MAASVLAKTE 2:  
an innovative engineering contract

ARTIFICIAL UNDERSEA RIDGES  
for restoring depleted fisheries

INTRODUCING “NINA”:  
a personal commitment to safety

DREDGING THE RIVER NIGER  
to improve inland water transport
Terra et Aqua is quarterly publication of the International Association of Dredging Companies, emphasising “maritime solutions for a changing world.” It covers the fields of civil, hydraulic and mechanical engineering including the technical, economic and environmental aspects of dredging. Developments in the state of the art of the industry and other topics from the industry with actual news value will be highlighted.

- As Terra et Aqua is an English language journal, articles must be submitted in English.
- Contributions will be considered primarily from authors who represent the various disciplines of the dredging industry or professions, which are associated with dredging.
- Students and young professionals are encouraged to submit articles based on their research.
- Articles should be approximately 10-12 A4. Photographs, graphics and illustrations are encouraged. Original photographs submitted, as these provide the best quality.
- Digital photographs should be of the highest resolution.
- Articles should be original and should not have appeared in other magazines or publications.

- In the case of articles that have previously appeared in conference proceedings, permission to reprint in Terra et Aqua will be requested.
- Authors are requested to provide in the Introduction an insight into the drivers (the Why) behind the dredging project.
- By submitting an article, authors grant IADC permission to publish said article in both the printed and digital version of Terra et Aqua without limitations and remunerations.
- All articles will be reviewed by the Editorial Advisory Committee (EAC). Publication of an article is subject to approval by the EAC and no article will be published without approval of the EAC.

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Terra et Aqua is published quarterly by the IADC, The International Association of Dredging Companies. The journal is available on request to individuals or organisations with a professional interest in dredging and maritime infrastructure projects including the development of ports and waterways, coastal protection, land reclamation, offshore works, environmental remediation and habitat restoration. The name Terra et Aqua is a registered trademark.

For a free subscription register at www.terra-et-aqua.com
This complex mega infrastructure project demanded an imaginative approach from the start, resulting in a transparent Design Construct and Maintenance (DCM) contract.

Winner of the IADC Young Authors Award explains how human–made undersea ridges were used to attract marine life and boost the productivity of Japanese coastal fisheries.

The IADC Annual Safety Award: A change in values meant a change in attitude on the work floor, where each person is willing to speak up to warn colleagues for unsafe situations.

The Nigerian National Inland Waterways Authority wants to increase inland water transportation of goods and improve the living standards for the populations living along the river.

Two books on beach management and a new PIANC report on coral reefs are reviewed.

Announcing 2011 conferences and Calls for Papers for WEDA, CEDA, Smart Rivers and PIANC COPEDEC.
Asia seems to be a magnet for summits this autumn. The Group of 20 has just convened there to evaluate the international economic situation, but the global dredging industry was there earlier. In September the 19th World Dredging Congress WODCON XIX was held for the first time in Beijing, China. Once in three years one of the three sister associations (CEDA, EADA and WEDA) that comprise the World Dredging Association is chosen to organise this international conference. This year the honour fell to the Eastern Dredging Association supported by the Chinese Dredging Association (CHIDA) and China’s leading dredging company China Communications Construction Company Ltd. In attendance were some 500 participants, representing all aspects of the industry, including delegates of both local and international dredging contractors, their supporting maritime construction industries, scientists and academics, government officials and port authorities. Some were speakers, some were exhibitors, all were networking, learning and exchanging ideas and knowledge.

Focusing on the theme, “Dredging makes the world a better place,” more than 130 paper presentation covered subjects ranging from explanations of highly technical, advanced technologies to environmental challenges confronted and conquered, innovative Research & Development, modern management skills and novel contract forms, predictions and overviews of the future of dredging, and the urgency of safety issues (see also the IADC Safety Award, page 23). Reflecting the conference’s global nature, the papers discussed projects and research from China, Japan, Korea and Singapore to Belgium, the Netherlands, Germany, the U.K. and the U.S. No stone – or grain of sand – was left unturned. From this wealth of information the International Association of Dredging Companies was able, with great difficulty, to narrow its selection for the IADC Young Authors Award for the Best Paper which was granted to a young Japanese engineer (see page 12). Dredging is, however, a hands-on business and so the conference did not stop at discussions and exhibitions. Seeing is believing and site visits to the newly developed port of Tianjin, China’s largest artificial port, to the Cao Fei-dian Reclamation Area still under construction, and to the Port of Qinhuangdao, China’s largest coal harbour, added immensely to the edification of the conference-goers.

This issue of Terra et Aqua reflects the expertise and innovative spirit that drives dredging and indeed contributes to “making the world a better place” – economically, environmentally and socially. With articles ranging from the Maasvlakte 2 port expansion project in the Netherlands, to the creation of artificial reefs for fish farming in Japan, to the river training works along the meandering Niger River, Nigeria, Terra reports how dredging stimulates the economy by increasing the potential of water-borne trade, providing coastal protection to vulnerable areas and stabilising food resources. To paraphrase one author: Being involved in maritime infrastructure projects gives a great sense of fulfillment as we make long-term, structural contributions to the welfare of populations all over the world.

Koos van Oord
President, IADC
MAASVLAKTE 2: AN INNOVATIVE CONTRACTUAL AND SYSTEMS ENGINEERING APPROACH

ABSTRACT

The Port of Rotterdam Authority (PRA) awarded the Maasvlakte 2, Contract 1, to PUMA, a joint venture comprising dredging and marine contractors Boskalis and Van Oord. The PRA applied a “fit for purpose” format for this mega infrastructure Design Construct and Maintenance Contract (DCM), including an innovative Systems Engineering approach. The tender process and the Systems Engineering principles are described here. Also the benefits of the applied contractual approach are highlighted.

The authors acknowledge that the Port of Rotterdam Authority actually developed the described Tender procedures. Likewise they prescribed the application of the system-oriented approach to be complied with by all Tenderers. This article was first published in the Proceedings of PIANC MMX, 125th Anniversary PIANC, International Navigation Congress, Liverpool, May 2010 and is reprinted here in a slightly revised form with permission.

INTRODUCTION

On September 5, 2005 the Port of Rotterdam Authority (PRA) started a prequalification procedure to select suitable contractors for the Maasvlakte 2 project phase 1. The Maasvlakte 2 Contract 1 comprises 700 ha port areas, hard and soft defences of 11 km in total length, 530 ha of harbor basin, quay walls and infrastructure.

Three contractors were selected and the tender phase started in January 2006. The PRA decided to apply the Design Construct and Maintenance principle to this huge contract for obvious reasons:

• to incorporate construction expertise in the design process
• to avoid disputes between designer and contractor
• to make cost savings by having a design made by the contractor with the convenience of construction in mind

In February 2008 the contract was awarded to PUMA (Projectorganisatie Uitbreiding MAasvlakte) which consists of dredging and marine contractors Boskalis and Van Oord. The first container terminal is scheduled to be operational in 2013.

Innovative contract based on the use of Systems Engineering

The tender period for Maasvlakte 2 and in particular the award procedure is described in further detail in the following section. Important parts of the tender procedure were the design brief and instructions to tenderers. The design brief prescribed that the design should be based on a system-oriented approach, in other words Systems Engineering.

For several years now, both clients and contractors of large infrastructure projects in the Netherlands have been experimenting with innovative contracts based on the use of Systems Engineering. A shift in roles and tasks is taking place in the construction industry in the Netherlands. Clients are increasingly asking contractors to take on the responsibility for preparing designs at a much earlier stage.

The reason for introducing this method based on Systems Engineering is the political and social demand to reduce the involvement of the Dutch government and the need to involve the market sector to a greater extent and at an earlier stage in the design, construction and management of infrastructure. Another reason is the call for transparency and better process control.
Systems Engineering provides a method that identifies the roles and tasks of all parties involved with the lifecycle of public works and water management systems, from the planning stage to construction continuing to maintenance and even restoration, an approach that provides clear insight at any time into the decisions made during the process – even after the project’s completion.

In line with Systems Engineering the design brief only comprised the functional requirements and the geometrical outline (layout) of the future Maasvlakte 2 port facility – the so-called programme of requirements.

This article discusses the innovative contractual approach, which includes the use of Systems Engineering. The resulting innovation in design and equipment is also described. The insight for both contractor and owner as generated by the implementation of Systems Engineering makes it easier to optimise the design when new options and new knowledge provide opportunities to reconsider and improve the design. A good example is the partnering with the client resulting in an optimisation of the hard sea defence design which is described briefly in section on “Contract Award and Partnering”.

**TENDER PERIOD AND PROCEDURE**

The PRA prescribed a step-by-step approach, leading to the final award of the contract as follows:

- **Discussion phase** January–May 2006
- **Offer phase** May–July 2006
- **Negotiation phase** July 2006–Spring 2007
- **BAFO phase** Spring–October 2007
- **Award phase** From October 2007
- **Contract award** 27 February 2008

**Discussion phase**

In this phase the tenderers discussed with the PRA: the project, the programme of requirements, the draft contract, the risks and other aspects excluding financial issues. The purpose of this phase was to enable the PRA to further clarify the project in order to enhance the tenderers’ understanding. On the other hand, the tenderers were given the opportunity to verify their interpretation of the scope of works. The discussion phase was strictly structured. The input of the tenderer was critical. The PRA could order particular documents to be submitted for discussion, like the so-called requirements tree and verification matrix (RTVM).

Some comments made by the tenderer concerning, for example, the draft contract and leading to contract changes, were possibly to be made public, i.e., had to be communicated with all tenderers (via tender instructions) to ensure equal treatment. The same core team from PRA conducted the bilateral discussions between PRA and the various tenderers, to guarantee uniformity and transparency and thus equal treatment of the tenderers. Obviously the team leader of the tenderer’s core team had to have full authorisation, to be confirmed in a letter at the start of the discussion phase.

Although outside the scope of this article, it is worthwhile mentioning that the PRA scheduled the various procedures to run simultaneously such as:

1. Tender process for construction of Maasvlakte 2,
2. Obtaining clients for the Port Areas and
3. Applying for main permits concerning partial planning, environment and compensation for the loss of natural assets.

The simultaneous running of these procedures was done to achieve early commencement of the project construction phase (see Figure 2).
Apart from achieving the earliest commencement of the works, this project approach also made it possible to achieve early mutual understanding between PRA and the contractor on the possible restrictions for contractors as (to be) attached to the main permits. Simultaneously scheduling tenders for construction and maintenance resulted in almost 3 years’ acceleration compared to the traditional approach of first arranging permits, followed by assessment and award by the PRA.

**Offer phase**

This phase started after completion of the discussion phase. In this phase the tenderers prepared their offers and submitted their tender. The PRA ranked the offers on the basis of award criteria and award method, as described in the tender brief (see under “Contract Award and Partnering”). The offer phase was completed by sending invitations to two successful tenderers to enter the negotiation phase.

**Negotiation phase**

The PRA started to negotiate with the two tenderers who submitted the best offers. After this phase the BAFO phase started, in which the tenderers prepared their best-and-final offer (BAFO), followed by assessment and award by the PRA.

