and heritage responsibilities and at the same time help delivery of a local initiative that can stimulate regeneration. British Waterways is the public corporation that cares for the 2,200-mile (3,540 km) network of canals and rivers in England, Scotland and Wales.

Through considering a series of physical elements of the resulting partnership project this article will demonstrate how a distinctive, lively and vibrant waterspace can be reborn with historic features and contemporary design sitting comfortably alongside each other.

2. STOURPORT'S HISTORY AND IDENTITY

The Staffordshire & Worcestershire canal terminating at basin complex at Stourport was amongst the earliest canals to be built. So how did the birth of Stourport come about?

James Brindley (1716-1772) completed the pioneering canal project for the Duke of Bridgwater in 1765. This connected the Duke's coal mines in Worsley with Manchester, a distance of 14 miles (23 km). Just one year later in 1766 the 46 miles (74 km) Staffordshire & Worcestershire canal at received parliamentary assent and after the canal company bought two fields besides the river Severn at Lower Mitton construction began. On 1 April 1771 the Birmingham Gazette reported that the southern half of the canal was "*open for business with Wharfs and Warehouses made and Wharfingers fixed.*" Until now Brindley had called the terminus of the canal Newport but the newspaper article now confirmed the terminus was to be called Stourport.

Dramatic growth followed the opening and the multiple commercial and domestic uses in around the basins evolved over the following period. For twenty years the canal and basins were the only waterway connecting the English midlands with the river Severn and it prospered under this monopoly. The Tontine Hotel was Stouport's unofficial business centre and in and around it revolved the life and work of the port. The building formed the centrepiece of the new enterprise and dominated the local business scene [ENGLISH HERITAGE, 2007]. Figure 2 shows the Tontine Hotel in 2005 and prior to commencement of its conversion to residential accommodation currently underway by a private developer.

Fig. 2: The Tontine Hotel (2005)

Stourport became the very epitome of the commercial confidence of the age [Green, C., 1999] and enjoyed around four decades of expansion and related prosperity. Figure 3 shows a view of the basin complex at Stourport in 1776, showing the industrious nature of the town related to the inland navigation operations. In this respect it was considered to be national significance:

> *"About 1766, where the river Stour empties itself into the Severn below Mitton, stood a little alehouse called Stourmouth; near this place Brindley has caused a town to be erected, made a port and dock yards, built a new and elegant bridge, established markets, and made it the wonder not only of this country, but the nation at large." [NASH, Dr., T., R., 1799]*

By 1815 the annual dividends distributed by the canal company had peaked. Competition from the rival Worcester & Birmingham canal and rail transport then signalled the beginning of a long

III. Stourport in 1776

Fig. 3: Print by James Sherriff 1776

and laboured decline in Stourport's wealth and success, as can be seen in this quote from a late nineteenth century commentator on the fate of the Tontine Hotel:

> *"A sad contrast to its former self. Railways have robbed the Severn and canal of traffic.... we now find the Tontine, a large square block, with rooms sufficient to make up a hundred beds and equally extensive stabling now diminished to one of the smallest inns in town..." [RANDAL, J., 1882]*

Commercial uses limped on to the twentieth century with present-day recollections recorded of the use of steam dredgers and similar to keep the navigation workable [CORRIE, E., 1998]. The local manufacturing industry components – the tannery, foundry and carpet factory – eventually closed and the railway ceased operation in 1970. The resulting brownfield sites were used for new housing and much of the working industrial heritage was swept away. The canal was finally taken under the control of the British Transport Commission in 1948. However, at that time and for the following fifty years or so it was difficult for British Waterways and its predecessors to justify and find adequate resources to effectively maintain investment in the working infrastructure of the canal and basins.

With imposed underinvestment in the canal infrastructure and the weakened prospects more generally for market towns, the economic health and wellbeing of Stourport and its canal basins eventually stood alongside that of other locations in the UK.

3. ASSEMBLY OF THE RESTORATION PROJECT

The early years of the twenty first century saw the dawn of ideas emerging for fresh look at how Stourport might meet its future by capitalizing on its past. It was a neat turn of events. Perhaps echoing the enthusiasm of the early canal pioneers. Discussions between British Waterways and local government representatives revealed a shared understanding of the need to engage all relevant local partners in any substantial restoration of the basins and its setting. Stourport was now to look at how it might recognize its canal heritage as a unique asset.

This would include addressing and respecting formal protection of the town's historic waterway environment as a central component of a town regeneration plan. With the support of a wide partnership, key stakeholders could all contribute to the development of the project. The initial core partnership consisted of Advantage West Midlands (the West Midlands Regional Development Agency), British Waterways, Worcestershire County Council and Wyre Forest District Council. With some joining at the implementation stages of the project, the wider partnership eventually included:

Arts Council England
Arts and Business
Disability Action Wyre Forest
English Heritage
Ernest Cook Trust
Hereford and Worcester Garden Trust
Heritage Lottery
Morrison Construction Ltd
RegenWM
Staffordshire and Worcestershire Canal Society
Stourport Forward
Stourport on Severn Civic Society
Stourport Town Council

It is interesting to note that the formation of Stourport Forward (a Company Limited by Guarantee with board members elected from the local authority and interested groups) was a direct consequence of the partnership objectives. Stourport Forward was ultimately to be the delivery body for the project, with a central role in the Market Towns Initiative. Beyond the project's life it would form the basis of a practical exit strategy and Stourport Forward remains active today.

In 2003 the core partners commissioned a study to develop a strategic assessment of the development potential of the riverside and canal basins area that might contribute to the physical, economic and social revitalization of Stourport town centre. The brief required the consultants to consider the restoration and regeneration of the canal basins so that it might act as a catalyst for influencing and encouraging further improvements in the town. The report was to be undertaken by independent consultants and this concluded that a partnership initiative could make possible a mixed use development which functions as a coherent and integrated whole to the benefit of residents, visitors and users of the location [GHK, 2003].

Understanding and translating how Stourport assumed its present form was acknowledged crucial to public enjoyment of the place if a partnership restoration project was to succeed. By exploring its history alongside undertaking sympathetic building works and engaging with the community, the project could celebrate the town's unique qualities and character. The consultants' study became the fuel that ignited the partners' proposals to design a framework that met Heritage Lottery Fund objectives and complimented and added value to the Market Towns Initiative, a programme sponsored by the Regional Development Agency aimed at breathing new life into the region's market towns. Key objectives of the application for Heritage Lottery funding were to:

- Stimulate the economic regeneration of the area as a focus for wider inwards investment, reclamation of derelict and under used or contaminated land and buildings, and job security and creation.
- Secure the long-term conservation and enhancement of the areas special character, heritage and townscape through good design, management and conservation best practice.
- Address the weaknesses of the Towns tourism and heritage potential and provide an improved recreational facility and regional visitor attraction.
- Provide improved signage and interpretation including a hierarchy of gateway, directional, and interpretative information at key locations to enhance visitor enjoyment and intellectual access to the heritage asset.

- Provide access and circulation improvements that' result in improvements in porosity, visibility, safety, vehicular and pedestrian flows.

4. THE PROGRAMME TAKES SHAPE

Approval of the Heritage Lottery Fund application was achieved in mid-2005. This event was instrumental in facilitating wider investment in the project to address both the physical elements of the restoration as well as a range of community-based interpretive initiatives and events. It was a determining moment in the progression of the work and meant that the overall investment package was now a realistic proposition.

The eventual overall project partnership funding formula is summarized in Table A.

Partner	**Financial contributions**
Heritage Lottery Fund	£ 1,575,000
British Waterways	£ 1,265,000
Worcestershire County Council, Wyre Forest District Council, Advantage West Midlands, Arts Council, The Waterways Trust, volunteers (financial and in kind contributions)	£ 514,000
Total	**£ 3,354,000**

Table A: summary of Stourport basins restoration project funding formula

Fig. 4: Barge Lock 2006 before restoration

The aim of the partnership remained the delivery of a sustainable and viable place whilst safeguarding and enhancing heritage value. For the engineering and construction aspects of the project, existing historic elements would be repaired or updated sympathetically whilst new additions would look to responding sensitively to existing building forms, reinforcing the importance of its context whilst embracing changes. This philosophy would relate the subtle differences in functional use of sites, buildings and facilities to the inherited historic landscape that was an acknowledged part of the town's tradition.

In looking at how the approach of being both sympathetic to the past and deliver innovative modern solutions was applied to the construction phase of the project, we will consider three discrete stages of the works. These were all relatively modest in terms of needed funding, but they all provide a snapshot of how the partnership drove forward in faithfully respecting heritage needs in repairing a structure; facilitating the restoration of a prominent building frontage using a historically sensitive approach; and converting an underused open space by means of modern interventions with the potential to become tomorrow's heritage.

5. HERITAGE THAT WORKS

British Waterways has a methodical and detailed system that ensures regular inspection of its key assets (bridges, locks, etc). This inspection and the related programmed maintenance system underpins the continued safe operation of the waterway network. However, the absence of needed resources for day to day maintenance works over many years at the Stourport basins regrettably brought about situations as shown in Figure 4 on the previous page.

