FACTS ABOUT
An Information Update from the IADC
number 04 | 2012

INITIATING HYDRAULIC FILL PROJECTS

WHAT IS HYDRAULIC FILL?

Hydraulic Fill is fill in which the materials are deposited by a flowing stream of water. This fill material will originate from a borrow area or dredging site and be transported to the reclamation area by dredger, barge or pipeline. It is then placed as a mixture of fill material and process water in the reclamation area. Hydraulic Fill has a wide variety of applications for infrastructure construction projects.

WHAT KINDS OF PROJECTS USE HYDRAULIC FILL?

Hydraulic Fill is used for reclamation projects, which means land creation for a range of purposes – from building or extending an airport platform to land for residential or recreational areas to industrial construction such as an LNG plant or nuclear power station. Other projects where Hydraulic Fill is used are the restoration of eroded beaches and construction of coastline defences as well as for environmental and habitat restoration or creation, for instance, of wetlands.

WHY IS KNOWLEDGE ABOUT HYDRAULIC FILL MATERIAL AND HYDRAULIC FILL PROJECTS IMPORTANT?

No two situations are the same. The quality of the Hydraulic Fill to be used is crucial to the quality of the end product. The end product or application will have specific performance requirements and the characteristics of the fill mass will determine how well these performance criteria are met. The physical conditions of project areas may differ dramatically. Wave climate, currents, water depth and subsoil conditions as well as the sensitivity of the environment and availability of fill at or nearby the site are essential factors to be considered. Determining the characteristics of the available borrow material such as type, grading and silt content is also important as these may vary considerably. In some cases the borrow material may need specific construction and/or treatment methods in order to become suitable fill material.

WHAT KIND OF KNOWLEDGE ABOUT HYDRAULIC FILL IS IMPORTANT?

Detailed knowledge from a wide variety of disciplines in geotechnical engineering, hydraulic engineering and mechanical engineering combined with practical know-how and experience of dredging and filling techniques are all critical. Insufficient information about the technical specifications of a reclamation project can lead to inadequate and conflicting specifications, to construction requirements that cannot be met and/or to excessive costs for fill treatment and testing.

These developments may frustrate the tender process, may cause serious problems during construction and quality control and may lead to long-lasting, costly arbitration cases. The formulation of generally accepted guidelines and reasonable specifications should be established. In this way the client can understand and properly plan a reclamation project and the consultants and contractors have adequate guidelines for design and quality control.

WHAT DRIVES THE DESIGN PHILOSOPHY OF A HYDRAULIC FILL PROJECT?

The design philosophy of a Hydraulic Fill project should match the anticipated loading response of the fill mass to the requirements imposed by the future use of the reclaimed land – all within the technical boundary conditions of the project.

Pictured above: A trailer suction hopper dredger placing sand fill in a reclamation area by rainbowing.

The requirements for a beach nourishment project, for example, differ from those of a reclamation area for an airport, which differ again from the requirements for a container terminal. Therefore, one can reasonably assume that the corresponding technical specifications resulting from the design process will also differ. For instance, to make a project feasible, fill material may not have to be restricted to sandy material; with certain technical measures and under certain conditions, cohesive and fine-grained materials (clay, silt) also may be used. The use of carbonate sands under some circumstances is also possible. Following this design philosophy should ensure that geotechnical specifications are reasonable, measurable and feasible.

WHAT STEPS NEED TO BE TAKEN DURING THE FIRST PHASE OF A HYDRAULIC FILL PROJECT?

To realise an optimal design, each project must be based on: the functional and performance requirements of the new land; the availability of suitable fill material; the soil conditions at the fill area; and the selection of dredging equipment appropriate to the related construction methods.

That means that from the very start the use of the reclaimed land should be defined and the availability and quality of a source for the suitable fill should be located. Data should be collected including legal aspects, environmental requirements and initial project planning. Feasibility studies should be conducted and the type of contract should be established.

The design of a Hydraulic Fill project should be a logical process that results in the best and most economical match between the properties of the reclaimed area and the requirements imposed by the future use of the reclaimed land, all within the boundary conditions of the project and the results of the Environmental Impact Assessment. The design process quite often followed is that of the so-called “Systems Engineering” approach.

WHAT IS SYSTEMS ENGINEERING?

Systems Engineering is a worldwide accepted tool for the design of complex projects. Many sectors of industry such as aero and space technology, telephone systems, the defence industry and computer technology follow this system. This method has also proven its suitability for large infrastructure works and has been successfully applied to projects which have a Hydraulic Fill component.