**BAFO phase**

The BAFO phase comprises four parts: General part, technical part, financial part and maintenance part.

In the tender procedure, and in particular in the discussion phase, system-oriented design played an important role (actually dictated by the client). Every tenderer had to further develop the programme of requirements as provided by the PRA on the Systems Engineering method. In addition to the requirements, the contractor also had to describe which verification method(s) had to be applied. For this the so-called requirement tree and verification matrix (RTVM) was prepared. The RTVM provided proof that the solution designed (choices made by the tenderers) indeed fulfilled the programme of requirements as provided by the PRA. The tenderer had to submit the prepared RTVM as an integral part of the submission. The RTVM would become eventually part of the Contract to be awarded.

**SYSTEMS ENGINEERING PRINCIPLES**

The instructions in the design brief were an important part of the tender procedure and the innovation of the project.

The principles of Systems Engineering play an important role in this contract. Already during the design period it was prescribed in the design brief that the design should be based on Systems Engineering. But what are the principles of Systems Engineering? What is Systems Engineering?

Numerous definitions of Systems Engineering can be given. The International Council on Systems Engineering (INCOSE) defines Systems Engineering as follows:

An interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem.

The Dutch public works sector and the large infrastructure projects apply a more practical interpretation of Systems Engineering, which is more to the point and focuses on the best and feasible elements of Systems Engineering for such kind of projects.

The applied definition of Systems Engineering for large infrastructure projects

Systems Engineering is a systematic, structured and transparent way of handling technical and contractual information through all project phases. It helps create transparency and manage change and interfaces in the project.

The core elements of Systems Engineering are:

- Analysing and presenting the client’s requirements in a systematic and structured way (identifying the problem and the project, specifying the requirements)
- Translating the client’s requirements into products to be designed and built in a systematic, structured and transparent manner (Design & Construct process)
- Transparent verification of the specified requirements for the products designed and constructed (delivery of a suitable and accepted product)

Furthermore, Systems Engineering is being welcomed by more and more partners in large infrastructure projects in the Netherlands. This increases the need to define and agree on how to apply Systems Engineering in such projects. In other words: there is a need to collaborate on developing a language for the construction industry. It is important that the contracting authorities and the contractors work according to the same basic principles. This effort, in which PUMA actively took part, has resulted in the development of “Guideline Systems Engineering for Public Works and Water Management” [ref.1]. Based on this
The system is constructed and tested (verified and validated) during the construction phase. The operation and maintenance phase consists of the operation of the system and the provision of services within the targeted environment, and is designed to ensure that a consistent level of effectiveness is provided in relation to utilisation and business operations.

The engineering process is carried out for the first time during project execution by the contractor. This involves the concept, development and construction. Once the system is developed or even in operation it is possible to improve and renew the system. New options arise, allowing for improvement, and users have new or revised requirements. The engineering and construction processes are re-executed in order to produce a design based on the new option or renewed requirements. The renewal or improvement of a system can be repeated several times during the lifecycle of a system.

Once the system is in operation it will require maintenance after a period of time. Maintenance and/or replacement keeps the system in such a condition that it continues to meet the originally specified requirements. The engineering and construction processes will have to be partially re-executed as part of the maintenance process. It should be noted here that repeating the engineering and construction processes once again does not mean that the entire process starts from scratch. When proper asset management practices are used, all the system information is still available. We repeat the engineering and construction process in order to, where necessary, adjust requirements, consider new options and variants and modify the design to accommodate the results of the changes.

**Systems Engineering during the development phase**

For a project like the Maasvlakte 2, the development phase is most important and most interesting from a Systems Engineering point of view. After all what will be constructed and operated is born in this phase. The physical solution of the system is shaped and becomes visible.
What are the Systems Engineering principles leading to the best solution for the system? In the development phase the engineering process is a generally applicable process. It consists of three sub-processes:

- Requirements analysis
- Structuring and allocation
- Design

These consecutive sub-processes form an iterative process leading to the solution with the agreed and acceptable level of detail. At the end of the process, the solution is specified and is compared to the specified requirements and solution space. This is the verification of the physical solution against requirements. In Figure 4 this process is presented together with the input and output. The scenario with respect to the input and output process is visualised and described below.

The input into the engineering process is the output of the concept phase, the programme of requirements. This process always starts with a problem statement and the related need(s) of the client/contracting authority and other stakeholders. The input specification describes the problem statement and the solution space and is represented in Figure 4 as an empty box with a question mark. The output specification is the solution proposed or designed plus the margin (dependent on uncertainty and risk) and is represented in the figure as a circle. This specification of the solution is prepared by the contractor following the engineering process during the development phase. In other words: the solution-independent system of the client is transformed into a physical solution-based system by the contractor (Figure 5).

The verification/validation process takes place simultaneously. The result of this process is to prove that the solution plus its margin meet the requirements, in other words, the solution fits into the given solution space.

**CONTRACT AWARD AND PARTNERING**

**Award criteria and assessment**

The award was based not only on lowest price, but also on other aspects. Before being considered for ranking, the tenderer’s bid had to comply with three so-called knockout criteria.

1. **Time criterion**
   - The contractor shall be able to complete the work within 4 years and 10 months, including some intermediate milestones during the construction period.

2. **Technical criterion 1**
   - The offer complies with the programme of requirements, to be checked by assessing the requirements and verification matrix. The tenderer does not submit a design, as traditionally done with technical description, drawings and design reports.

3. **Technical criterion 2**
   - The design shall successfully pass physical and numerical model testing.

Only if the tenderer has passed all the above criteria will he/she be considered for ranking. The criteria for ranking are based on a mix of construction costs, time, maintenance costs and risks (contractual risk share). On top of that the tenderer could achieve bonuses (for ranking purpose only) when some critical parts are completed earlier than specified by the PRA; these are: date of completion of the recreation beach (latest date for completion June 1, 2012) and nautical access to the first container terminal (latest date April 1, 2012).

Indexation of cost is applicable and based on the tenderer’s selection of proposed indices by the owner. The ranking has been made on Nett Present Value (NPV) per July 1, 2007. The NPV of the construction costs, calculated by the tenderer, was based on the financial format for payment as prescribed by the PRA (certificates) as well as the progress of the work (progress payments), mainly dictated by the construction programme of the tenderer.
Partnering

The contract was awarded to PUMA, based on the submitted offer, and according to the above-mentioned award criteria, and assessment. During negotiations after the submission of the best and final offer, however, it became apparent that further optimisation of the hard sea defence was possible. This submitted design partly consisted of a cobble beach (length 1.3 km) (Figure 6) which could possibly be extended (with some modifications) to replace the more expensive remaining structure (length 2.2 km) (Figure 7) in whole or in part. The latter was a traditional S-shaped breakwater design with a primary armour layer of concrete cubes. The cobble beach design resulted in cost-savings but could require more maintenance. It was decided to include a partnering clause in the contract to jointly investigate the possibility of applying the

cobble beach design of the hard sea defence and, if successful, to share the benefits equally. Partnering indeed appeared to be successful and led to cost savings design, both minimising investment as well as maintenance (Figure 8) replacing the cross sections as shown in Figures 6 and 7. This design again had to be completely tested in physical scale models before the final go-ahead for construction could be given by the PRA. The design of the sea defences is dealt with by G.L.A. Loman et a.l. [ref. 2] (Figure 9).

SYSTEMS ENGINEERING IN THE CONSTRUCTION PHASE

Systems Engineering is focused on the needs of the client or stakeholder throughout the lifecycle. In the first two phases, the concept and development phases, the solution of the system is developed based on and according to the Programme of requirements. The construction of the solution designed is the next phase. The challenge of the construction phase is illustrated in Figure 9. This schoolbook example shows the need for regular checks against the requirements and the client’s needs. A good verification process is required throughout all phases of the project’s lifecycle.

In order to be able to set up a good verification process, it is important to describe which verification method(s) are acceptable as early as when the requirements are prepared. For this the so-called Requirement Tree and Verification Matrix (RTVM) is prepared. In the RTVM all the requirements are listed together with the verification method. The contractor manages the RTVM in a transparent and traceable way such that the client is up to
date with the verification process during the execution of the project. For the Maasvlakte 2 project, PUMA manages and administers the RTVM in a web-based environment. The client can log in and look into the RTVM whenever he/she wants and wherever he/she is.

**Contractor and client**
The responsibilities of the contractor and client overlap. The client’s responsibilities focus on formulating specific requirements that the designs must meet and on monitoring these requirements during the design and construction process, while the contractor’s responsibilities are to develop a design/solution meeting the specific requirements and verify that these requirements are met during the construction phase. In other words the client and the contractor have the same objective with respect to the monitoring of requirements during the construction phase: Monitoring and gathering proof that a properly constructed system is built that meets the client’s requirements. Obviously the verification process plays a key role in meeting the objectives. Verification provides proof that something is constructed according to specified requirements.

Scheduling and planning verification will be essential (Figure 9). In principle verification of the requirements will take place during every phase of the project. Each discipline, the engineering department, the work preparation department and operations, will contribute to the verification process. Each discipline will be responsible for the verification effort to be executed during the phase for which it is responsible. The verification effort per phase and discipline are made transparent and traceable by the use of the RTVM. The RTVM database is managed and administered in a web-based software tool. This keeps both the contractor and client up to date and aware of the verification process. In other words they are aware of the quality of the work and the constructed product with respect to the requirements during the lifecycle of the project.

**Integral project management**
The verification process is a key issue for project management. Hence project management efforts and tools should be applied to actively follow up on the objective to monitor and gather proof.

Project management (together with Systems Engineering) frequently uses breakdown structures:
- **The System Breakdown Structure (SBS)** and the specification breakdown structure. The system breakdown structure (SBS) represents the decomposition of the system in a hierarchical way. The requirements, interfaces and preconditions are grouped and allocated to the components of the SBS.
- **The Work Breakdown Structure (WBS)** contains all the activities that must be executed for a project. The WBS is an important tool for managing projects.

These structures support the top-down approach used in complex systems and help manage the complexity of a system. A good system breakdown improves manageability. The work breakdown structure is of central importance to project monitoring and control. Risks, time and money are linked to the work breakdown structure (Figure 10).

At the start of the construction phase the WBSs are prepared. The WBSs are used to manage the available resources and interfaces between separate activities. In addition, for each activity or group of activities in the WBS, requirements are allocated and managed as such. For the construction phase of Maasvlakte 2 a number of WBSs were prepared for the entire system and in more detail for different subsystems. In the WBS the activities that must be executed are listed and grouped so that the hierarchy and the relation between the (key) activities are visible. Based on the WBSs, the management appoints special task forces. Each task force consists of
a representative of the design/engineering department, work preparation department and of operations. Together with the appointment the project management can provide the task force with useful (background) information such as the project vision/objectives/uncertainties and success criteria for the specific activity. This methodology assures the management of the project in an integral and controlled way. In addition typical design and construct problems – interface problems between design/engineering and operations – can be foreseen earlier, controlled and minimised.

**RESULTING BENEFITS OF APPLIED CONTRACTUAL APPROACH**

**Quality management**

A mutual benefit for contractor and client is well-monitored and controlled project execution throughout the project organisation and the systems lifecycle to ensure that requirements are consistently met. In other words: good quality management (Figure 11).