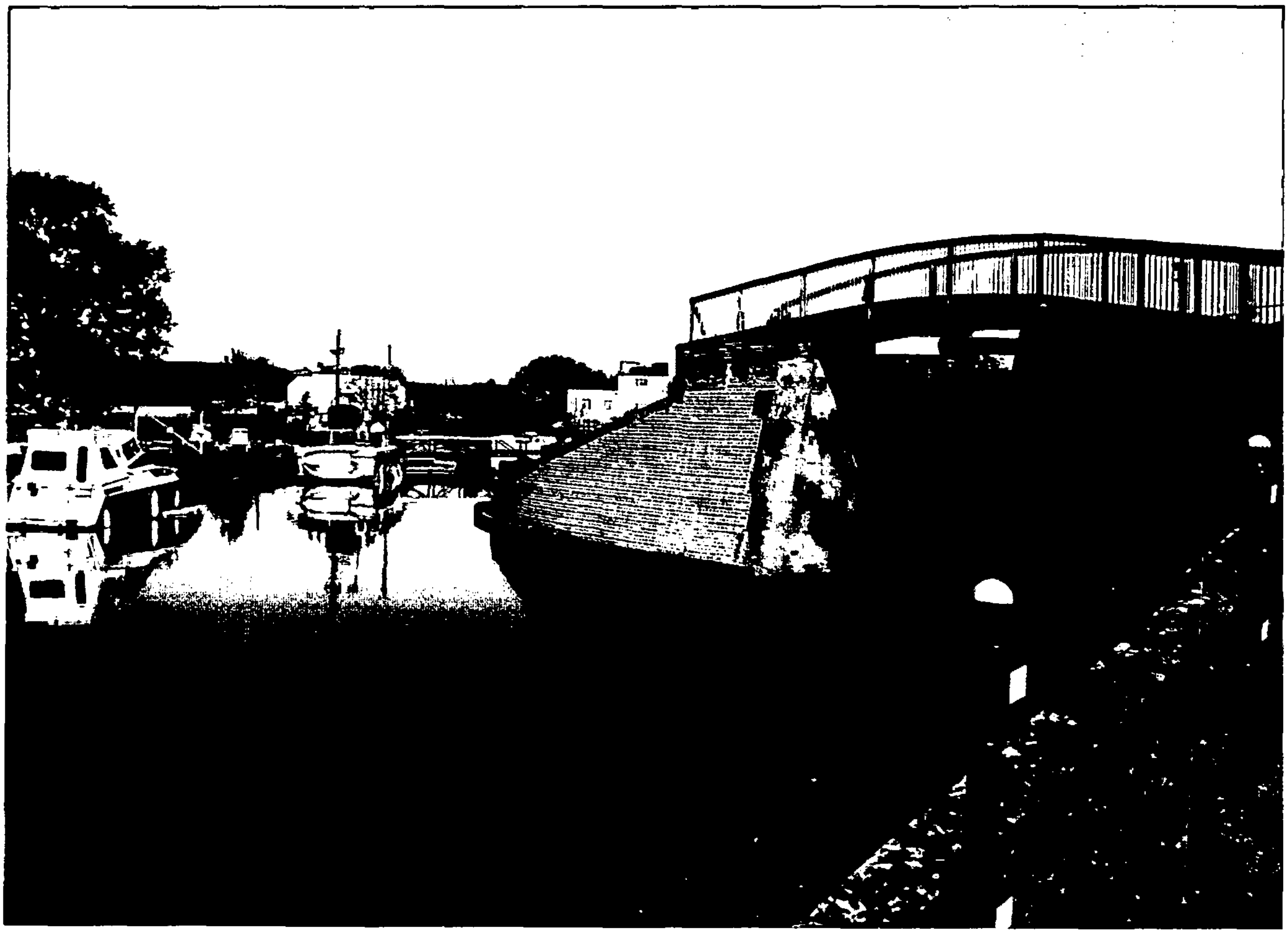

Fig. 5: Barge Lock in 2007 after restoration

Fig. 6: House in Severnside before restoration in 2004

Here the approach walls of a lock have become invaded by vegetation and coping stones lost or corroded due to frost and weather damage. The structure is not unsafe or inherently unstable, but the structure has lost the simple elegance of traditional functional canal architecture which had been built using local materials and techniques. This structure provides the first example of where true and authentic application of construction techniques was called for in the restoration plan. The results can be seen in Figure 5 (page 92) where this visually important and functional part of the basins has been repaired using traditional lime mortar, suitable reclaimed brickwork and materials including replacement sandstone copings. The completed work confirms how the efforts have lifted and improved the impression given by the structure. It now appears virtually in its original form and, more importantly for the aims of the restoration project, it looks cared for.

The second example where an interpretation of heritage values has been applied can be seen in the work undertaken to a prominent town house and its key elevations which had been subject to many changes since it was built around 1800. See Figure 6.

The property's façade had been altered many times since its construction. The changes has sometimes been insensitive to the original design with original windows and openings having been removed or replaced, hanging basket brackets fixed, boundary walls and enclosures constructed, altered and eventually timber fences added. What would be appropriate reinstatement works for the restoration project in this case? How could a "proper" elevation be re-established whilst respecting current residential user needs? Figure 7 shows how the building was restored and provided with traditional timber sash windows, including a period-style shop bay window and lead canopy.

Fig. 7: House in Severnside after restoration in 2007

Research had shown the building had been used for some time as a shop and the window now provided a modern facility and a visual reference to its pedigree. Also, a more contemporary interpretation of a boundary wall using railings has been installed. This continues the style of boundary enclosure to be found nearby on other buildings on the site. The results demonstrate how the building now contributes to the preservation of local distinctiveness with a finished design that avoids being dogmatic in strict interpretation of the concept of restoration. The finished elevation is sensitive to the context of form, scale, texture and materials. An objective as recommended by guidance recently published on the promotion of high quality waterside development [BRTISH WATERWAYS & ENGLISH HERITAGE, 2009].

Complementary new development and the third example of applying modern design solutions can be seen in the work undertaken to an underused car parking and pedestrian area immediately beside the main canal basin. The area was bounded by a blank brick wall with fixed functional steel seating and topped by metal railings. The uninviting and utilitarian nature of the area meant it was not well used and was an inefficient use of the space it occupied. See Figure 8.

Fig. 8: Open area before in 2006

The approach here was to provide a more open aspect for pedestrians with a timber seating area. Modern and traditional materials for the work were selected to be sensitive to their specific environment, as now recommended in the national guidance [BRITISH WATERWAYS & ENGLISH HERITAGE, 2009]. The area now has a more open aspect with details reflecting its historic context including text carved into the new sandstone wall. The date *1766*, seen carved to the bottom left in the new wall is a continuation of wording set in the frontage facing the canal basin. See Figure 9. The text on the wall comes from note book of the canal surveyor (John Fennyhouse Green) who was working under the direction of James Brindley when the site was selected for the location of the canal basin. The positioning of the lettering means that shadows cast by early afternoon sun make the text much clearer to read and mirror the time of day when Green and Brindley took their key decisions to build the canal basins. The non-rusting unpainted steel posts are a reminder of an industrial past and the new street lamp to be seen rising in the sky over the buildings to the left of the photograph are reminiscent of the mast of the historic commercial craft that plied the river navigation when the basins were constructed and to be seen in the 1776 print shown in Figure 3.

Fig. 9: Open area after restoration in 2008

6. HERITAGE FIT FOR THE FUTURE - CONCLUSIONS

Active historic sites require respect for authenticity and integrity in new developments; conservation needs to be a reference point in enabling progress to be delivered in a sensitive way. The challenge in applying a fresh approach to the unique historic landscape in Stourport was responding to a wish to facilitate regeneration on the one hand, while simultaneously respecting the inherited townscape and its setting on the other.

The central concern of the partnership in introducing physical and sometimes functional changes was to enhance the experience when visiting the site; the quality of life for local users; and improving the living, working and leisure surroundings.

This has been achieved and use of the site has been adapted without compromising existing values flowing from the character of Stourport's historic fabric. This means not only improved technical standards, but also inclusion of appropriate contemporary high-quality interventions based upon consideration of their value. They have enhanced the assets for the local community and serve educational, leisure and tourism functions.

The Stourport basins restoration project has resulted in the regeneration of an area encompassing no less than 29 listed buildings and helped to kick start wider town regeneration plans. It has achieved recognition via a number of local and regional awards and in 2008 received the British Urban Regeneration Association (BURA) Waterway Renaissance heritage category award and the special award for outstanding achievements. In September 2009 it gained the National Lottery heritage category award after a televised nationwide public vote. This is an impressive list of tributes for such a relatively modest initiative but fairly reflects its significance.

The three examples from the project set out above show how an asset from the past can become a living contributor to the future of a community. A key message is that those seeking to assemble regeneration plans should view the historic environment as an asset to sustainable development. Today's visitors to Stourport basins can enjoy and engage in the site. Visitors still to come will be able to recognize it as their legacy with the new development having breathed life and long term sustainability into a historic setting. It confirms changes can be true to their context and become heritage for the future.

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SUMMARY

The built environment of the United Kingdom's waterways is a remarkable working heritage infrastructure. The special identity for Stourport-on-Severn can be seen in its canal basins placed at the central part of the town. There can be few places with such a strong association with a single determining feature - its canal basin infrastructure. This makes Stourport Britain's premier canal town and an important national heritage asset.

A partnership involving British Waterways (the public corporation that cares for the 2,200-mile/3,540 km network of canals and rivers in England, Scotland and Wales) and key stakeholders determined that the protection and presentation of the historic environment must lie at the centre of efforts to bring vitality back to town.

By exploring its history alongside undertaking sympathetic building works the project could thereby celebrate the town's unique qualities and character.

By the summer of 2008 the canal basins at Stourport had been restored over a four year period. This was delivered via the local partnership with the £ 3.2 m (€ 3.6 m) costs funded by British Waterways, the Heritage Lottery Fund, the West Midlands Regional Development Agency and many other players.

The work has regenerated an area encompassing no less than 29 listed buildings and helped to kick start wider town regeneration plans.

Alongside comprehensive engagement of the local community, physical elements of the restoration work have included faithful traditional construction techniques, removal of unsympathetic modern additions and introduction of new high-quality contemporary features and these themes are explored by the article.

The concluding message for those seeking to assemble regeneration plans is that historic environment is an asset in seeking to achieve sustainable development.

Winner of the 2008 Waterways Renaissance Awards Outstanding Achievement award and chosen by the public as winner of the 2009 national UK Lottery funded projects heritage category award, the Stourport basins restoration project is an acknowledged excellent example of incorporating heritage values into regeneration plans.

By breathing life into a historic setting it shows how changes can be true to their context and become heritage for the future.

RÉSUMÉ

Le réseau des voies d'eau du Royaume-Uni constitue une infrastructure patrimoniale remarquable. Les bassins du canal de Stourport-on-Severn, positionnés dans la partie centrale de la ville, sont une spécificité. Il y a sans doute peu d'endroits aussi structurés par une seule caractéristique majeure: l'infrastructure des bassins du canal. C'est ce qui fait de Stourport la première "ville canal" britannique et un important atout du patrimoine national.

Un partenariat impliquant « British Waterways » (la compagnie publique en charge du réseau de 2 200 miles -3 540 km- de canaux et de rivières d'Angleterre, d'Ecosse et du Pays de Galles) et d'autres parties prenantes clés a déterminé que la protection et la présentation de cet environnement historique devaient être au centre des efforts pour redonner de la vitalité à la ville.

En intégrant l'histoire de son patrimoine bâti, le projet pourra valoriser les qualités et le caractère uniques de la ville.

A l'été 2008, les bassins du canal de Stourport ont été restaurés après quatre ans de travaux. Cela a été rendu possible par un partenariat local incluant « British Waterways », le fond patrimonial de la loterie nationale, l'agence de développement régional des "West Midlands" et beaucoup d'autres qui a permis de rassembler 3,2 millions de livres (3,6 millions d'euros).

Le projet a permis la restauration de pas moins de 29 édifices classés et a aidé au démarrage de projets de rénovation plus large de la ville.

S'appuyant sur un engagement massif de la communauté locale, les éléments physiques du travail de rénovation se sont basés sur la reprise fidèle de techniques de construction traditionnelles, le retrait des extensions modernes dysharmonieuses et l'introduction de nouveaux éléments contemporains de haute qualité et ces aspects sont détaillés dans l'article.

Le message de conclusion pour tous ceux qui chercheraient à mettre en ?uvre des projets de rénovation est que l'environnement historique est un atout dans la recherche d'un développement durable.

Vainqueur du prix 2008 de la réalisation exceptionnelle de l'année aux récompenses de la renaissance des voies d'eau et désigné vainqueur par le public du prix 2009 des projets financés par la loterie du Royaume-Uni dans la catégorie patrimoine, le projet de restauration des bassins de Stourport est reconnu comme un excellent exemple de l'intégration de valeurs patrimoniales dans des projets de rénovation.

En insufflant de la vie dans un cadre historique, il montre comment des changements peuvent être adaptés à leur contexte et devenir un élément de patrimoine pour le futur.

ZUSAMMENFASSUNG

Die bebaute Umgebung der Wasserstraßen des Vereinigten Königreichs stellt eine bemerkenswerte Erb-Infrastruktur dar. Die besondere Identität für Stourport-on-Severn ist aus seinem Kanalbecken ersichtlich, welches sich an zentraler Stelle der Stadt befindet. Es gibt nur wenige Orte mit so einer starken Anbindung an ein einzelnes bestimmendes Merkmal – seine Kanalbecken-Infrastruktur. Das macht Stourport zu Britanniens wichtigster Kanalstadt mit einem bedeutenden Wert für das nationale Erbe.

Eine Partnerschaft zwischen British Waterways (der Behörde, die für das 2.200-Meilen/3.540 km Netz von Kanälen und Flüssen in England, Schottland und Wales verantwortlich ist) und wichtigen Geldgebern hat festgelegt, dass der Schutz und das Erscheinungsbild dieser historischen Umgebung im Mittelpunkt der Anstrengungen stehen muss, um Vitalität in die Stadt zurückzubringen.

Beim Erkunden der Geschichte und durch das Bauen passender Gebäude könnten die einzigartigen Qualitäten und der Charakter der Stadt zelebriert werden.

Bis zum Sommer 2008 wurde das Kanalbecken in Stourport über einen Zeitraum von vier Jahren restauriert. Dies wurde durch eine örtliche Partnerschaft ermöglicht, die die Kosten von £ 3.2m (€ 3.6m) aufbrachten: British Waterways, der Heritage Lotterie Fond, die West Midlands Regionale Entwicklungsbehörde und viele andere Mitwirkende.

Durch die Arbeiten wurde ein Gebiet mit nicht weniger als 29 aufgelisteten Gebäuden restauriert und verhalf dabei der Stadt zum Anstoß weiterer Restaurierungspläne.

Neben umfassendem Engagement der lokalen Behörden umfassten die physischen Elemente der Restaurierungsarbeiten exakte herkömmliche Bautechniken, das Entfernen unpassender moderner Anbauten und die Einführung neuer hochqualitativer zeitgeschichtlicher Elemente; diese Themen werden in diesem Artikel erörtert.

Die zusammenfassende Botschaft für diejenigen, die versuchen, Restaurierungspläne zu erstellen, ist, dass eine historische Umgebung für den Versuch, eine nachhaltige Entwicklung zu erreichen, einen Wert darstellt.

Als Gewinner des 2008 Waterways Renaissance Awards Outstanding Achievement Preises und von der Öffentlichkeit 2009 zum Gewinner des nationalen UK Lotterie Fonds im Bereich historischer Projekte gewählt, stellt die Restaurierung des Stourport-Becken-Projekt ein ausgezeichnetes Beispiel für die Verbindung von alten Vermögenswerten mit Erneuerungsplänen dar.

Indem historischen Stätten Leben eingehaucht wird, wird gezeigt, wie Veränderungen wahrheitsgetreu umgesetzt werden können und so ein Erbe für die Zukunft werden.

PLANNING A PORT DEVELOPMENT AT CORITO IN ANGUILLA, BRITISH WEST INDIES

by

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KEY WORDS

Multipurpose port, economic analysis, capacity assessment, coastal modelling, environmental and social component

MOTS-CLEFS

Port multi-produits, analyse économique, estimation de capacité, modélisation côtière, composantes environnementale et sociale

1. PROJECT BACKGROUND

The Government of Anguilla intends developing a new general cargo port at Corito Bay, which is located on the south side of the island of Anguilla in the British West Indies. The development is to replace an existing facility at Road Bay on the north side of the island that primarily handles cargo vessels. Passenger ferry operations will not be considered in this development as these services currently operate from Blowing Point Harbour, also located on the south side of the island to the west of Corito Bay, and designated as a tourist area on the island. In 2002 Halcrow undertook the "*Anguilla Port Development and Management Study*", which identified Corito Bay as the preferred location for a cargo port. The existing jetty structure at Road Bay is in poor condition, the depth of water restricts the size of vessels that can be accommodated, and the area available for cargo handling and storage is limited. This limits the basic economic viability of further port development at Road Bay, with the additional factor of the area possessing considerable potential for tourism development. Following this study, Halcrow was appointed to provide consultancy services that encompassed planning and design of the new facility based on the approach and the particular site location recommended in the 2002 Study.

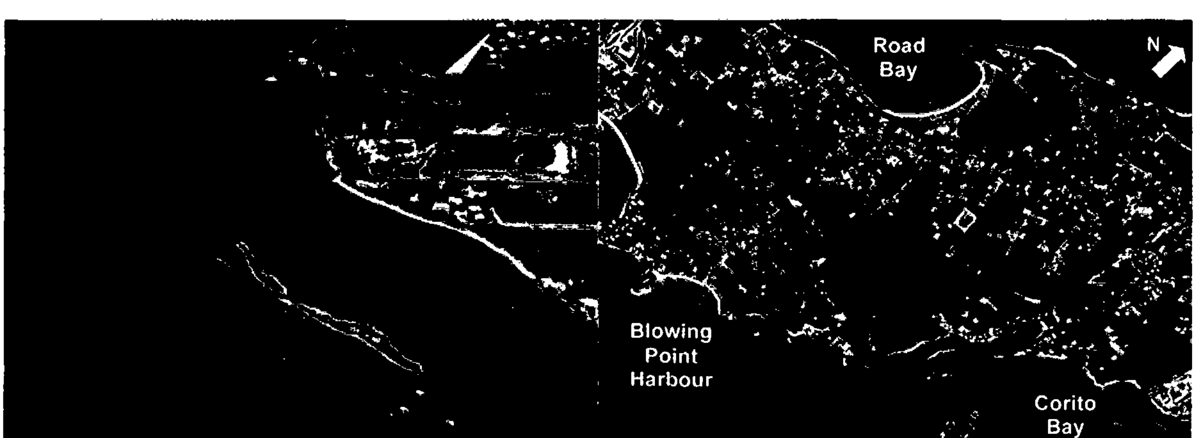

Fig. 1: Aerial view of the proposed site for the Corito Port Development (Source: Halcrow & Google Earth)

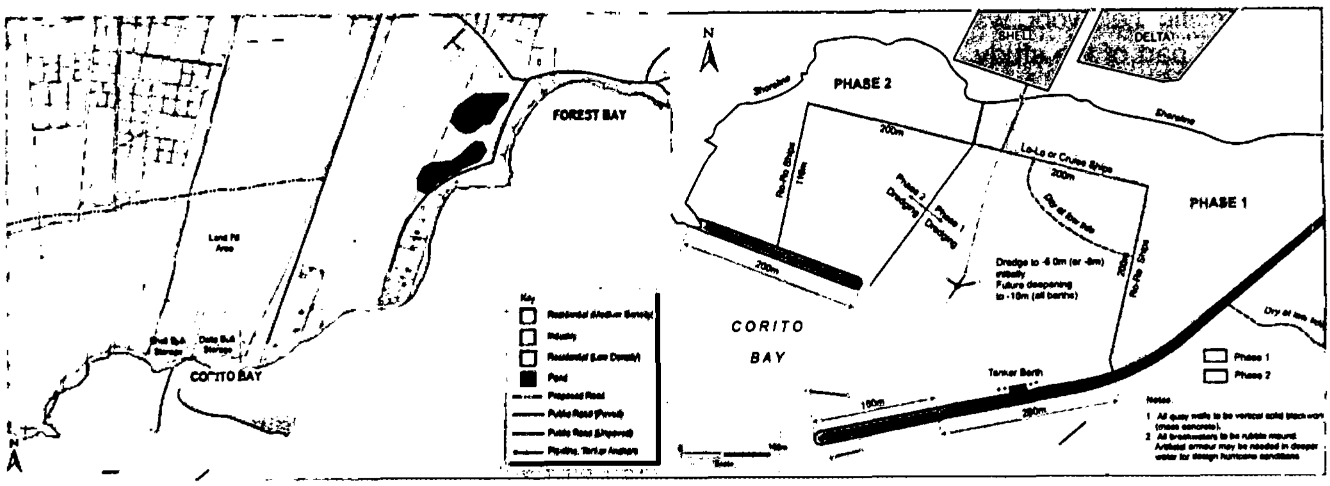

Fig. 5: Layout of proposed Corito Port Development (Source: Halcrow)

SUMMARY

The Government of Anguilla intends developing a new multipurpose port at Corito Bay that primarily handles cargo vessels. Passenger operations will not be considered in this development. In 2002 Halcrow undertook a study which identified Corito Bay as the preferred location to replace the existing facility at Road Bay, which is in poor condition, has water depth restrictions, and limited storage area. Halcrow was subsequently appointed to provide consultancy services to plan and design the new facility in accordance with the recommendations of the 2002 study. Planning involved identifying all factors relevant to the development following interviews with stakeholders, port users, etc.; completing an economic analysis up to 2035 to determine shipping and cargo trends; undertaking a capacity assessment to ascertain the size of harbour; completing site specific fieldwork to aid in the planning and design of the port; performing coastal modelling to optimise the port layout; undertaking navigation simulation exercises to confirm navigation access of the layout; assessing potential environmental and social impacts of the development and devising mitigation plans.