Quality management plays a key role in being able to guarantee the quality of a product, service or process. Quality management serves to standardise and formalise processes. An important component of quality management is the use of quality assurance. This method imposes requirements in terms of the way in which client and contractors communicate with each other in relation to the verification process. It is important to find a quality system with a quality assurance function that addresses all the processes used during the execution of this innovation in Systems Engineering based projects. The challenge for the large infrastructure project is to collectively agree on a suitable quality management system. Only then will it be possible to account for quality, and consequently effectiveness and efficiency. For the Maasvlakte 2 project a custom-made quality management system was developed. In short this custom-made quality system focused on quality control in line with the verification process of Systems Engineering and was based on ISO 9001.

**Transparent and traceable process**

It is often said that the difference between traditional engineering and Systems Engineering is that Systems Engineering is (more) transparent and traceable. The core element in Systems Engineering is the explicit documentation of information, something that in the traditional process flow usually only takes place within the heads of those involved. The main benefits of the transparency and traceability of the Systems Engineering process are:

- Preventing errors and the cost of failure – open communication and transfer of the documented information between parties and from one phase in the construction process to another
- Project managers, as well as clients, have an insight into the status of quality and progress during the project
- Changes and new options can be dealt with more easily. The traceability of requirements makes it easy to determine the impact of scope or configuration changes.

To elaborate on the latter benefit: During the execution of a large infrastructure project new options, optimisation and/or improvements of the design present themselves. The Systems Engineering process, especially the traceability of requirements, makes it fairly easy to deal with such opportunities. The impact of the changes can be determined. Analysing of the effect created by the change (or new option) on the requirements and the quality of the system/product can be done more systematically.

Figure 11. The dredger Sliedrecht 27 at work behind breakwater Maasvlakte 1 (left) and (above) the construction of deep-sea and barge/feeder quay walls for the future container terminal.
result between Client and Contractor. Because of the volatile wave climate of the North Sea, it was decided to use as little floating equipment as possible for the construction of the hard defence. For installation of the concrete cubes (each weighing 40 tonnes) a special innovative crane was developed and constructed (Figure 12). This so-called Blockbuster is able to install the blocks (including the clamp for hoisting, weighing 50 tonnes) at 63 m from the centre of the undercarriage.

In other words: which requirements have to be replaced or rephrased? Which have not been affected by the change? Is it still in accordance with the primary or the main functional requirement of this specific part of the system? Based on such an analysis the client and contractor can make well-considered decisions. An example of this, and underlining this benefit, is the “partnering result”, a new optimised design for the hard sea defence as described above in the section “Partnering”.

Innovative design and equipment

The Design Construct Maintenance Contract format indeed allowed the contractor to develop the design of the sea defence so that it makes optimal use of existing construction expertise and actual knowledge of the equipment and materials available. For further elaboration of that design see [ref.2]. As a result of the fact that the hard sea defence was designed in a systematic, structured and transparent manner it was much easier to achieve mutual agreement on the improved (partnering) design. Indeed the new option, which arose from discussions in the award phase (see discussion above), did not necessitate the entire design process to start from scratch, but had to be partially re-executed, i.e., only those parts which had an effect on relevant specific requirements. The transparency provided by the system-oriented approach appeared to be essential to arrive at the agreement on the innovative partnering

CONCLUSIONS

The Port of Rotterdam will be expanding into the North Sea. The realisation of the Maasvlakte 2 entails the creation of a new world-class port and industrial area. The selected Contract format, Design Construct and Maintenance Contract (DCM), and the system-orientated approach resulted in a “value for money product” for the following reasons:

• Construction experience was efficiently incorporated in the design process.
• Disputes between Designer and Contractor were avoided.
• Cost savings were achieved as a result of the Contractor making the design with the convenience of construction in mind.

The option for possible savings in the design of the hard sea defence, which became apparent in the Award Phase was successfully implemented via an additional Partnering Clause in the finally awarded Contract. The Partnering resulting in a new design of the hard sea defence was in particular successful as a result of the applied system-oriented approach (Systems Engineering). The inherent mutual transparency created through this approach was a key factor in reaching agreement between Client and Contractor.

REFERENCES


ESTABLISHING A STONE-DUMPING PROCESS FOR CONSTRUCTING ARTIFICIAL UNDERSEA RIDGES

ABSTRACT

A sea area with an upwelling provides an advantageous environment for the development of a highly productive food chain and hence a rich fishery. Accordingly, projects in Japan are underway to construct human-made undersea ridges for artificial upwelling generation in order to boost the productivity of national coastal fisheries and, consequently, secure sustainable fisheries resources. An example of such a project is provided by a group of approximately 15-m high human-made undersea ridges constructed using ashcrete blocks or natural rocks on a 70- to 80-m deep seabed, with the neighbouring ridges spaced about 60 to 80 m apart.

When seabed current flows interact with the human-made undersea ridges, upwelling will occur and bring nutrient-rich deep water up to the surface to help the enrichment of the local food chain consisting of phytoplankton, zooplankton and fish, with the largest species of the last being the top predator.

Successful generation of artificial upwelling depends critically on the location, design, and configuration of these human-made undersea ridges. This demands a very high level of construction accuracy. In order to accurately build underwater structures by dumping rocks from split hopper barges down to a deep underwater site, the stone-dumping process must be optimised taking into consideration not only accurate determination of ship position but the natural conditions, such as tides, in the area.

This report provides introductory descriptions of the various efforts incorporated into the human-made undersea ridges constructed by Tomac Corporation, on a 76-m deep seabed offshore west of Nagasaki City, Nagasaki Prefecture, Japan, during the period from 2008 to 2009. It was first published in the Proceedings of WODCON XIX in Beijing, China in September 2010 and is reprinted here in a slightly revised version with permission.

INTRODUCTION

It has been feared in recent years that the growth rate in global food production may fail to keep up with the growth rate in the world population. With its national food self-sufficiency rate down to approximately 40%, Japan depends on imports for almost all kinds of food products.

The securing of domestic fisheries resources has been increasing in importance. The vast exclusive economic zone in the waters surrounding Japan is one of the world’s three largest fisheries. The fish resources of more than one-half of the indigenous species have been low for a long time, and so have the annual per-species catch rates.

Accordingly, Japan has implemented a variety of different measures to restore and rebuild its over-fished fisheries resources. Under such circumstances, Japan plans to construct human-made undersea ridges along the coastal areas to produce places of artificial upwelling and thereby improve basic productivity.

UPWELLING

An upwelling is a complex and extensive mixture of currents and eddies of water that flow upward from the deep sea to shallow sea levels. When large-scale human-made undersea ridge structures are developed to artificially produce upwelling, nutrients will be supplied to the surface layers from the deep sea. A constant supply of nutrients from deep to shallow sea levels reachable by sunlight...
A human-made undersea ridge was constructed by dumping 7,363 m³ of stone on a seabed (~76 m) offshore west of Ioujima, Nagasaki City to produce artificial upwellings in order to improve the local fishery productivity. To achieve this, a fleet consisting of a split hopper barge (800 m³), a pusher (880 kw), a support boat (560 kw) and a survey boat (740 kw) were mobilised.

LOCATION AND SCOPE
Stone that was placed at the job site offshore of Ioujima, Nagasaki City, Nagasaki Prefecture was carried out by lightering the stones from the base port, New Nagasaki Port, Nagasaki City. A shuttle was maintained along the transfer route (8 miles long) every day. This report describes the execution of the construction of one of the three sections of the total project length, that is, the final phase, Phase 3 Eastern Section (L = 11.8 m).

PROJECT OUTLINE
The project, the Western Nagasaki Wide-Area Fishery Development Work (Western part of Nagasaki Prefecture, was commissioned by the Nagasaki Prefecture Fishery Department Fishing Port and Fisheries Development Section. The main Contractor was Ohishi Construction Co., Ltd. and the subcontractor was Tomac Corporation. The job site was located offshore west of Nagasaki City and the project period took place from December 25, 2008 to March 19, 2009 (Figure 2).

Each year at selected conferences, the International Association of Dredging Companies grants awards for the best papers written by younger authors. In each case the Conference Paper Committee is asked to recommend a prizewinner whose paper makes a significant contribution to the literature on dredging and related fields. The purpose of the IADC Award is “to stimulate the promotion of new ideas and encourage younger men and women in the dredging industry”. The winner of an IADC Award receives €1000 and a certificate of recognition and the paper may then be published in Terra et Aqua.
Using the post-dumping mound geometry prediction system, the mound geometry was predicted on the basis of the results of the bathymetric survey to determine the dumping point (coordinates).

**PROCESS IMPROVEMENT CONSIDERATIONS**
The following describes (a) the major challenges of special note in the construction process, (b) consideration and measures for improved work efficiency, and (c) the process leading up to the implementation of the proposed measures. This includes:

1. Influences of the constantly changing tides (tidal current rate and direction)
2. Establishing a reliable barge position holding method and a clear chain of command and communication reliant on the guide system
3. Optimising the stone-dumping process and the post-dumping mound geometry prediction system so that a man-made undersea ridge can be built true to its design cross-section.
4. Conducting a high-precision bathymetric survey for appropriate dumping point determination and mound geometry prediction.

**CONSTRUCTION METHOD**

**1. Influences of the local tide on the stone-dumping operation**
When dumping stone from a barge, the influences of the changing tide cannot be ignored. Stones dumped offshore may not always sink vertically because of potentially significant influences of the local tide. Hence, the local tide characteristics were measured and analyzed to clarify the tendencies of the tidal current rate and direction and their influences on the stone-dumping operation. Table II and Figure 4 show an excerpt of the tidal current measurement data and the details of the tidal current conditions (rate and direction) analysis based on the obtained data.

**VESSELS EMPLOYED**
Table I above lists the main vessels employed for the work. In order to dump one-tonne stones, a split hopper barge compatible with large-sized materials was deployed. The push boat employed was a single low-speed engine powered vessel. A twin high-speed engine powered survey boat with high maneuverability was used because of the requirement to conduct a high-resolution bathymetric survey for accurate as-built geometry control.

**CONSTRUCTION FLOW**
The human-made undersea ridge construction work was carried out according to the following workflow:

1. The fleet moved from the moorings to the stone-dumping site.
2. The tidal current direction and rate at the stone-dumping point was measured at four-metre intervals down to the target depth.
3. Based on the measured tidal current direction and rate, calculations were made to correct the dumping point (coordinates).
4. Using a guidance system, the barge was moved to the vicinity of the specified point. The barge was then guided with the support boats along her sides.
5. The barge was held at the specified point to slowly dump the stones.
6. After placement of all the stones, the barge was moved back to the loading site. Meanwhile, the survey boat conducted a multi-narrow beam bathymetric survey.
7. After returning to the port, the barge reloaded with stones using a self-propelled grab hopper dredger.
8. The barge’s position holding performance during the dumping operation and the bathymetric survey results were analyzed to examine the movements of the boats and the barge and the time required for full gate opening and to improve construction accuracy.
9. Using the post-dumping mound geometry prediction system, the mound geometry was predicted on the basis of the results of the bathymetric survey to determine the dumping point (coordinates).
2. Tendencies of tidal current conditions (each water depth range)
The water depth was divided into three parts: 0 to 26 m (Figure 6), 26 to 50 m (Figure 7), and 50 to 76 m (Figure 8), to analyze the tidal current rate and direction tendencies for each water depth range. Thus, each water depth range shows no tendency with respect to tidal current rate. The average value of $V = 12.9$ cm/s was obtained.