RÉSUMÉ

Le gouvernement de l'île d'Anguilla a l'intention de développer un nouveau port multi-produits dans la baie de Corito qui permettra, avant tout, la manutention de marchandises. Le transport de passagers ne sera pas pris en compte dans ce projet. En 2002, Halcrow a réalisé une étude identifiant la baie de Corito comme le lieu optimal pour remplacer l'infrastructure existante de Road Bay qui est en mauvais état, a des contraintes de profondeur et un espace de stockage limité. Halcrow a été désigné pour la fourniture de services de consultation pour planifier et dimensionner la nouvelle infrastructure en accord avec les recommandations de l'étude de 2002. La planification a impliqué l'identification de l'ensemble des facteurs pertinents pour le développement grâce à des entretiens avec les parties prenantes, les usagers du port, etc ; la réalisation d'une analyse économique à horizon 2035 pour déterminer les tendances du transport de marchandises ; l'évaluation de la capacité pour établir la taille du port; l'achèvement du travail de terrain spécifique pour aider à la planification et au dimensionnement du port ; la réalisation d'une modélisation côtière pour optimiser le plan masse ; la réalisation d'exercices de simulation de navigation pour confirmer le dimensionnement des accès navigables ; l'évaluation des impacts environnementaux et sociaux potentiels du développement et la définition de mesures d'atténuation.

ZUSAMMENFASSUNG

Die Verwaltung von Aguilla beabsichtigt die Entwicklung eines neuen Vielzweck-Hafens in der Corito Bay, der in erster Linie Frachtschiffe betreut. Passagierbetrieb wird bei dieser Entwicklung nicht berücksichtigt werden. Im Jahr 2002 führte Halcrow eine Studie durch, die ergab, dass Corito Bay eine bevorzugte Lage hat, um die vorhandene Vorrichtung in Road Bay zu ersetzen, die in einem schlechten Zustand ist, Wassertiefen-Begrenzungen unterliegt und nur begrenzte Lagerflächen hat. Anschließend wurde Halcrow dazu beauftragt, in Übereinstimmung mit den Empfehlungen der Studie von 2002 Beratungsleistung für die Planung und Gestaltung der neuen Anlage zu erbringen. Die Planung beinhaltete das Feststellen aller entwicklungsrelevanten Faktoren, basierend auf Interviews der Geldgeber, der Hafenbenutzer etc., um bis 2035 eine ökonomische Untersuchung zu vervollständigen, die Schifffahrts- und Fracht-Trends festlegt, eine Kapazitätsschätzung vornimmt, um die Hafengrößen sicherzustellen, ergänzt durch spezielle Arbeiten vor Ort, um bei der Planung und Gestaltung des Hafens behilflich zu sein; die Modellierung des Küstenverlaufs wurde untersucht um die Gestaltung des Hafens zu optimieren, Schifffahrtssimulation durchgeführt, um die Gestaltung der Hafenzufahrt zu untermauern, es wurden potenzielle Einflüsse der Entwicklung auf die Umwelt und das soziale Umfeld eingeschätzt und Änderungspläne wurden erdacht.

RECENT TRENDS IN THE APPLICATION OF GENERIC SEDIMENT MANAGEMENT SYSTEMS

by

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KEY WORDS

Mud management, auto-flushing, EFOS, nautical depth

MOTS-CLEFS

Gestion des boues, auto-chasse, EFOS, profondeur nautique

1. As recently as the 1960s managing muddy sediment in ports and harbours was at the limit of our technological society to deal with, 'coping' strategies rather than solutions were often resorted to. We have had impounded dock systems for 300 years but until recently there was no alternative to repetitive "fetching and carrying" of deposited mud via the locks, the means of incursion in the first place. Traditional 'dig and dump' maintenance often led to offshore placement beyond coastal circulation cells, leading to permanent loss from vulnerable low-lying erosive coastlines, or following placement within such cells, repetitive and ultimately costly return. The most intractable of all materials was the often-contaminated fluid mud. Dredgers carried inefficiently cargoes of 'black water', extended periods of overflowing attempting to raise solids content were largely fruitless. The material spread widely on offshore release and there was, at times, a degree of truth in the claim that the mud got back to the dredging site, or the next port in the down-drift direction, before the dredger.

2. Rapid increases in ship size and increased efficiency of 'landside' management of cargo in the international port and shipping industry are now, belatedly, being matched by modern 'waterside' methods to manipulate flows and sediment. Publication of PIANC Report 102 'Minimising Harbour Siltation' highlights five readily exportable substantive, generic Sediment Management Systems (SMSs), all NW European in origin. (A 'generic' method solves a site-specific problem but when tailored to local idiosyncracies is universally applicable at self-similar sites). The most important issue to flag is the very large rise in earning capacity, coupled with reduction in fixed operating costs attendant on adopting these technologies. Commercial acceptance is being engendered by a shift in the previous resistance of those considering themselves to have a vested interest in preserving a status quo. PIANC Report 102, plus increasingly draconian environmental legislation, are spurs to what presently seems a large scale shift favouring uptake of these methods.

3. Enshrined within these developments is that, for the first time, the disciplines of the applied marine sciences are being adopted to support or supplement traditional engineering. Similarly, all embrace the vital sustainability factor, KSIS (Keep Sediment In the System). Progress has been especially rapid in Germany which has inventive scientists, receptive port authorities, and involved government in this sphere. With the Entrance Flow Optimisation System (EFOS) the need is to understand and learn how to reduce water and sediment exchanges across entrances to blind-ending basis. With Auto-flushing (Figure 1), Passive or Active Nautical Depth, and In Situ Conditioning (Figure 2) the focus is on mud rheology. Rapid and accurate density measurement based on the 1.2 t m-³ depth is shifting towards acoustic measurement of Shear Stress, Viscosity and Attenuation, involving the search for a Yield Point in the fluid mud cloud. All these are measured at present in Emden, the prototype port for the latter two advanced technologies.

4. By reducing or avoiding altogether need for conventional mud maintenance dredging, major environmental benefit arises. As no sediment is relocated there is no "disposal site" or licence need. The concept called 'environmental windows' becomes irrelevant. 'Dredging' involves digging deposited mud and requires a licence. These are 'anti-siltation devices' dealing with suspensions and don't need a dredging licence. Regulatory authorities are aware of these technologies and, in some countries, are already acting in a pro-active manner by informing port authorities that existing disposal/placement sites will soon be closed. This encourages the shift to these sustainable methods.

5. The pioneer ports for these technologies are Rotterdam, Hamburg, Antwerp, Zeebrugge, Emden and Leer. Bremen and Bremerhaven have made good progress. From 1975 the author is unaware of any deep-draughted vessel handling problem sailing through fluid mud in Rotterdam or elsewhere. A handbook explains alterations in ship behaviour and training is provided. Similarly, harbour pilots soon learnt that entering basins with an EFOS installation in place was easier than without. There is currently a strong swing towards building new conditioning vessels and on forming commercial alliances incorporating the skilled input of contractors. Adoption of generic SMSs permits ports to adopt wholly novel and more commercial harbour configurations not previously economically or environmentally viable, i.e. the semi-enclosed Deurganckdok in Antwerp, a port formerly constrained by its restriction to impounded dock systems. Similarly, plans are under discussion to build new ports in muddy coastal zones with 'auto-silt rejection" as a designed-in feature. In some cases this may permit port operating economics to become viable where this is not the case with traditional mud maintenance dredging and disposal.

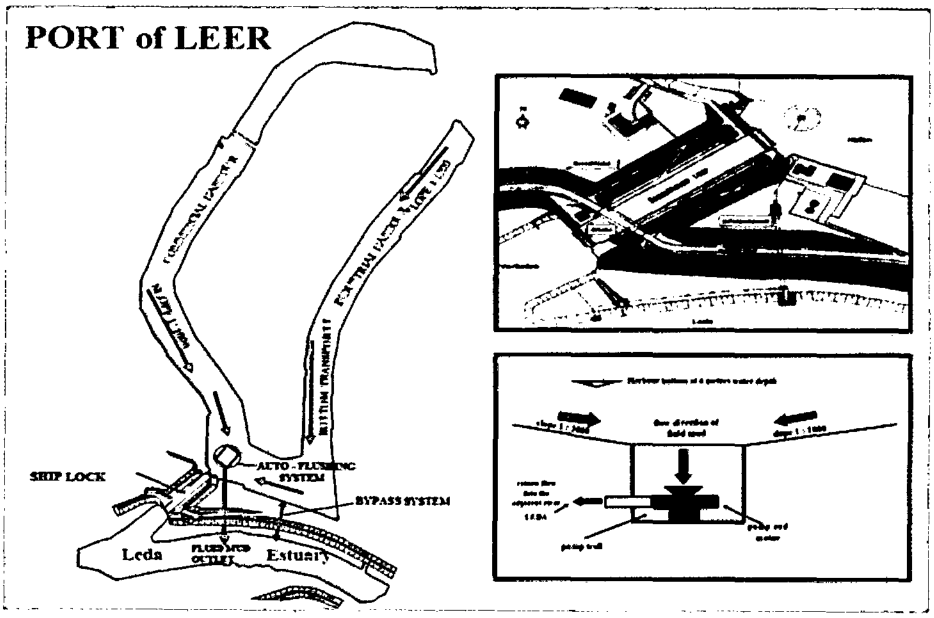


Fig.1: Map shows auto-flushing installation at Port of Leer with dock bed slope and site of underwater pump immediately inside ship lock. Insets show entrance with pump, pipes through embankment, plus simplified cross-section.

Fig. 2: Fluid mud spreading across the open hopper of the conditioning vessel. The flow is laminar and the surface 'ropey', both features of gentle lava eruptions from basic, Hawaiian-type volcanoes. Mud is re-oxygenated on its way to the outlet. Scale L-R ~5 metres. Inset: Conditioning Vessel "Meerval" in entrance to Emden docks passing a car carrier.

6. In parallel, there is the emerging vision amongst NW European dredging companies that the days of high volume/low unit return rates of mud maintenance may be numbered and are being replaced by high added-value/low volume treatment methods. The alternative is still profitable. Were it to evolve, it represents a significant break with tradition.

7. Fluid mud has been shifted from a pernicious, unwelcome waste to a valuable resource with a beneficial use. The implication is that approaches such as placing mud with treatable contaminants in a Confined Disposal Facility becomes unnecessary. Until recently Active Nautical Depth had only been applied to lock entrances and semi-enclosed basins, but the first experiments to apply the technique as a substitute for capital dredging to deepen a fairway have begun. The implication is that, instead of a port authority being 'fettered' (as up to the 1960s) by a material almost entirely intractable to technology, sediment managers are going out with the deliberate objective of creating fluid mud where none occurred before. Sediment management is already stepping beyond the narrow confines of ports into whole system management, as in the Scheldt and Ems.

8. Physical and chemical oceanography, with marine microbiology, are already complex topics in their own right, but academics have begun manipulating all these together at one time. The scientific community needs to enquire whether technologies beyond these five generic SMSs can be developed. Similarly, from this initial starting point we need to consider which cohesive sediments can be manipulated in this way, which bacteria are involved, and which anthropogenic contaminants can be destroyed in this manner? There can be no wise management without understanding muddy coastal systems and estuaries. In particular, a bright light needs to be shone on the vital discipline of mud rheology and progress needs to be made devising better in situ measuring devices.

SUMMARY

PIANC Report 102 'Minimising Harbour Siltation' was commissioned by MarCom and published in November 2008. Its working group scoured the world seeking experience of generic technologies for minimising/avoiding mud deposition in harbours and approaches. By 'generic' we mean solutions to problems at particular sites which, when tailored to local idiosyncracies, can be applied at self-similar sites wherever they occur. Consequently, these methods are especially valuable. The study spanned types of harbour configuration, mechanisms of transport and deposition, field measurement, mathematical and physical modelling, but focussed centrally on these 'anti-siltation' methods.

It grouped problems by port configuration: - impounded dock, ship lock entrance, semi-enclosed basin, channel, etc. and by solutions via three alternatives: KSO 'Keep Sediment Out', KSM 'Keep Sediment Moving', KSN 'Keep Sediment Navigable'.

Rigorous scrutiny led to five principal separate, proven technologies being recommended:

1.	Auto-flushing	(impounded docks and semi-enclosed basins)	KSM
2.	Entrance Flow Optimisation Systems (EFOS)	(semi-enclosed basins)	KSO
3.	Passive Nautical Depth	(fairways, entrances, semi-enclosed basins)	KSN
4.	Active Nautical Depth	(...... ditto ...)	KSN
5.	In-situ Conditioning	(... ...ditto....)	KSN

For each, the high economic and environmental benefit has been documented. Most of these have been pioneered in the world's biggest ports but an emerging trend since publication is a rapid increase in uptake rate at new and smaller ports focussed in the immediate timescale on Germany, Belgium, France, China, Brazil, with an emerging interest in the USA.

RÉSUMÉ

Le rapport AIPCN 102 "Diminution de l'envasement des ports" a été dirigé par MarCom et a été publié en Novembre 2008. Son groupe de travail a observé les expériences mondiales en matière de technologies génériques permettant de minimiser le déposition des boues dans les ports et sur leurs abords. Par "générique", nous voulons dire solutions aux problèmes sur des sites particuliers qui, après certaines adaptations locales, peuvent être appliquées sur des sites similaires soumis à des problèmes identiques. Par conséquent, ces méthodes sont particulièrement intéressantes. L'étude traite différents types de configuration portuaire, les mécanismes de transport et de dépôt, les mesures, la modélisation mathématique et physique, mais en se focalisant sur les méthodes « anti-envasement ».

Le rapport classe les problèmes en fonction de la configuration du port : bassin fermé, écluse, bassin semi-fermé, canal, etc... et en fonction des solutions à travers trois alternatives : KSO pour "Keep Sediment Out", KSM pour "Keep Sediment Moving" et KSN pour "Keep Sediment Navigable".

Un travail rigoureux a permis de dégager cinq roupes où des technologies éprouvées sont recommandées :

1.	"Auto-chasse"	(bassins fermés ou semi-fermés)	KSM
2.	"systèmes d'optimisation des courants de marée" (EFOS)	(bassins semi-fermés)	KSO
3.	"profondeur nautique passive"	(voie de navigation, entrées, bassins semi-fermés)	KSN
4.	"profondeur nautique active"	(...... idem ......)	KSN
5.	"traitement in situ"	(...... idem ......)	KSN

Pour chacun de ces groupes, les bénéfices économiques et environnementaux ont été documentés. La plupart de ces méthodes a été mise en place dans les plus grands ports mondiaux mais la nouvelle tendance est de les appliquer à moyen terme dans les nouveaux et plus petits ports en Allemagne, en Belgique, en France, en Chine, au Brésil, avec un intérêt naissant aux Etats-Unis.

ZUSAMMENFASSUNG

Der PIANC Report 102 "Minimising Harbour Siltation" (Verminderung der Hafenverschlammung) wurde von MarCom in Auftrag gegeben und im November 2008 veröffentlicht. Die Arbeitsgruppe durchsuchte die Welt nach Erfahrungen mit allgemeingültigen Technologien zur Verminderung/ Vermeidung von Schlammablagerungen in Häfen und Hafenzufahrten. Mit „allgemeingültig" meinen wir Problemlösungen für bestimmte Orte, die, auf andere örtliche Gegebenheiten angepasst, wieder angewendet werden können. Folglich sind diese Methoden besonders wertvoll. Die Studie umfasste Typen von Hafen-Konfigurationen, Transport- und Lagerungsmechanismen, Naturuntersuchungen, mathematische und physikalische Modellierung, konzentrierte sich jedoch auf diese „Anti-Verschlammungs"-Methoden.

Sie fasste Probleme nach Hafenkonfigurationen – aufgestautes Dock, Schiffsschleusen-einfahrt, halb eingeschlossene Becken, Kanal, usw. – und nach Lösungen gemäß den drei Alternativen KSO "Keep Sediment Out" (Lass das Sediment draußen), KSM "Keep Sediment Moving" (Halted das Sediment in Bewegung), KSN "Keep Sediment Navigable" (Halte das Sediment schiffbar) zusammen.

Eine strenge Untersuchung führte zu fünf einzelnen, bewährten Technologien, die empfohlen werden:

1.	Auto-flushing	(aufgestautes Dock und halb eingeschlossene Becken)	KSM
2.	Entrance Flow Optimisation Systems (EFOS)	(halb eingeschlossene Becken)	KSO
3.	Passive Nautical Depth	(Fahrrinnen, Zufahrten, halb eingeschlossene Becken)	KSN
4.	Active Nautical Depth	(..... ditto .....)	KSN
5.	In-situ Conditioning	(..... ditto .....)	KSN

Für jede einzelne wurde der wirtschaftliche und umweltgerechte Vorteil dokumentiert. Viele von ihnen wurden in den größten Häfen der Welt in Pionierarbeiten getestet, aber ein auftretender Trend seit der Veröffentlichung ist ein rapider Anstieg in der Anwendung bei neuen und kleineren Häfen mit dem Fokus auf einer sofortigen Umsetzung in Deutschland, Belgien, Frankreich, China, Brasilien und einem steigenden Interesse in den USA.

THE NETHERLANDS

Pilot inland cargo RORO service: Hoorn-Tiel-Rotterdam 2009

Since the introduction in the 1950's, Roll-on/roll-off (RORO) technology has enabled a large efficiency gain in the transportation of wheeled cargo like cars, lorries and trailers. The technology has been most successful in ocean-going vessels. Congestion in the economic heart of The Netherlands is putting pressure on the transport sector to look for alternatives to road haulage. A RORO service can offer a reliable scheduled delivery against the same price as road transportation for non time critical cargo (trailers).

The Dutch Ministry of Transport and Public Works decided to execute a test with an inland RORO vessel, sailing from Rotterdam to Tiel, Zaandam and Hoorn, in the spring of 2009. The RORO vessel is equipped with a flexible loading bridge, allowing loading and unloading trailers. A series of tests have been conducted on April 19-22, 2009. The vessel transported twenty-eight trailers on five different routes. Eleven companies participated in the test. This type of inland navigation has never been executed in The Netherlands before. The vessel is carrying trailers unaccompanied, therefore the lorry can be used for other jobs while the trailer is transported over water.

The objectives of the test are the assessment of the technical operations and possibilities to integrate the service in existing supply chains. Besides trailers the vessel could also transport rolling equipment like cranes are tractors and is therefore very versatile. The vessel can accommodate thirty-one trailers on two decks and can also navigate in coupled operation (with an extra barge), which increases the capacity (seventy-two trailers). The loading bridge can cover differences in height between the water level and quay wall of approximately 1 to 3 m. This allows the vessel to berth easily at almost any quay wall, without extra investment in the quay structures or harbour basins.