The tidal current flow direction was observed to be primarily from south to north. Meanwhile, although not so clearly, water depth: 50 to 76 m reveals that the most frequent range of occurrence was in the range of $\theta = 337.5^\circ$ to $360^\circ$. The tidal current flow direction also remained from south to north.

Compared with the other water depth ranges, Figure 8 showed somewhat greater variations in numerical values. Thus, each water depth range shows no distinct tendency with respect to tidal current rate. Meanwhile, the tidal current direction averaged at $\theta =$ approx. $6.0^\circ$, approx. $6.0^\circ$, and approx. $4.3^\circ$ in the water depth ranges of 0 to 26 m, 26 to 50 m, and 50 to 76 m, respectively.

3. Dumping point offsetting in response to tidal current conditions
Based on the vertical distribution of the observed tidal current rate, the dumping point was corrected using Formula 1:

$$\frac{L_{ct} \cdot U_p}{h} = 0.8 \frac{U_f}{U_p}$$

where:

- $L_{ct}$: Horizontal travel
- $U_f$: Tidal current rate
- $U_p$: Typical sinking rate
- $h$: Water depth

Table III shows an excerpt of the results of the offsetting using Formula 1.

4. Observations on tidal current conditions
Figure 4 shows that the tidal current rate and direction varied vertically during the first measurement. No distinctive tendency in the variations was observed. Considering the distribution of measured tidal current rate according to the predictions by Formula 1, it is unlikely that significant influences occurred on the position and geometry of the mound. This time, a two-metre mesh grid was used for surveying. It turned out that such influences fell within the margin of error of measurement.

Comparisons of the tidal current-corrected dumping points and the centers of gravity of the actually formed mound, however, revealed a maximum shift as large as approximately 5.7 m was measured. It was considered that this may have been caused by factors other than the tidal current, such as the accuracy of the tidal current correction (Formula 1) or the oscillations and positional deviations of the vessels during the dumping operation.

Table II. Measured tidal current rates (excerpt)

<table>
<thead>
<tr>
<th>Measured depth</th>
<th>1st dumping</th>
<th>2nd dumping</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jan. 26</td>
<td>Jan. 28</td>
</tr>
<tr>
<td></td>
<td>$V$ (cm/s)</td>
<td>$\theta$ (˚)</td>
</tr>
<tr>
<td>6</td>
<td>14.0</td>
<td>2.4</td>
</tr>
<tr>
<td>10</td>
<td>6.7</td>
<td>10.7</td>
</tr>
<tr>
<td>14</td>
<td>5.1</td>
<td>1.1</td>
</tr>
<tr>
<td>18</td>
<td>4.2</td>
<td>8.6</td>
</tr>
<tr>
<td>22</td>
<td>2.8</td>
<td>12.2</td>
</tr>
<tr>
<td>26</td>
<td>4.1</td>
<td>24.8</td>
</tr>
<tr>
<td>30</td>
<td>4.9</td>
<td>88.8</td>
</tr>
<tr>
<td>34</td>
<td>6.0</td>
<td>114.5</td>
</tr>
<tr>
<td>38</td>
<td>6.8</td>
<td>110.7</td>
</tr>
<tr>
<td>42</td>
<td>5.6</td>
<td>121.0</td>
</tr>
<tr>
<td>46</td>
<td>5.0</td>
<td>135.0</td>
</tr>
<tr>
<td>50</td>
<td>6.5</td>
<td>143.5</td>
</tr>
<tr>
<td>54</td>
<td>7.5</td>
<td>158.3</td>
</tr>
<tr>
<td>58</td>
<td>8.0</td>
<td>166.8</td>
</tr>
<tr>
<td>62</td>
<td>8.5</td>
<td>161.6</td>
</tr>
<tr>
<td>66</td>
<td>9.5</td>
<td>174.2</td>
</tr>
<tr>
<td>70</td>
<td>3.3</td>
<td>102.6</td>
</tr>
<tr>
<td>74</td>
<td>6.4</td>
<td>110.9</td>
</tr>
<tr>
<td>Ave.</td>
<td>6.4</td>
<td>110.9</td>
</tr>
<tr>
<td>Max</td>
<td>14.0</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Figure 4. Tidal current measurement results.
Figure 5. Frequency distribution of tidal current rate and direction (whole of the water area).

Figure 6. Frequency distribution of tidal current rate and direction (water depth: 0 to 26 m).

Figure 7. Frequency distribution of tidal current rate and direction (water depth: 26 to 50 m).

Figure 8. Frequency distribution of tidal current rate and direction (water depth: 50 to 76 m).
2. Positioning method
Considering that the job site was of a relatively small scale, a method was used based on existing technical resources instead of introducing a dynamic positioning system (DPS) capable of automatically controlling the propulsion system aboard a boat to hold her position on a point offshore. Before dumping stone, the split hopper barge had to first be pushed to the area above the job site and guided to a specified point by the push boat. She was then accurately positioned by the two support boats. In the original plan it was intended to hold the position of the barge by direct application of vertical tension with the support boats at the centers of her sides (Figure 9). The barge, however, kept moving to the front, back, left and right and could not hold its position very well.

After reconsideration, it was decided to shift the tension applying points 10 metres astern from the centres of the sides of the barge so that it would be pulled not vertically downward but astern (Figure 10).

Consequently, the barge would constantly be pulled astern by the support boats. At the same time, however, the push boat would apply a propulsion force in the “ahead” direction so that the forces applied on the barge would be balanced. Thus, the barge would be able to remain still at a point, facilitating maneuvering and position holding.

Table III. Tidal current offset and mound points

<table>
<thead>
<tr>
<th>Dumping No.</th>
<th>Date</th>
<th>Point</th>
<th>Planned point</th>
<th>Dumping point after current offsetting</th>
<th>Mound point</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>(1) Coordinates</td>
<td>(2) Coordinates</td>
<td>Offset (2) – (1)</td>
</tr>
<tr>
<td>1</td>
<td>Jan. 26</td>
<td>X-axis</td>
<td>200.000</td>
<td>199.556</td>
<td>– 0.444</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Y-axis</td>
<td>100.000</td>
<td>100.130</td>
<td>0.130</td>
</tr>
<tr>
<td>2</td>
<td>Jan. 28</td>
<td>X-axis</td>
<td>200.000</td>
<td>202.327</td>
<td>2.327</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Y-axis</td>
<td>100.000</td>
<td>99.795</td>
<td>– 0.205</td>
</tr>
<tr>
<td>3</td>
<td>Jan. 29</td>
<td>X-axis</td>
<td>206.000</td>
<td>208.835</td>
<td>2.935</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Y-axis</td>
<td>100.000</td>
<td>98.249</td>
<td>– 1.751</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Y-axis</td>
<td>83.000</td>
<td>85.162</td>
<td>2.162</td>
</tr>
<tr>
<td>5</td>
<td>Feb. 2</td>
<td>X-axis</td>
<td>203.000</td>
<td>202.068</td>
<td>– 0.932</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Y-axis</td>
<td>118.000</td>
<td>117.563</td>
<td>– 0.437</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Y-axis</td>
<td>77.000</td>
<td>75.605</td>
<td>– 1.395</td>
</tr>
<tr>
<td>7</td>
<td>Feb. 4</td>
<td>X-axis</td>
<td>201.000</td>
<td>200.666</td>
<td>– 0.334</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Y-axis</td>
<td>122.000</td>
<td>121.947</td>
<td>– 0.053</td>
</tr>
<tr>
<td>8</td>
<td>Feb. 5</td>
<td>X-axis</td>
<td>217.000</td>
<td>217.550</td>
<td>0.550</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Y-axis</td>
<td>100.000</td>
<td>98.248</td>
<td>– 1.752</td>
</tr>
<tr>
<td>9</td>
<td>Feb. 6</td>
<td>X-axis</td>
<td>190.000</td>
<td>189.469</td>
<td>– 0.531</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Y-axis</td>
<td>100.000</td>
<td>101.938</td>
<td>1.938</td>
</tr>
<tr>
<td>10</td>
<td>Feb. 7</td>
<td>X-axis</td>
<td>200.000</td>
<td>201.365</td>
<td>1.365</td>
</tr>
</tbody>
</table>
3. Guiding system and chain of communication

A guide system was developed that enabled the respective workboats to check on their positions and directions in real time. This system was used for computerised barge guiding in synch with instructions communicated via transceivers. The barge was equipped with a GPS, and the support boats were each installed with a GPS and a gyrocompass as the position finding and inter-vessel communication equipment to facilitate the barge guiding operation. The vessels were interconnected via a wireless LAN network to allow on-screen monitoring via the laptop computers aboard the workboats (Figure 11).

4. Post-dumping mound geometry prediction system for stone-dumping optimisation

The following procedure was used to accurately build a human-made undersea ridge with its cross-section exactly as specified:

(1) Predict the geometry of an undersea mound of dumped stones. Determine the dumping points and sequence to ensure that the cross-section of the mound will be as specified.

(2) Compare the predicted and actual mound geometries and review the prediction method as needed to improve prediction accuracy.

(3) Compare and check the mound geometry predicted during the dumping operation and the actual mound geometry. If adjustments are required, review the dumping points and sequence.

The mound geometry was predicted as follows: The actual mound geometry of a barge full of dumped stone was modelled in advance. Based on each model, the subsequent model of the mound was obtained with the dumping point shifted accordingly. The models thus obtained were all superposed on top of each other. The review of the prediction method was as follows: Each mound geometry modelled was compared with the post-dumping mound geometry and then modified to reflect the latter. What follows describes in detail how to determine the individual dumping points and sequence based on the whole stone-dumping process simulated using the mound geometry models that were based on the analysis results obtained by the distinct element method.

Distinct element method

An analysis method, in which the object of analysis is modelled as an aggregate of free-moving polygonal, circular, or spherical elements, to allow sequential tracking and analysis of the movements of the individual elements at individual times with inter-element contacts and sliding considered.

1) Post-dumping mound geometry prediction system

In order to prepare a stone-dumping plan appropriate for the conditions of this construction work, the mound geometry was simulated using a solid-liquid two-phase-flow model based on the distinct element method.

Dumping conditions

- Water depth: approx. 76.0 m
- Barge: Fukumaru FK-800, hold capacity 800 m³
- Barge hold dimensions: L 25.40 m, B 10.00 m, H 4.30 m Opening width: 5.67 m
- Stone: 1.0 t/piece

Simulated model conditions

- Water depth: 76.0 m
- Barge hold dimensions: L 25.40 m, B 10.00 m, H 4.30 m Opening width: 5.6 m
- Stone model: 1.40 t/piece (D = 1.003 m)
Cases studied

In the actual construction, a barge with a hold capacity of 800 m$^3$ was loaded with 600 m$^3$ of stone. Two cases are considered here in which the split hopper barge had her bottom opened both rapidly and slowly to dump the stone (Tables IV and V).