The tests show positive results in relationship to sustainability. The tests have reduced the road haulage movements with a length of 3.805 km (or in terms of congestion parameters: 1 vessel is 1 km less congestion). If the test is run as scheduled services, the reductions could reach:

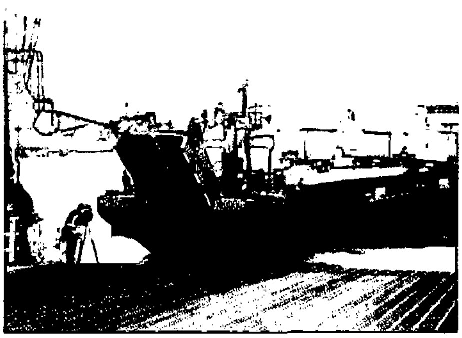
- Approximately 1,3 million road haulage transport km per annum (260 km less congestion) with one RORO vessel
- Approximately 2,75 million road haulage km per annum (550 km less congestion) with the RORO vessel in combination with a RORO push barge.

The test resulted in a reduction of 5,200 kg CO_2 and 38 kg NO_x,. The test did not reduce the exhaustion of fine dust, but produced similar results as road haulage. The break-even point (RORO versus road haulage) is twelve trailers per route in the exhaustion of CO_2 and NO_x,. Significant reductions of noise can be reached If the vessel carries more than eight trailers.

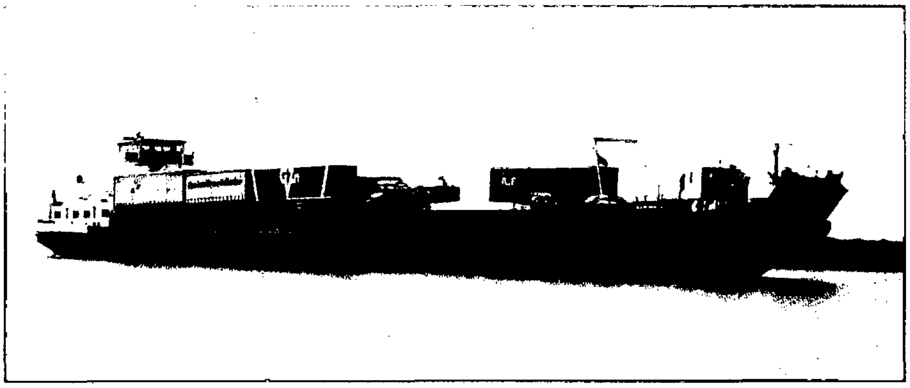
In the current market circumstances (financial crisis) the RORO concept is not expected to be financially feasible because of the competition with road haulage. The market prices in road haulage have decreased dramatically. The public authorities could consider compensating potential exploitation losses. An interesting opportunity to use the RORO concept lies in the upcoming reconstruction of the motorway A15 between Rotterdam and Germany. This can be combined with the supply of construction materials to the port expansion project Maasvlakte II. The RORO concept could serve as a kind of public transport and safeguard transport companies from severe delays during the reconstruction of motorway A15.

Arne Baruch
Senior Advisor, Ministry of Transport and Public Works in the Netherlands

Hans Vermij
Strategic Advisor, DHV, the Netherlands



Ms Vera docking in Rotterdam



RORO vessel ms Vera with trailers

EUROPE

Barges way ahead of Copenhagen

European inland navigation can already meet the 30% reduction target – and companies and governments who support inland navigation will get a short cut in reducing their own carbon emissions.

Notwithstanding the Copenhagen summit results, we all agree that achieving significant carbon reduction aims is vital. Only we can make this world a better living place for the present and future generations. And European inland navigation is ready to make a substantial commitment to helping the world to work together to achieve those aims. Inland navigation is already the most environmentally friendly form of transport (3,5 times less CO_2 per ton-km, in comparison to road), but that's not enough. It has reduced its fuel consumption since 1990 by 15 %. Today, the sector is actively working to make even more of a contribution to cutting down on global warming and the European Barge Union (EBU), European Skippers Organisation (ESO) and Inland Navigation Europe (INE) are confident that the challenge will be met.

The technology and techniques exist to allow inland navigation to say that we can achieve a 30% reduction in carbon emissions today. A fuel performance contest project in the Netherlands has already achieved these savings thanks to fuel-saving on-board equipment and this can be applied across the entire European fleet. This, in combination with RIS (River Information Services – an intelligent transport system that connects ship to shore) means ship operators can use optimal cruising speeds and optimal vessel operation, responding to the conditions on the river, to achieve even further reduction in carbon emissions as long as navigable waterways are well maintained.

This makes transport by water the obvious choice for companies wanting to make their own contribution towards reducing carbon emissions and global warming. Including waterways and transport by barge in the supply chain is an intelligent business choice – not only does this reduce carbon emissions, it also avoids road congestion. And encouraging modal shift to increase use of water transport is an intelligent political choice for governments wanting to keep the promises they have made over the last fortnight.

With the rest of the world looking for reductions by 2030, inland navigation will look towards carbon neutrality by 2030. We do not have to wait – and we will not wait. As the oldest form of transport, we are committed to use the newest forms of technologies. With the support of government and business, projects already in existence, such as electric ships, clean fuel cells and using liquefied biogas can be accelerated and we can and should not just reduce the harm we do to the environment but eliminate it.

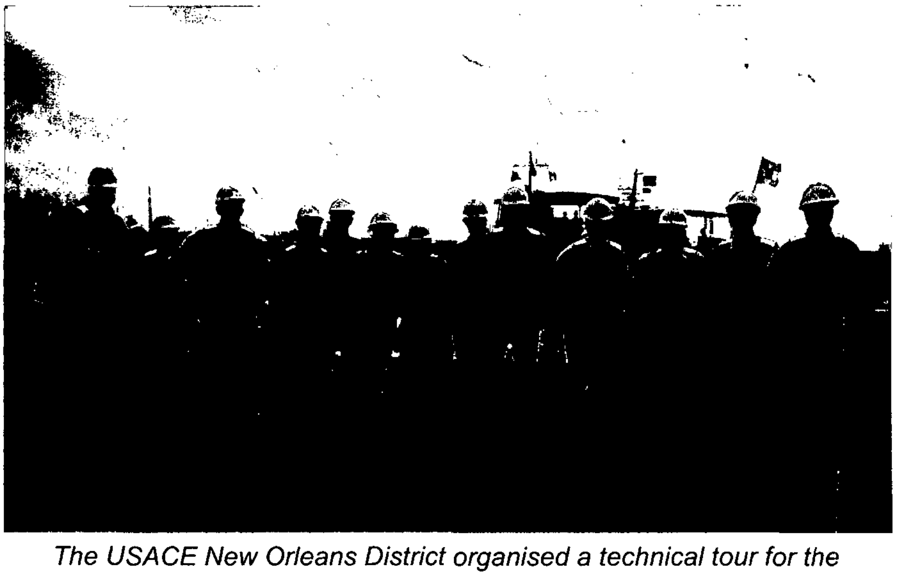
Caroline Smith
Inland Navigation Europe (INE)

UNITED STATES

PIANC 'Navigates the Environment' - Highlights from Recent Environmental Meetings in New Orleans

On October 28, 2009, in New Orleans, Louisiana, the US Section of PIANC held a one-day technical seminar on 'Navigating the Environment – Managing Risks and Sustaining Benefits'. The seminar was organised by PIANC's international Environmental Commission (EnviCom) and PIANC USA. Over seventy people participated in the technical seminar which focused on topics such as Climate Change, Ecosystems and Dredging, Comprehensive and Sustainable Sediment Management, and Coastal Flood Risk Management. There were presentations from more than twenty experts from the United States, Germany, United Kingdom, and The Netherlands, who represented government agencies, ports, universities and other non-profit organisations.

An informal 'Young Professionals' Happy Hour was held in the hotel lobby bar immediately following the



The USACE New Orleans District organised a technical tour for the EnviCom members where they sailed along the Gulf Intracoastal Waterway to see the ongoing construction of the navigable hurricane storm surge barrier in the vicinity of the Bayou Bienvenue Wetlands Complex.

seminar, which gave the YPs an opportunity to meet and mingle. The evening networking reception was held at the Plimsoll Club, with its exclusive location atop the World Trade Center and a spectacular panoramic view of the Crescent City and Mississippi River.

EnviCom and the PIANC USA Commissioners held committee meetings in New Orleans in conjunction with the seminar. In addition, the USACE New Orleans District organised a boat tour for the EnviCom members, where they sailed along the Gulf Intracoastal Waterway to see the ongoing construction of the navigable hurricane storm surge barrier in the vicinity of the Bayou Bienvenue Wetlands Complex. The presentations from the seminar have been posted on the PIANC USA website (www.pianc.us), along with the seminar attendance list and photos.