Thus, it turned out that the more rapidly the bottom of the barge opened, the wider and lower the mound, and the more slowly the bottom of the barge opened, the narrower and higher the ridge.

By narrowing the stone-dumping range and increasing the mound height, it was possible to dump stones and construct the ridge with pinpoint accuracy.

2) Stone-dumping plan

A stone-dumping plan support system was used to examine the dumping plan. The stone-dumping plan system displays seabed geometry data on the computer screen so that the operator, while viewing the seabed geometry on the screen, can specify the points for dumping stones on the seabed from the barge. This system instantaneously displays on the computer screen in 2D and cross-sectional images of the stone mound geometry prediction model superposed on the seabed geometry. The operator repeats the image superposition process, with the dumping points shifted, until the specified reference values are reached.

Using the stone-dumping plan support system and incorporating the results of the mound geometry simulations, a stone-dumping plan was developed that would ensure a satisfactory as-built geometry. Figure 12 shows the stone-dumping plan thus developed. The white numerals in Figure 12 indicate the ordinal numbers and centres of the stone-dumping points.

3) Review of the mound geometry prediction model

The mound geometry prediction model is a representation of the stone mound geometry analysed by the distinct element method. The analysis, however, assumes that all the individual stones are identical and spherical. The shapes of individual stones are not taken into consideration. Therefore, differences were expected to be found between the prediction model and the actual mound geometry. Such differences were identified using bathymetric survey results every time before and after dumping stone. Every time after dumping stone the prediction model was adjusted and reviewed to reflect the actual mound geometry.

a. Adjustment of the mound volume

The mound volume based on the prediction model was multiplied by the factor $K_v$ to agree with the actual mound volume:

$$V_1 = K_v \times V_0$$

b. Dimensional adjustment of the mound

The center of gravity of the mound geometry prediction model was aligned with that of the actual mound. The fore-and-aft (Y) and the side-to-side (X) dimensions were changed to agree with those of the actual mound. The mound height was adjusted to keep the dumped stone volume unchanged.

$$Z_1 = Z_0 \times K_z$$

$$K_z = \frac{(L_0 \times W_0)}{(L_1 \times W_1)}$$

Table IV. Cases studied

<table>
<thead>
<tr>
<th>Load volume (m$^3$)</th>
<th>Dumping time (s)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>600</td>
<td>1</td>
</tr>
<tr>
<td>Case 2</td>
<td>600</td>
<td>120</td>
</tr>
</tbody>
</table>

* Time required to achieve the full-opening bottom door (width of 5.6 m)

Table V. Simulation results

<table>
<thead>
<tr>
<th>Load volume (m$^3$)</th>
<th>Case 1</th>
<th>Case 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dumping time (s)</td>
<td>1</td>
<td>120</td>
</tr>
<tr>
<td>Mound volume (m$^3$)</td>
<td>421.1</td>
<td>534.9</td>
</tr>
</tbody>
</table>
c. Mound height adjustment
The height of the prediction model was changed to agree with that of the actual mound. The X and Y dimensions were adjusted to keep the dumped stone volume unchanged.

Dimensional adjustment of the mound:
\[ L_1 = L_0 \times (K_s)^{0.5} \]
\[ W_1 = W_0 \times (K_s)^{0.5} \]
\[ K_s = \frac{V_1}{Z_1} \]

4) On the stone-dumping plan support system
The stone-dumping plan support system supports the creation of a work plan that specifies the points for dumping stone on the seabed from the barge. The seabed geometry data obtained from the bathymetric survey results are displayed on the computer screen so that the operator, while viewing the seabed geometry on the screen, can specify the points for dumping stones on the seabed from the barge. This system instantaneously displays on the computer screen the plane and cross-sectional view images of the stone mound geometry prediction model superposed on the seabed geometry.

The operator repeats the image superposition process, with the dumping points shifted, until the specified reference values are reached.

This system uses a mesh map color-coded by depth as the method of on-screen two-dimensional representation of the seabed geometry (Figure 13). This is because the on-screen data must be updated every time the dumping point is shifted. In other words, in this way, image rendering goes faster and mesh counting becomes possible, facilitating an easy grasp of the volume of stones to be dumped. Additionally, the cross-sectional view screen displays pre- and post-stone dumping seabed geometries side by side and then displays control reference geometries so that it can be determined immediately whether the post-stone dumping seabed geometry meets the control criteria.

5. Introduction of multi-narrow beam bathymetry
The multi-narrow beam bathymetry system consists of a narrow multi-beam echo sounder for water depth measurement, a GPS for spatial positioning, a gyrocompass for survey boat oscillation measurement, and an oscillation sensor. This system synchronises bathymetric, positional, and oscillation data, enabling high-precision bathymetric surveys. This system digitises all measurement data, allowing simultaneous viewing of the seabed geometry and bathymetric data. The measurement data are compiled into a database, allowing visual representation of changes in the seabed geometry over time. Thus, the as-built geometry of the stone mound was accurately and easily grasp (Figure 14).

6. The layer thickness control system
The layer thickness control system uses database software for bathymetric data management and allows visualisation of work progress. Capable of bathymetric database management, this system enables planar visualisation (surface plane viewing) of bathymetric values of the whole or partial job site area. The system allows the operator to collect geometric data on the mound of dumped stones by obtaining differences between the pre- and post-stone dumping elevation data stored in the database.

Bathymetric data collected before and after stone-dumping are converted into two-metre mesh data for registration in the layer thickness control system (survey DB). The registered bathymetric data can be displayed as surface plane views. The mesh size settings for plane views can be changed from the registered value of two metres to the desired size (Figure 15).
The chronological cross-sectional view feature allows viewing of cross-sections of measurement history within the desired survey range (Figure 16). The dates of measurement data are displayed in a list format along the right edge of the screen. The date information can be toggled between show and hide.

The surface plane view screen displays bathymetric values plotted as mesh maps. The mesh size can be changed as desired. To display ground surface undulations, the mesh size is reduced. To display average ground surface elevations, the mesh size is increased. The chronological cross-section view is used to extract bathymetric values for specified points from the database and plot these values in color-coded line graphs for bathymetry dates.

The post-dumping geometry plane view feature is used to view stone-mound geometries based on pre- and post-stone dumping survey data (Figure 17). Mound geometries are converted into vessel-by-vessel data and compiled into a database. Registered mound geometries are statistically processed into mound geometry prediction models vessel by vessel.

7. Improved efficiency of barge loading of stones

The efficiency of stone-dumping was further enhanced by improving the process of loading stones from a self-propelled grab hopper dredger to the split hopper barge (Figure 18).

At first stones were loaded flat to the fore and aft ends of the barge hold. This resulted in small quantities of stone being left behind at the fore and aft ends of the hold. It was considered that these stones had received a greater restraining force when being dumped than those in the middle and consequently had become stuck and left behind.

As a solution to the problem, a method of loading stones into the hold so that the stones were piled into the shape of a top-wide/bottom-narrow trapezoidal prism was devised and implemented. This ensured vertical dumping of all stones from the hold which helped to prevent such problems as stone clogging. Thus, the stone-dumping operation was made easier and more efficient.
OUTCOME OF MEASURES TAKEN

As described above a variety of different improvement measures were implemented, including the as-built mound geometry prediction system. Consequently, the barge position was successfully held in the self-imposed target error range of ±2.5 m during all 16 dumping operations. The as-built-mound-geometry prediction system enabled careful examination and accurate determination of the stone-dumping points based on rigorous simulations.

Thanks to the newly introduced high-precision multi-narrow beam bathymetry the day-to-day stone-dumping point relocation and adjustments to the stone-dumping procedure was successfully performed. Figures 19 and 20 show the results of the first and the 13th stone-dumping operations, respectively.

The meshes in these figures have a grid pitch of 1 m. The red frames stand for 5 × 5 m squares, and the blue frames for 2.5 × 2.5 m squares. It is apparent that there were fewer and smaller variations in the barge position during the first dumping operation than in the 13th dumping operation. The duration indicated in the figures is the length of time the barge remained still at any one point. Again, the barge performed better in the 13th dumping operation than in the first dumping operation.

Figure 21 shows the differential map of the ridge, in which the differences between the design values and the post-dumping survey result values are color-coded. In Figure 21, the red areas indicate points higher than the corresponding design values, while the blue areas indicate points lower than the corresponding design values. The color intensities reflect the magnitudes of deviations from the design values. As can be seen in Figure 21, there were fewer blue areas (lower-than-design-value areas) and red areas (higher-than-design-value areas) this time than before. Therefore, it can be said that this time a ridge truer to the design than the previous one was built.

The above results prove that the measures to solve some problems encountered during the construction work were the most appropriate for safe and efficient execution for construction of this kind (Figure 22).

CONCLUSIONS

In this construction work, the barge was accurately and efficiently guided and the stone-dumping points were determined. More importantly, a satisfactory level of performance in undersea ridge construction was eventually achieved.

Orders for similar construction work at different locations and under various environmental conditions are expected to be achieved. Construction techniques, including the improvement measures taken on this project, will be further refined in order to expand this type of work both at home and abroad.
ABSTRACT

Although in the last decade safety incidents at Boskalis had been reduced by 70 percent, injuries and accidents still happened. After a two-year study including a safety survey amongst the workforce and clients, the company recently launched NINA – No Injuries, No Accidents – a new safety awareness programme that moves away from a culture of Instructions and Procedures to a culture of Values. A culture where each employee, from management to crewmembers, takes responsibility for ensuring that risks are minimised and people are stimulated to address risky situations.

INTRODUCTION

On July 15 2010, the new Boskalis safety programme NINA – No Injuries, No Accidents – was launched: Peter Berdowski introduced NINA to the staff at the head office and a special NINA site (www.boskalis-nina.com) went online. The site clearly explains the NINA goals and philosophy, and in several brief interviews the Boskalis Management Team members describe their commitment to the safety programme. Simultaneously, the entire workforce throughout the world received information describing the background, content and implementation of the programme. This ambitious approach to the safety campaign demonstrates a new course for safety and an even deeper commitment to fulfilling the role of a safe maritime engineering contractor.

TAKING SAFETY ONE STEP FURTHER

For all major dredging contractors, safety is an essential issue and all have safety systems in place. Despite best intentions the Boskalis directors found that accidents were still occurring. Although in the last decade safety incidents at Boskalis had been reduced by 70 percent, injuries and accidents still happened. To get beyond this impasse, management decided to take a critical look at the accepted safety culture.

In 2009, Boskalis carried out a safety survey amongst the entire workforce and numerous clients. The main conclusion was: Most safety programmes focus on procedures and instructions. Do this, don’t do that. To achieve the shared objective of a work floor free of incidents and accidents, something else was necessary. People’s attitudes and conduct had to change, their values had to change.

To actually be in a position to work safely, the development of a culture based on values is indispensable. And in that culture, people need to promote safety actively and talk to one another about safety problems. They need to trust their fellow workers and management and be able to speak up and speak honestly if they believe a situation is dangerous.

The conclusion was that a culture of “these are the rules, I must obey,” is not sufficient. A culture of “I want to work safely and have the back up of an organisation which supports that”. To achieve this, the top management had to commit to it; and to win trust they had to act with transparency and encourage people to speak up.
IADC 2010 ANNUAL SAFETY AWARD

AVOIDING THE USE OF A BANKS- OR FLAGPERSON DURING DRY PLANT OPERATIONS

Each year the International Association of Dredging Companies (IADC) singles out a specific project or programme amongst its members as an example of excellence in safety. This year the IADC Board is happy to announce that the 2010 Safety Award has been presented to Royal Boskalis Westminster NV. In 2009 Royal Boskalis Westminster conducted a comprehensive study on the possibilities of safer work methods for ‘heavy dry plant equipment.’ Several superior work methods were developed.

Challenges and risk factors
Common practice in the Middle East has been to use a banks- and/or flagperson to guide dry plant operations. These activities are dumping/backfilling and reclamation with heavy dry plant equipment such as dumpers, trucks, wheel-loaders and bulldozers. This has resulted in a few serious accidents over the last years during dry plant operations.

Consequently, in 2009 Boskalis decided to investigate the root causes aiming to prevent reoccurrence. After review, several improvements such as use of a traffic plan and instructions to subcontractors have been implemented. In the preparation phase, the risk of dry plant operations is now included in the Risk Assessment of projects. And during the Execution phase, Project HSE induction is given to all employees. Especially risks during dry plant operations and with heavy dry plant equipment such as dumpers, trucks, wheel loaders and bulldozers are explained to operations and to the involved employees.

Also a practical solution was introduced to ban the use of a banks- or flagperson during backfilling operations. This eliminated the root cause of the accidents which occurred.

A system was implemented whereby the operators of the wheel loader and/or bulldozer signal to the dumper drivers as to where to dump. The operators and divers receive a simple training and induction on site how to handle these activities. The implementation of this idea resulted in improved traffic control and segregation of work activities so that no employees are in the vicinity of heavy equipment and thus cannot be hit by such.

So far, good experiences have resulted on projects. No banks- or flagpeople have been appointed and no further accidents have occurred. Safety statistics have from 2000 through 2009 have indicated a steady decline in Lost Time Injury Frequency (LTIF).
The NINA programme addresses these issues by setting out unequivocal standards and explaining clearly the expectations for staff and sub-contractors regarding safety conduct. The basis for the NINA safety programme is a Vision Statement, which is based on five core values and five rules.

VALUES & RULES

The five core values tell people what we expect from one another in terms of safety. Each value starts with the word “I” to emphasise individual commitment and responsibility (Figure 2). The fundamental value is that each person is responsible for his or her own safety, but also for the safety of colleagues. So adhering to the Values means taking action when unsafe situations are observed and talking to others if we think they are at risk.

These actions must be taken regardless of rank or position: No one on any level of the organisation should be angry or insulted if a colleague makes a suggestion that prevents an accident or saves a life. Each and every employee must always be open to feedback from other people about their safety conduct.

One of the main focuses of the launch was to gain the trust of all employees and convince them that everyone in the organisation, including (top) management, will work on the basis of these values and encourage others to do the same.

The five rules constitute a set of useful tools that support the values and put them into hands-on practice. To establish a healthy and safe working environment, one must be aware of the associated risks. Health and safety risks vary from project to project, and from place to place. Having the right tools on hand for assessing risks, taking the right action and informing everybody involved are essential steps in the implementation process. The objective is to discuss which initiatives to take and which instruments and tools to use to make the values and rules a success on each specific project, vessel or work location. Every project has its own specific size, activities and local conditions so instruments can be used flexibly.

Figure 1. To launch the NINA programme, Peter Berdowski is shown signing the poster listing the five core values of the programme.

Figure 2. The poster with the five core values and five rules.
CONCLUSIONS

The global introduction to NINA is now in full swing. NINA is backed up by an extensive training and workshop programme that gives all employees an understanding of the NINA principles and shows them how to put the principles into practice. The introduction process will continue over the next few months. During that time, NINA will be presented through training sessions, start-up meetings and site visits. The important aim of this training programme is to win the trust of all employees and convince them that addressing issues to improve safety and notifying someone when a situation seems unsafe is in everybody’s best interest.

In addition, the dedicated site www.boskalis-nina.com clearly sets out the NINA goals and philosophy. The NINA site keeps everybody informed of the latest developments and also makes it possible to send feedback about NINA and safety problems in general.

COMPONENTS OF THE PROCESS

Extensive weekly training sessions and workshop programmes must be conducted. The first took place in the Netherlands in late August. Now 40 to 50 workshops on all layers of the company are taking place every week. From September onwards, the global NINA start-up meetings in Boskalis’ home markets on international projects and on the fleet are underway (figures 3 and 4).

A new Q-Aid quality management system was released in August 2010, incorporating the NINA principles, and the NINA site www.boskalis-nina.com was launched.

The training and workshop programme is tailor-made and focuses on several levels of training:
• Senior Management Training
• Management Training
• Do-it Training for Supervisors
• Do-it Workshop for Operational Personnel

The idea behind NINA is to help achieve the shared goal of an injury/accident-free workplace. Injuries and accidents can only be avoided if everyone is equally committed to the programme.

Figure 3. A group discussion during a training session.

Figure 4. Studying “My NINA Implementation Plan”.

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ABSTRACT

The Federal Republic of Nigeria is desirous to develop her inland waterways through the agency the National Inland Waterways Authority (NIWA), which operates on behalf of the Federal Ministry of Transportation. By a Presidential directive the development of a Master Plan together with a Bankable Feasibility Program was started early 2006. The overall project scope for the project included the following aspects:

- Prepare a Comprehensive Master Plan for the development of the inland waterways in Nigeria
- Carry out a feasibility study on the socio-economic, financial, technical and environmental viability of such a project justifying required investments
- Develop a Marketing Plan to promote inland waterway transport as an important and attractive mode of transport.
- Execute the construction works itself.

The River Niger measures a total length of 4,200 kilometres and is one of the longest rivers in Africa. Navigation on the River Niger is not new. Already in 1832 the steam vessel Alburkah sailed up the river and managed to reach Lokoja which lies 500 km inland from the Atlantic Ocean. The total length of the Lower River Niger to be dredged between Baro and Warri measures approximately 575 km.

The river has a strong meandering character and has no regulating measures to guide the flow (Figure 1). Another significant characteristic of the river is its water level which varies up to 9 metres between the dry season and the rainy season. To maintain water depths during the dry season would require so-called River Training Works.

INTRODUCTION

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CHALLENGES: EXTREME DEPTH CHANGES
The execution of a large-scale project as the River Niger project has many challenges. During the rainy season (June till September) the output of the river increases from 1,800 m³/sec to more than 20,000 m³/sec. This has a major impact on the current, which can peak to more than 3 m/sec.

During the dry season the river becomes so shallow that, in addition to the construction of a navigation channel, measures are going to be taken to guide the water in such a way that the minimum water depth can be guaranteed. These so-called River Training Works include the construction of cross dams which block branches of the river and provide guidance of the main stream and protection of the river banks by the construction of groynes.

THE PROJECT
The total length of the Lower River Niger to be dredged between Baro and Warri measures approximately 575 km and has been divided into 5 sections. Van Oord has been awarded sections 3 and 4 with a total length of approximately 250 km. These two sections stretch from the Jamata Bridge north of Lokoja to the Niger Bridge at Onitsha and also include the River Training Works, which are unique to this section and not included in the other sections.

DESIGN AND SOLUTIONS
The tender design was drafted by Royal Haskoning in 2002 and describes a navigation channel alignment and the locations of the cross dams and groynes. As the actual project execution only started in 2009 the design needed to be verified to check if its parameters were still valid. This formed part of the scope of work for the contractors.

For this reason a survey team started early 2009 with a so-called “Thalweg Survey” to verify if the original channel alignment was still located along the deepest points in the river. The main goal of this Thalweg survey was to ensure that the Navigation Channel Alignment was following the deepest part of the river to minimise maintenance activities in the future. On completion of the capital dredging this Thalweg Survey proved to be an accurate basis for the channel alignment.

To ensure safe navigation of the vessels the alignment also has to meet with some other design parameters:
• Channel shall be minimum 60 metres wide with a minimum depth of 2.5 metres
• Curve radiuses are to measure a minimum of 600 metres
• Each kilometre of the alignment shall only include one change in direction
• The angle between the channel alignment and the main stream of the river shall not exceed 30º
• Operators shall have a line of sight of minimum 5 ship lengths

Clearly, a compromise between all the parameters had to be found, keeping in mind that the volume of material to be dredged was to be kept to a minimum.

PROJECT EXECUTION
Two cutter suction dredgers, CSD Eendracht and CSD Calabar River (Figure 2), are operating on the Lower River Niger Project. In addition, a large spread of auxiliary equipment is on site to allow the dredgers to work independently (Figure 3). The equipment includes two house boats, two multicasts, three tugboats, a workshop barge, 5 storage pontoons, 5 crew tenders and various dry earth moving equipment. All the equipment arrived on site during August 2009. The dredging activities commenced on September 17, 2009 after the official flag-off ceremony in the presence of the President of Nigeria, His Excellency Yar’Adua. The dredged soil, mainly sand, is deposited along the riverbanks and in special depots along the river. Purpose of these depots is to sell the sand and use the income for the development of villages and

Figure 2. The cutter suction dredger Eendracht on the Niger.

Figure 3. Various auxiliary equipment on the river project.
roads along the river (Figure 4). To date Van Oord has completed the capital dredging of the Navigation Channel covering the full length of 250 km between Jamata Bridge north of Lokoja and the Niger Bridge at Onitsha. Also a total of 300 navigation buoys have been supplied and placed to mark the alignment of the navigation channel to its users. In addition to the capital dredging activities the contract also include maintenance dredging for a period of two years which has also been allocated for the construction of the afore-mentioned River Training Works.

RIVER TRAINING WORKS
At various locations the river is so shallow that even with maintenance dredging the water depth of 2.5 metres cannot be guaranteed. To solve this problem a total of 18 cross dams are to be constructed. The main purpose of a cross dam is to block a secondary branch of the river to guide the water towards the navigation channel alignment. This will increase the velocity of the water and therefore the erosion of sediment on the bottom to ensure the required water depth. The cross dams are to be constructed using sand dredged from the Navigation Channel and are protected by a layer of rock materials contained in gabions. In addition to the cross dams, the contract also provides for the construction of 14 groynes. The main purpose of these groynes is not the guidance of the river flow but to protect some of the outer bends of the river to stop erosion.

LOGISTICS AND THE SITE
From logistic aspects the contract stipulates that dredging is to be executed from upstream to downstream. As facilities along the river are limited, Van Oord also mobilised two large house boats to house the crew and staff for the execution of the works. This results in a transient site character whereby all equipment is moving in one spread down the river. Besides accommodations, the house boats also provide catering and medical facilities.