- Technical presentations link: http://www.pianc.iwr.usace.army.mil/con2009nav.cfm

- Photo gallery link: http://www.pianc.iwr.usace.army.mil/negallery2009NTE.cfm

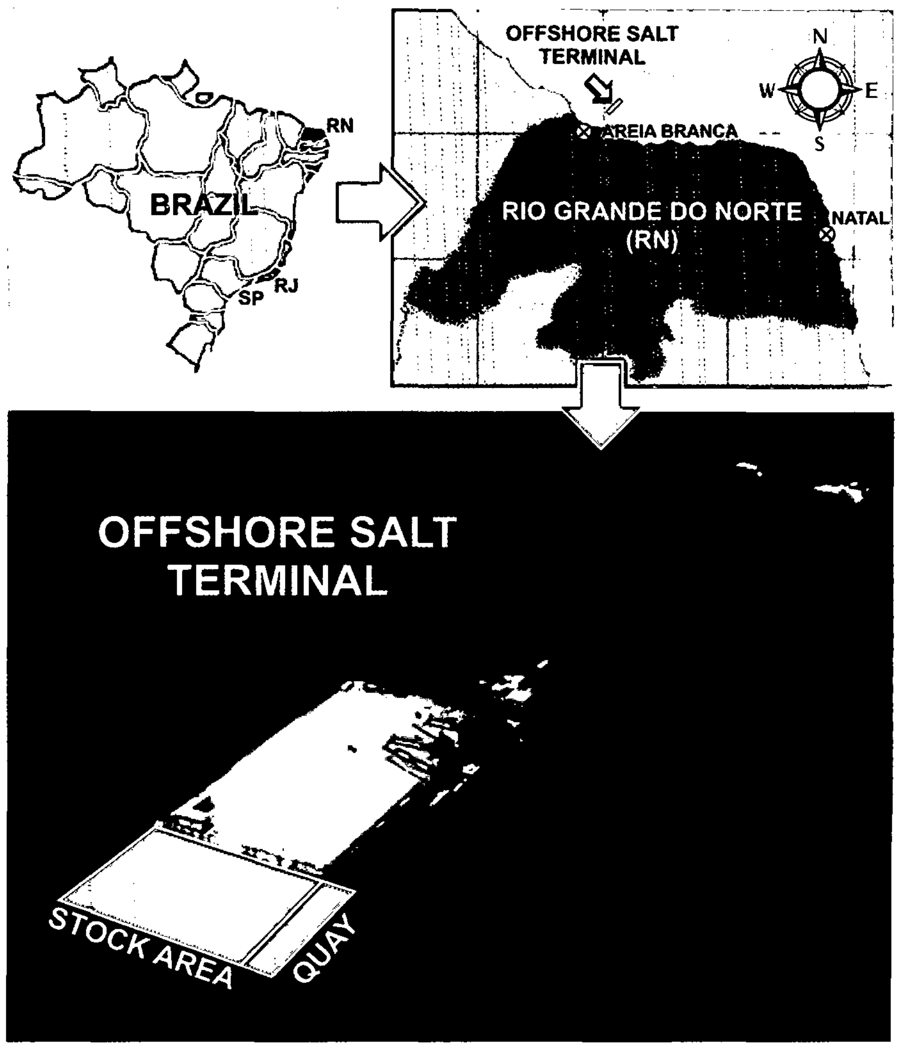
Kelly Barnes
PIANC USA

BRAZIL

Offshore Salt Terminal – Areia Branca

Codern – Cia Docas do Estado do Rio Grande do Norte, a governmental company responsible by the Areia Branca Offshore Salt Terminal operation since 1972, has decided to expand the island to increase its storage capacity. The joint venture CCQ (Constremac/Carioca/Queiroz Galvão) started in November 2009 the construction of the island expansion. The terminal is located at 14 km offshore Areia Branca, Rio Grande do Norte, Brazil, and the project comprises an extension of approximately 100 m using steel sheet piles cells. The project of the barge's wharf was conceived using a deck on pile steel structure and steel jackets. Detailed design and construction methods are being developed by EXE Engenharia, Curitiba, Brazil.

Leandro Sabino
EXE Engenharia

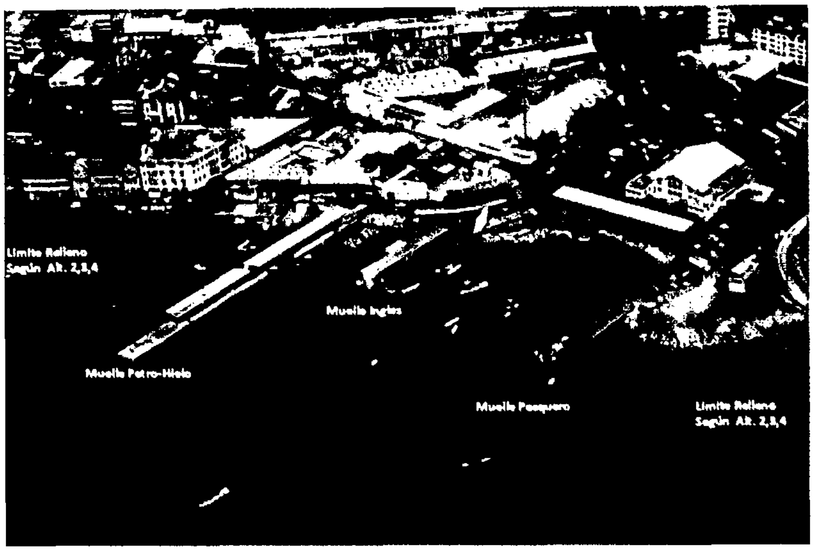


Areia Branca Offshore Salt Terminal – Existing structures and expansion layout - Aerial View

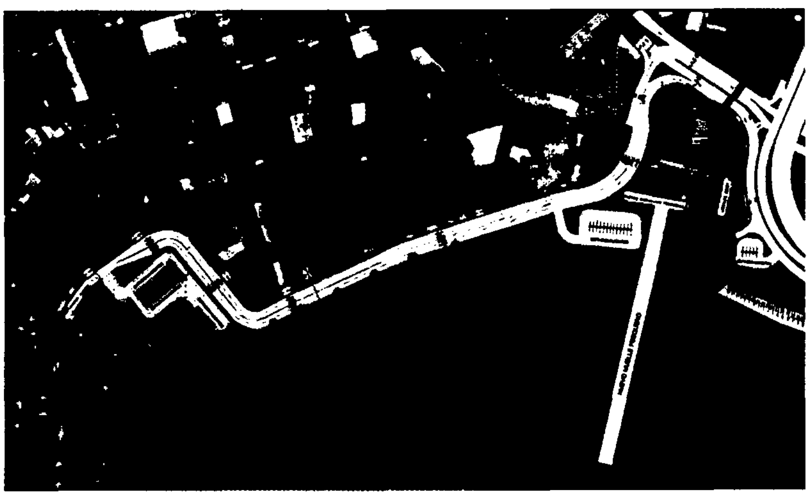
PANAMA

Multipurpose Pier, Cinta Costera, Panama City

The government of Panama is widening, in about 24 m, the Avenida Pablo Arosemena, next to the Seafood Market in Panama City. The existing small piers which are used by fishermen, passengers and coastal shipping will be demolished and replaced by a new multipurpose pier approximately 135 m in length. The project is being implemented by the Brazilian



Cinta Costera currently



Widening of the Cinta Costera and multipurpose pier

Contractor Norberto Odebrecht SA and detailed design is being developed by EXE Engenharia, Curitiba, Brazil.

Leandro Sabino/
EdersonLucas Garrett
EXE Engenharia

IAPH

As of December 1, 2009 Mr. Susumu Naruse has taken office as IAPH Secretary-General, succeeding Dr. Satoshi Inoue, as so appointed at the IAPH Board of Directors meeting in Genoa, Italy, May 2010. Mr. Naruse is not new to IAPH. Since 1999, he has played an active part in the Association, serving on the Executive Committee (2001-2006) and on the IAPH Port Planning & Development Committee (PPDC) firstly as a member, Vice-Chairman and then Chairman. As Chairman of the PPDC, he took the leading role in preparing very stimulating reports entitled 'Forecasts of the World Container Throughput', 'Cruise Terminal Planning' in 2007 and 'Introduction to Port Preparedness for Tsunami' in 2009. As entrusted by the Board, Mr. Naruse is determined to do what he can do for further development of this global association in the years ahead.

Bahia Mar Yachting Center, a truly unique facility and winner of the 2010 PIANC Marina Excellence Design Jack Nichol Award

The Recreational Navigation Commission is excited to announce that the Bahia Mar Yachting Center has won the 2010 PIANC Marina Excellence Design Jack Nichol Award. The selection committee determined the Bahia Mar Yachting Center best represents the functional, aesthetic, and environmental evaluation criteria.

Located in Fort Lauderdale, Florida, Bahia Mar Yachting Center is a start-of-the-art, dual function facility serving as both a public yacht center that offers world class facilities to some of the world's most luxurious yachts and a boat show venue - home of the Fort Lauderdale International Boat Show.

The marina's principle features include large full-service slips with corresponding clear water widths to accommodate today's longer and wider boats, Bellingham Marine's Unifloat® concrete floating dock system with extra wide walkways and high dock freeboard, a functional slip layout that meets the needs of the marina as well as the boat show, and a site electrical transformer and distribution system that provides ample power to account for the high utility demands imposed by the boats on a daily basis as well as the massive utility demands of the boat show.

Bahia Mar Yachting Center is a state-of-the-art, dual function facility serving as both a public yacht center and a boat show venue

The elegance of Bahia Mar reflects the beauty of the boats moored along her docks

The marina's full-service slips offer the latest in modern amenities including multiple telephone lines, high speed digital lines for computer equipment, high speed internet access, direct access to sewage pumpouts, and an option of single- or three-phase electrical service for slips over 80 feet. Floating walkways and finger piers are extra wide and stable designed to cater to large vessels and to handle golf carts, small forklifts, large crowds, and the extra boats that come for the annual Fort Lauderdale International Boat Show. Bahia Mar also includes a number of innovative design features that enables the facility to make an easy transition from marina to boat show venue. Utility and structural connection points for temporary docks, storage cabinets, and extra utility outlets are just a few of the items incorporated into the design of the marina to accommodate the boat show.

In addition to its highly functional design centered on comfort and convenience, the marina is a certified Clean Marina by the state of Florida. Also, a number of design features and operational programs have been incorporated to promote water quality and reduce the marina's impact on the surrounding environment.

Operating as a dual purpose facility, ease, convenience, and accessibility are at the very core of Bahia Mar's design. The elegance of Bahia Mar reflects the beauty of the boats moored along her docks. A truly unique facility, Bahia Mar seamlessly combines innovation, functionality, and beauty to create a marina that promotes public access and the boating lifestyle.

Bob Nathan, Lars Odhe,
Jessica McIntyre
& Fabiana Maccarini
PIANC RecCom Editing Committee

ON THE CALENDAR

Smart Rivers 2011 Conference – Save the date!!!

Mark your calendar for the next instalment of the outstanding Smart Rivers Conference series, a biennial forum bringing together an international group of professionals involved in inland / river transport from around the world.

This three-day technical specialty conference is organised by PIANC USA, along with more than twenty partnering organisations. The concept of 'Smart Rivers' sprang from a group started in 2004 called 'SmartRivers21', an international coalition intent on realising 'Strategic Maritime Asset Research and Transformation for 21st Century River Systems'. It began with a co-operation agreement between American and European partners, and was followed by the organisation of Smart Rivers 2005 Conference in Pittsburgh, Pennsylvania. The Smart Rivers 2006 Conference was held in Brussels, Belgium, and the 2007 conference was held in Louisville, Kentucky. The organisers decided to move to a biennial schedule and Smart Rivers 2009 was held last September in Vienna, Austria.

Themes for the 2011 conference in New Orleans will include topics such as 'Smart' Service Design and Innovation, System/Technology, Public Policy/Finance, Environmental Management, Flood Protection/Mitigation, Port & Landside Economic Development, etc., with a particular emphasis on making this a global conference. A Call for Abstracts will be issued this summer (2010). Two full days of technical sessions are planned for September 14 & 15, 2011, along with industry exhibits, networking functions, workshops and technical tours.

2011 Conference Hotel:
Westin New Orleans Canal Place
100 Rue Iberville, New Orleans, LA 70130 USA
For Inquiries: 1-(504) 566-7006
http://www.starwoodhotels.com/westin/property/overview/index.html?propertyID=1763

Presentations from Smart Rivers 2009 are posted at www.smartrivers.org.

Kelly Barnes
PIANC USA

7th Annual Conference ESPO

On May 27-28, 2010, ESPO is organising its 7th Annual Conference in Helsinki, Finland, in partnership with the Port of Helsinki and the Finnish Port Association. The central theme of the Conference will be 'Living and Working with Ports', a theme which puts the human face of our global industry centre-stage.

Some highlights of the programme:

- Dr. Jean-Paul Rodrigue of Hofstra University New York will discuss with industry leaders the implications of the crisis in terms of market structures and organisation in the port and shipping sector
- The ports of Gijón (winner of the first ESPO Award) and Helsinki will present creative ways in which ports can function in harmony with surrounding communities.
- A series of parallel workshops will compare practical solutions to promote the port as a place to work, live and experience.
- ESPO will introduce its new ESPO Code of Practice on Societal Integration of Ports.
- Prof. Theo Notteboom of the Institute of Transport and Maritime Management Antwerp will present a state-of-the-art report on port labour and port-related employment in Europe and discuss his findings with policy-makers, port authorities, service providers and trade unions.
- Lloyd's List Brussels' correspondent Justin Stares will moderate a thought-provoking political debate with Members of the European Parliament on the future direction of European port and transport policies.

Preceding the actual conference, a special interest seminar is scheduled on the development of Russian and Baltic Ports, which is organised in co-operation with the Russian State Port Agency 'Rosmorport' and the Baltic Ports Organisation. To round off these two intensive days of debate, we are offering a technical visit to Vuosaari Harbour, the brand-new outer harbour of Helsinki, as well as a relaxing post-conference tour on Saturday to the beautiful neighbouring port-city of Tallinn.

You will find the full programme enclosed. Registration can be done online via the conference website (www.espo-conference.com) where all practical information can be found as well.

Patrick Verhoeven
Secretary-General of ESPO

NEWS FROM THE NAVIGATION COMMUNITY

The 5th International Conference and Exhibition Danube Summit 2010

The 5th International Conference and Exhibition Danube Summit 2010 will take place on May 31-June 2, 2010 in Linz and Enns. The event will be organised by EWP Communication and via donau. Host of the event this time is Christian Steindl, Managing Director of the Port of Ennshafen.

Under the motto 'Green Danube: putting companies back into the black', all members of the Danube Community are invited to attend the 5th Danube Summit. In the classical tradition, this event will bring together key actors and high-ranking officials of the Danube riparian countries who will together seek solutions for the future development of a sustainable and ecologically sound transport on the Danube River. The event will also include exhibitions, technical visits as well as networking and social events. All the ingredients are gathered to make it a must-attend Danube experience.

The Danube Summit is not restricted to members of the Danube Community. Any person with a professional interest in inland waterway transport, transport and logistics or telematics is most welcome to attend as a delegate.

A preliminary programme will be available shortly on the Danube Summit website at www.danubesummit.com.

For more information about the exhibition, please contact Borka Mikulic (borka.m@danubesummit.com – +44 (0) 1275 540 582). To register as a delegate, please contact Julian King (Julian.king@ewpcommunications.com – +44 (0) 1737 226153).

13th International Riversymposium

For the first time in its history, Riversymposium will be held in Perth, Western Australia and at a later time in the year, on October 11-14, 2010. The 13th International Riversymposium will bring together a diverse audience for interactive and vibrant discussion.

Managing our rivers has revolved around altering the movement of water – obviously through dams, extraction for irrigation, mining, water supplies, industry and water transfers and more cryptically when we consider groundwater use, virtual water, water sensitive urban design, water recycling and adjustments to environmental flows. The critical issues that will be discussed at the 13th International include:

- Water for industry
- Rivers and Catchments
- Community
- Policy and Regulation
- Water Sources
- Climate Change

For more information, please visit the website www.riversymposium.com.

3rd International Conference on the Management of Coastal Recreational Resources

The 3rd International Conference on the Management of Coastal Recreational Resources will be held in the historic city of Grosseto, situated in the magnificent region of Tuscany in Central Italy, on October 27-30, 2010. This conference is the third in the biennial series on Management of Coastal Recreational Resources (MCRR) organised by the Euro-Mediterranean Centre on Insular Coastal Dynamics (ICoD) within the International Environment Institute at the University of Malta. This international event is characterised by its focus on selected coastal management issues relating to beaches, yacht marinas, ecotourism and conservation, and the impact of coastal hazards on such resources.

The conference is aimed at academics in the natural and social sciences, researchers dealing with coastal hazards reflected by ongoing climate change, project managers, tourism professionals, infrastructure investors and staff from the private sector and government agencies whose work involves integrated coastal area management practices and the development and management of coast-related recreational amenities. The conference will also be of interest to managers of natural resources and environmental agencies, urban and coastal planners, non-governmental organisations (NGOs), environmental economists and coastal municipalities.

Conference topics include:

- Beach Management
- Yacht Marinas and Yachting-Related Activities
- Coastal Ecotourism
- Coastal Hazards

For further information about the 3rd International Conference on the Management of Coastal Recreational Resources (MCRR3), kindly contact the Conference Secretariat at mcrr3-2010@um.edu.mt or visit our website at http://www.um.edu.mt/iei/mcrr3-2010.

Organiser of the Ice Day Conference is the Centre for Maritime Studies of the University of Turku in Finland.

For further information on this conference, please contact Mrs. Marja Luomanen or Mrs. Kirsi Laitio (tel. +358 (0)40 779 9485 and tel. +358 (0)40 779 9483 or e-mails: marja.luomanen@utu.fi / kirsi.laitio@utu.fi) or visit http://mkk.utu.fi/dok/k2010/Iceday.pdf.

Offshore Arabia 2010 conference

The Offshore Arabia 2010 conference and exhibition will be held at the Dubai International Convention Centre, Dubai, UAE on March 29-31, 2010.

The event is held under the patronage of H.H Sheikh **Mohammed Bin Rashid Al Maktoum**, Vice-President and Prime Minister of UAE and Ruler of Dubai. Offshore Arabia 2009 comes at a time when global co-operation is most needed to facilitate the global dialogue in managing energy for sustainable growth and climate change. The event has evolved over the years and provides an excellent overview of a cross section of the key issues in the energy industry and the environment. Corporate Social Responsibility (CSR) will be integrated and highlighted as part of the oil industry's role in society. We intend to bring forth key issues and concerns and our aim is to have highly knowledgeable and skilled professionals provide a wider range of solutions by sharing their thoughts.

Energy and environment are essential to sustainable development, therefore we remain focused and committed to energy, environment, advanced technologies, renewables and sustainable development. We will continue to encourage growth as a basis for all human betterment. Incorporating within our mission, the UN Millennium Development goal, which calls for the implementation of sustainable development and its three pillars – economic development, social development and environmental protection.

More information about this event can be found at http://www.offshorearabia.ae.

Student and Young Professional Events at ASCE Ports 2010 Conference

The ASCE Ports 2010 Conference will take place in Jacksonville, Florida on April 25 - 28, 2010. During this conference, several Student and Young Professional Events will be organised:

- Young Professionals' Happy Hour: 5:00 p.m. – 6:00 p.m., April 25 (Sunday)
- Student Paper Competition Awards: 1:30 p.m. – 4:30 p.m., April 25 (Sunday)
- Student Poster Session: 10:00 a.m. -12:00 p.m., April 27 (Tuesday)
- Job Fair: 1:00 p.m. – 4 p.m., April 27 (Tuesday)

More information about this event can be found at http://content.asce.org/conferences/ports2010.

Kelly Barnes
PIANC USA

Port Infrastructure Seminar Delft University of Technology

Delft University of Technology is pleased to invite you to the Port Infrastructure Seminar on 22 and 23 June 2010.

This seminar is organised by the Faculty of Civil Engineering and Geosciences in association with the Port of Rotterdam Authority, Port of Amsterdam Authority and Dutch Ministry of Public Works, Transport and Water Management. It aims to stimulate innovation in port infrastructure design, operations and maintenance through the presentation and exchange of results of applied research and technologies.

In conjunction with the Seminar there will be a display of recent R&D and technological results, systems and services for the port industry. Prior to the Seminar, on June 21, there is the opportunity to visit Futureland, the visitor centre for the new port development Maasvlakte 2, and the ongoing works (www.futureland.nl).

In the beginning of 2010 a Second Announcement will present more information on the Program. Up-to-date information on the Seminar can be found on the website www.portseminar2010.tudelft.nl.

If you want to participate in this Seminar and present a paper, please send your abstract of maximum 300 words to portseminar2010@tudelft.nl before February 1, 2010. Authors will be notified by the seminar secretariat by March 1, 2010 on the acceptance of the papers and the further details of the paper submission.

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