Before mobilising to site all equipment was prepared at the Van Oord main yard in Port Harcourt situated in the Niger Delta. Given the shallow areas in the River Niger the equipment could only be mobilised to site during the high water period in 2009. The voyage whereby all equipment was travelling in a convoy escorted by security units of the army took exactly four weeks (Figure 5).
Working in Nigeria also means that the project team must liaise with the communities along the project site. This can be challenging. For this reason separate community liaison officers have been employed and trained where required. The main task for the liaison officers is to communicate with the various communities affected by the work and diffuse any potential situations. Where possible, requests are honoured. Compensation, if applicable, is agreed upon after consultation with the client (Figure 6).

**SOCIAL RESPONSIBILITY**

Working in an environment such as the River Niger project also means that the project team comes in contact with the true way of life of the local population along the river. The role of social responsibility is taken very seriously and many local community projects have been organised. These projects involve the construction of boreholes for the supply of water, construction of school blocks, support to orphanage houses, and so on. The local population welcomes these community projects as they have a positive effect on both the project execution as well as the general living standards along the river (Figure 7).

**CONCLUSIONS**

The River Niger Project is a multidiscipline project which offers numerous challenges. Scale, social and economic importance as well as the cultural and engineering challenges make it a unique project. To date the project is fully on track, various milestones have been achieved and the Capital Works have been completed.

For the coming two years the channel will need to be maintained and this includes the construction of the River Training Works. Participating in a project of this type gives a sense of fulfilment: It will increase the transport of goods over the water and will thus make a long-term contribution to the welfare of the population living along the river. The satisfaction of the client – the Nigerian Inland Water Authority – will hopefully lead to continuing activities even after the project has been completed.
BEACH MANAGEMENT – PRINCIPLES AND PRACTICE
ALLAN WILLIAMS AND ANTON MICALLEF (WITH CONTRIBUTORS).
Published by Earthscan, Dunstan House, 14a St Cross St., London EC1N 8XA, UK. 445 pages. Hardcover. June 2009.

BEACH MANAGEMENT MANUAL – 2ND EDITION (C685)
J. ROGERS, B. HAMER, A. BRAMPTON, S. CHALLINOR, N. COOPER ET AL.

These two extremely useful, but remarkably different, publications both deal with the complex task of managing beaches. The former, published by Earthscan, specifically attempts to deal with a holistic approach to beach management without going into the details of coastal engineering. The latter originates from the coastal engineering background of the 1st Edition (CIRIA R153, 1996) but shifts strongly away from coastal engineering towards the multi-disciplinary culture of modern beach management, with the social, aesthetic, ecological and sustainability aspects of the wider environment. Taken together, these publications provide a suitably comprehensive and diverse view of beach management practice around the world to-day.

If nothing else, I would recommend that every beach management practitioner reads Charles Finkl’s excellent Foreword to Allan Williams’s book. This encapsulates the philosophy adopted by the authors and describes beautifully why beach management is needed. “…when left to their own devices, humans tend to destroy that which they love”.

He points out that Nature doesn’t need to be managed – we only find ourselves in a position where we have to manage the beach resource when, in our view, we perceive things have gone wrong!

Beach Management – Principles and Practice is divided into two halves; the first half lays out the principles of beach management, whilst the second presents a dozen case studies from around the world.

The initial chapter describes the beach processes and types, and the key elements relating to management, all in the context of integrated coastal management. Following this are chapters which outline the fundamental concepts of beach management, the various models for determining beach management strategy and management plans and appropriate beach management guidelines. To the reader these are the over-arching framework chapters that set out the beach management process.

Following these chapters, there are five sections on related subjects, which the authors clearly feel require highlighting. These cover:
- beach-user questionnaire surveys,
- environmental risk management,
- innovative application of selected management tools,
- beach award and rating schemes, and
- a bathing area registration and classification scheme.

These sections describe interesting tools for enabling the beach managers to better carry out their complex tasks.

The remainder of the publication is devoted to a variety of case studies from around the world, each presented by a different author. Apart from the general implications of Beach Water Safety Management, Marine Policy and Legislation, there are specific studies: Two each in Sardinia and the United States and one each in Ireland,
Brazil, Turkey, Spain, New Zealand, and the UK. They include examples of where sustainable management has partially failed as a result of inappropriate activity-focussed practices (New Zealand). One paper actually highlights the consequences of poor geological interpretation of whether a site is hazardous or not (USA). It is surprising how rarely this sort of information is provided, and how informative and useful the negative aspects of case studies can be.

The book is well-illustrated, relatively easy to read and follow, and contains a wealth of information on this huge subject area. It provides interesting and enlightening information for regulators, coastal engineers and scientists, beach managers and environmental scientists. A good index and plenty of references make the information in the book accessible and verifiable. Notably, the authors have arranged for all royalties from the sales of this book go to The Prostate Cancer Charity; a highly commendable gesture and one that hopefully will be copied by others in the future for suitably worthy causes.

The Beach Management Manual, on the other hand, is more prescriptive and extremely comprehensive, but still has the appearance of a coastal engineering manual, albeit with a significant amount of material relating to the sustainability of beaches and their performance. As noted in the introduction:

“The manual is primarily aimed at the management of beaches for the purposes of flood and coastal erosion risk management…. While other objectives of beach management are part of a beach manager’s job, these roles tend to be site specific and there is little guidance available that would be applicable for all. Where possible guidance on other functions, such as amenity and tourism, environmental aspects and heritage, has been included or referenced.”

The authors of this impressive manual all belong to recognised centres of technical excellence in the maritime and coastal engineering world. These are the Halcrow and Royal Haskoning consultancies, HR Wallingford Ltd and the University of Southampton. It would be invidious to highlight any specific organisations or personnel amongst the authors, the Project Steering Group or the external reviewers, other than to say that Dick Thomas, the Chairman of the Project Steering Group, had at his disposal the cream of the UK coastal practitioners in terms of experience, design, contracting, environmental and regulatory matters.

As one has come to expect with CIRIA publications, the manual is well laid out, detailed, authoritative and scientific. However, owing to its size and the complexity of the subject matter, the potential target audiences are given guidance on which portions of the publication may contain suitable guidance for whom. Essentially, the manual is split into four parts, as follows:

Part 1: Introduction, describing the background, and giving beach management objectives, performance criteria and management options, for both intervention and non-intervention.

Part 2: Monitoring and performance of beaches. This sets out the reasons for and the benefits of collecting data on the condition and performance of a beach. Based on considerable experience, guidance is set out on planning, implementation and management of targeted beach monitoring programmes.

Part 3: Decision framework for beach management. Having described the performance criteria for a beach and an appropriate monitoring regime, this Part provides guidance on how to make informed and objective decisions on whether to intervene and, if so, to what extent.

Part 4: Technical appraisal methods. This Part sets out various methods for comparing the different options for beach management, taking account of both sustainability, and any inherent uncertainties. Information on modelling options, their advantages and disadvantages, and good design practices are also discussed.

Each chapter in the manual is provided with references and useful websites where appropriate, and numerous figures, case studies and explanatory boxes break up the text. It would be impractical to provide a critique of the whole of such a large manual, but my limited sampling convinced me that the publication was readable, and that it was relatively easy to identify the desired subject matter, which was clearly described. The authors and their guiding committee should be congratulated on achieving such clarity and consistency.

This manual contains a wealth of information, and although it is written primarily for beach managers in the UK, would be of interest to a wide range of coastal practitioners around the world and in a variety of disciplines.

In conclusion, both of these publications should grace the shelves of any library or technical reference section devoted to beach management and coastal issues. Each book is available through the website of its respective publisher.

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NICK BRAY
DREDGING AND PORT CONSTRUCTION AROUND CORAL REEFS, REPORT NO 108 – 2010

One third of the world’s population lives in coastal areas, where rapid development has meant increased construction of coastal infrastructure such as ports, navigation channels, coastal defences, land reclamation and beach nourishment. This has inevitably led to conflicting priorities between coral reef conservation and economic growth. The concern is that development of ports and harbours can lead to the direct loss of coral reef caused by the removal or burial of reefs as well as stress to corals caused by elevated turbidity and sedimentation rates during dredging. Some effects may be immediate; others develop over a longer time frame and may be temporary or permanent. This publication attempts to separate fact from fiction and describe the real threats to coral and the potential solutions.

A healthy coral reef provides a rich array of services to human communities, including providing food (especially protein), protecting shorelines, supporting the livelihoods of marginalized communities, supporting huge tourism industries and sustaining cultural traditions. In contrast, unhealthy or degraded coral reef systems can be linked to human diseases, decline in natural resources, increased vulnerability of the coastal area and loss of cultural traditions. One estimate puts the economic value of the world’s coral reefs at US$345 billion per year. In contrast the cost of damages and for restoration of coral reefs has been estimated to be in the order of US$1,000 per m². How to evaluate the impact of dredging projects on this valuable resource, how to monitor these impacts, and eventually how to mitigate them, form the core of this study.

Working jointly with the United Nations Environment Program (UNEP), PIANC Working Group 15 has developed guidelines for the implementation of best practice methodology in environmental assessment and environmental management for dredging and port construction activities around coral reefs and their associated communities. The emphasis in this publication is on shallow warm water ecosystems.

The Working Group recognises that knowledge gaps still exist, and that the methods for monitoring and mitigating unwanted impacts on corals and associated organisms and ecosystems still need improvement. Still experience shows that by adopting sound planning, impact assessment, monitoring and management practices, large benefits can be achieved in terms of avoiding or minimising adverse effects on the coral reef environment from dredging and port construction. The book outlines key activities that should be undertaken during the planning process, as well as key Environmental Impact Assessment (EIA) activities, baseline surveys and predictive modelling.

The members of Working Group 15 include experts from a wide range of disciplines and organisations: Mr. Tom Foster (CEDA) (Chair), DHI Water & Environment; Ms. Emily Corcoran (UNEP) (Vice-Chair), UNEP/GRID-Arendal (formerly UNEP-WCMC); Dr. Paul Erftemeijer (PIANC NL), Deltares; Dr. Caroline Fletcher (CEDA), HR Wallingford; Mr. Kobbe Peirs (PIANC BE), Jan De Nul; Mr. Constantijn Dolmans (PIANC ENVICOM), International Association of Dredging Companies (IADC); Dr. Adam Smith (PIANC AU), Great Barrier Reef Marine Park Authority; Dr. Hidekazu Yamamoto (PIANC JAP), Environmental Consultants for Ocean and Human (ECOH); and Mr. Matthew Jury, DHI Water & Environment. In addition, at an early stage the draft document was opened to external reviewers spanning the entire range of stakeholders from government authorities to IGOs, NGOs and contractors. The input provided by these reviewers helped with the focus and balance of the document and without a doubt has increased its value.

For anyone working in a coral reef area, this new publication is must-read. It offers a new focus on the importance and vulnerability of coral reefs. Yet it supports the developer with assessment tools to construct economically needed ports and harbours in a manner that protects the coral and encourages sustainability.

For further information and to order the report, please contact Mrs. An Van Schel (PIANC General Secretariat) at an.vanschel@pianc.org.
7th International SedNet Event
APRIL 6-9, 2011
VENICE, ITALY

This year’s SedNet conference is entitled “Sediments and Biodiversity: Bridging the Gap between Science and Policy.” SedNet is the European network which aims to incorporate sediment issues and knowledge into European strategies to support the achievement of good environmental status and to develop new tools for sediment management. SedNet brings together experts from science, administration, industry and consultants. It interacts with the various networks in Europe that operate at national or international level or that focus on specific fields (such as science, policy making, sediment management, industry, education). Recently, special attention has been devoted to the integration of sediment management in the EU Water Framework Directive implementation process.

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MTEC 2011
APRIL 13-15, 2011
SINGAPORE

The International Maritime-Port Technology and Development Conference 2011 or MTEC 2011 is the 3rd of the MTEC series of conferences held alternately in Singapore and Rotterdam. MTEC2011 is jointly organised by MPA, NUS and NTU, and co-organised by the Port of Rotterdam and TUDelft. An exhibition featuring the latest R&D and technological products, systems and services in the port, maritime and offshore industries will be organised. Papers will focus on four key areas: Green Port and Shipping, Port Planning and Development, Port Operations and Technology and Offshore & Marine Technology. Prominent invited keynote speakers will offer their views on the latest development, technologies, practices and trends in each of the four areas.

For further information visit:
www.mtec2011.org

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MAY 5-6, 2011
FOUR SEASONS HOTEL, LIMASSOL, CYPRUS

The ESPO 2011 Conference, organised in co-operation with Cyprus Port Authority, will explore the complex but fundamental theme, “Optimising Port Performance: Measuring and improving the competitiveness of the European port system”, with the help of port practitioners, (port) community stakeholders as well as policy and academic experts. ESPO is currently coordinating the EC co-funded project ‘PPRISM’ (“Port PerfoRmance Indicators – Selection and Measurement”). The project involves five academic partners and aims to identify a key list of sustainable, relevant and feasible indicators to monitor the overall performance of the EU port system and assess its impact on the society, environment and the economy of the EU. The interim results of this project, which will form the basis of a European Port Observatory, will be presented and discussed at the conference. The programme will include an update on relevant EU policy developments. Finally, continuing the series of regional seminars held in Marseilles (2009) and Helsinki (2010), a special interest seminar will be held on port development in the East Mediterranean and Black Sea.

For further information please visit:
www.espo.be and/or www.espo-conference.com

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IAPH 27th World Ports Conference
MAY 23-27, 2011
BUSAN, KOREA

The conference theme “Embracing Our Future - Expanding Our Scope” was chosen because 2011 will be a time when the port industry will be undergoing many changes brought on by the economic crisis. It is important that the industry find new strategies to prosper in this newly developing economic climate. It is also time to face imperative global concerns, particularly climate change and the role of ports in climate action. As such, it is vital that the port industry explore all possibilities and not be limited to only advancing current technological practices. World Ports Conference 2011 will explore ways in which ports can improve efficiency and lower their environmental footprint and especially broaden their scope to meet the challenges of the changing market.

For further information visit:
www.iaph2011.kr

CALL FOR PAPERS

WEDA31/TAMU42 Annual Meeting
JUNE 5-8, 2011
GAYLORD OPRYLAND CONVENTION CENTER
NASHVILLE, TENNESSEE, U.S.A.

The Western Dredging Association (WEDA) and Texas A & M University will host their Annual Western Hemisphere Dredging Conference, with the conference theme “Enhancing the Economy Through Dredging”. The conference will focus on dredging and environmental issues associated with dredging programmes that create a strong economy and enhance the marine environment. This conference will be a forum for discussions
**PRE-ANNOUNCEMENT**

**Contracting Without Limits**
**CEDA-IADC Contract Management Event 2011**

**JUNE 2011**
**LONDON, UK**

Contracting Without Limits will bring together the main players of construction projects – project owners, contractors and consultants – for an in-depth exchange of knowledge to explore the benefits of adopting the philosophy of “contractual partnering”, a co-operation between these players from the very early stages of project development and to identify obstacles to early co-operation and possible ways to deal with / remove these.

This free-spirited event aims to disseminate existing knowledge and to stimulate new, creative ideas for achieving solutions for Best for the Project (win-win). Whilst the event’s primary focus will be maritime infrastructure construction projects, experience, lessons learned in other industries will also be sought. The target audience comprises but is not limited to experts involved in maritime infrastructure projects: project principles/project owners (both experienced and less experienced), development agencies; dredging contractors; consulting engineers; construction lawyers and legal counsels; project financiers; advisors to decision makers.

The two-day event will consists of presentations by distinguished experts and interactive workshops, including:

- **Keynote speeches** to introduce the audience to the benefits of early contractor involvement and the challenges that project owners face.
- **Case studies** which focus on the thinking and strategy behind early co-operation and the creative ways found by the project owners in dealing with regulatory and other challenges.
- **Workshops** which build on the case studies and attempt to answer questions such as: What does the “ideal” contracting procedure look like? What are the obstacles to implementing the “ideal” procedure in current practice? What are the possible ways to close to gap between the “ideal” procedure and practice.

**For further information contact:**
CEDA: www.dredging.org; IADC: www.iadc-dredging.com

(<300 words). Submission of Abstract implies a firm commitment from the author to present the paper at the Conference.

The International Association of Dredging Companies will present its Best Paper Award for a Young Author 35 years of age or under. Authors who wish to be considered for this award are requested to indicate their birth date.

*Interested Authors should send their one page abstract to one of the following:*

Dr. Ram Mohan, Partner, Anchor Environmental QEA
Tel: +1 267 756 7165, Fax: +1 267 756 7166
Email: rmohan@anchorqea.com

Dr. Robert E. Randall, Professor & Director, Department for Civil Eng., Center for Dredging Studies, Texas A&M
Tel: +1 979 845 4568, Fax: +1 979 862 8162
Email: r-randall@tamu.edu

Robert Wetta, President, Dredging Supply Co., Inc.
Tel: +1 985 479 8050, Fax: +1 985 479 1367
Email: rbwetta@dscdredge.com

**CEDA Dredging Days 2011**
**NOVEMBER 9-11, 2011**
**AHOY ROTTERDAM, THE NETHERLANDS**

This is the Call for Papers for CEDA Dredging Days 2011, with the theme, “Dredging and Beyond”. Dredging is no longer a stand-alone exercise, but is part of a broader, more integrated project realisation process. The dredging industry is increasingly confronted by projects involving environmental protection, nature development, offshore energy production and mineral mining on the sea floor. We are no longer in the era of “Dredging and nothing but dredging”, we are in the century of “Dredging and beyond”.

CEDA Dredging Days provide an important forum for debating innovative approaches, and presenting cutting-edge dredging tools and technology. CEDA Dredging Days 2011 will focus on two main areas where this integrated dredging approach is emerging:

- Dredging and rock dumping for the offshore oil and gas industry and deep-sea mining
- Building with nature for soft and hard dredging solutions (coastal and inland)

Representatives of manufacturers, universities, research institutes, contractors, consultants and public authorities working in the dredging, deep-sea mining, offshore oil and gas fields as well as in coastal and inland flood protection are invited to submit papers for the conference. Topics of interest include but are not limited to:

- Dredging for the offshore oil and gas industry: challenges in deep sea or near shore conditions
• Deep sea mining for natural resources
• Building with nature for soft interventions and/or hard structures

Academic session
In addition to the main conference sessions, and in CEDA’s continued support of the industry’s younger members, students and young professionals are invited to submit abstracts of paper on any subject related to dredging. These will be presented as part of the new Academic Session - an integral, and popular, part of the technical programme. The International Association of Dredging Companies will present its Best Paper Award for a Young Author 35 years of age or under.

Submission of Papers
For full details of how to submit abstracts and papers, and the terms and conditions, prospective authors should visit the conference website at www.cedaconferences.org/dredgingdays2011. Titles and abstracts (maximum 300 words) of papers should be submitted on-line by January 14, 2011.

CEDA Dredging Days 2011 will be held in conjunction with Europort 2011 (November 8-11).

For further up-to-date information see:
CEDA Secretariat
Tel: +31 15 268 2575
Email: ceda@dredging.org
www.cedaconferences.org/dredgingdays2011

Smart Rivers 2011 Conference
SEPTEMBER 13-16, 2011
WESTIN CANAL PLACE
NEW ORLEANS, LOUISIANA, U.S.A.

The next installment 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 will take place in September 2011. This 3-day technical specialty conference is organized 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 cooperation agreement between American and European partners, and was followed by the organisation of Smart Rivers Conferences in Pittsburgh (2005), Brussels (2006), Louisville (2007), and Vienna (2009). The overarching theme of the 2011 Conference in New Orleans is “Systems Thinking,” with a particular emphasis on making this a global conference.

On the abstract submission:
• Designate the conference technical theme listed that best fits your presentation.
• Provide the required contact information (name, company, address, phone and email) for the corresponding author and any co-authors.
• Include a text-only summary description (limited to 500 words) of the topic of the presentation and a statement of why the presentation will be of interest and benefit to conference attendees.

Key Dates:
Abstracts Due: ......................... January 24, 2011
Author Notification: ..................... March 1, 2011
Presentations Due: ....................... August 30, 2011

Proposing authors must recognise that submission of an abstract indicates commitment to attend the conference to make the presentation. PIANC USA will accept or reject proposed presentations based on the information provided in the abstract. To the extent possible and appropriate, presentations will be assigned to conference technical sessions based on the theme identified by the author. PIANC USA reserves the right to assign presentations to other conference sessions.

For information about abstract submission or the conference, please contact:
PIANC USA
Tel: +1 703 428 9090
Email: pianc@usace.army.mil
www.pianc.us or www.smartrivers.org

PIANC-COPEDEC VIII
FEBRUARY 20-24, 2012
IIT MADRAS, CHENNAI, INDIA

The Indian Institute of Technology Madras is hosting PIANC-COPEDEC VIII with the theme, “Meeting the Challenges of the Coastal Environment”. This continues a tradition of special conferences held once in four years in a developing country. Previous venues were Beijing, China, Mombassa, Kenya, Cape Town, South Africa, Colombo, Sri Lanka and Dubai, UAE. The merger of PIANC with COPEDEC (Coastal and Port Engineering in Developing Countries) has greatly enhanced the viability and professional interest in the conference. Papers will be presented in seven broad themes with special reference to the needs of countries in transition: Port and coastal infrastructure engineering; Port, harbour and marine planning and management; coastal stabilisation and waterfront development; Coastal sediments and hydrodynamics; Coastal zone management and environment; Coastal risk management; Coastal and inland shipping; and Marine data acquisition and management. Abstracts should be submitted through the website or forwarded to the paper selection committee by email before March 31, 2011. Detailed information about registration and hotel will be issued in August 2011.

For further information please register at:
Email: copedec2012@iitm.ac.in
www.pianc-copedec2012
MEMBERSHIP LIST IADC 2010

Through their regional branches or through representatives, members of IADC operate directly at all locations worldwide.
MAASVLAKTE 2:
an innovative engineering contract

ARTIFICIAL UNDERSEA RIDGES
for restoring depleted fisheries

INTRODUCING “NINA”:
a personal commitment to safety

DREDGING THE RIVER NIGER
to improve inland water transport