Systems Engineering is an interdisciplinary exercise, focussing on defining a client’s needs and required functionality early in the development cycle. Thereafter, a structured evaluation and feedback system takes place as the cycle rolls out. First the client’s needs and functionality requirements are input to the design and feasibility analysis of the project. Steps in the development cycle are then evaluated at certain pre-defined moments and, if needed, adjustments are made. Such adjustments may include the design itself, but also the needs and functionality requirements formulated for the project. Structured evaluation and feedback throughout the development cycle aims to arrive at the most effective and economical solution of the client‘s needs. As the development cycle proceeds the outline of the system becomes increasingly detailed. To ensure the necessary expertise, the integrated approach may already enlist consultant/advisors and contractor specialists at an early stage of the development cycle.

HOW IS LAND USE DEFINED AND BY WHOM?

Land use is defined by the client as a set of functional requirements that are then translated into performance requirements. Functional requirements may be, for instance, the required capacity of a container storage area, or an airport including types of airplanes, or the area needed by the industrial users. Functional requirements also include the expected static and mobile loads, safety against external loads, environmental considerations and project boundaries.

Depending on the type of contract entered into by the parties involved, these functional requirements are translated by consultants and/or contractors into performance requirements like the size of the fill mass, criteria for (differential) settlement, slope stability, resistance against scour and minimum elevation against flooding.

HOW IMPORTANT IS THE AVAILABILITY OF A HYDRAULIC FILL SOURCE?

The availability of fill material is essential for realising a land reclamation. Fill may be obtained from a designated borrow area, from maintenance dredging or from capital dredging. For the feasibility of the project available volumes of suitable material and their distance from the fill area are important factors. Fine to medium quartz sands are preferable as fill material. However, if such quality is not available in the fill source, then lesser quality material, such as silts and clays, has to be accepted. This has its bearing on the design, the work methods and also on the costs.

WHAT TYPES OF DATA SHOULD BE COLLECTED FOR THE DESIGN AND CONSTRUCTION OF A HYDRAULIC FILL SITE?

For the analysis of the feasibility of the project and for the definition of the functional fill requirements, data need to be available at an early stage of the project realisation process. Additional investigations may be required in hydraulic, meteorological, morphological and environmental parameters that affect the design.

Data is required about the subsoil parameters of both the Hydraulic Fill area and the borrow area. These are collected with a detailed soil investigation programme including sampling, drilling and laboratory investigations. Soundings of the fill and borrow areas are used to establish the bed elevation and volumes. For provisions required for environmental permits, knowledge about whether or not the

material to be used is contaminated is essential. To determine the loads and possible erosion, the water levels and wave climate in the fill area must be investigated. In some cases investigating both the borrow and placement areas for the possible presence of ordnance may be necessary.

WHAT ARE THE LEGAL MATTERS REGARDING HYDRAULIC FILL PROJECTS?

Legal matters about a Hydraulic Fill project can be related to applicable legislative and government directives. Such issues include nature and environment, zoning plans and local regulations. Various work permits are usually required from regulatory agencies and responsibilities are often specified within this framework. The procedural periods for these legal aspects can be quite lengthy and should be considered early on to avoid delays at a later stage.

WHAT ARE THE ENVIRONMENTAL REQUIREMENTS FOR HYDRAULIC FILL PROJECTS?

Three basic environmental requirements need to be fulfilled: demonstrate that no contaminants are present in both the borrow and fill areas; determine the impact of the project on flora and fauna; and determine the possible effects of the extraction of fill material on the environment.

Environmental effects must be within the limits stipulated in permits and described in an Environmental Impact Report (EIR). If these effects are not within the prescribed limits, measures must be indicated to minimise or compensate the environmental impact/effects. Therefore, knowing the extent of environmental impacts early in a project is important. For instance, when large volumes of fill material are dredged, transported and placed, some of this material may be eroded during the construction or user phase. Determining whether or not this eroded material settles elsewhere and whether or not this may cause a problem (by local siltation) is essential. In case of unacceptable settlement, measures must be defined to prevent such settlement.

The extraction of borrow material as well as the placement of fill material in the coastal zone or a riverbed can change the sea currents or river flow, which can cause changes in erosion patterns and siltation. This must be considered both at the design stage and during construction.

WHAT ELEMENTS SHOULD BE INCLUDED IN THE INITIAL PROJECT PLANNING FOR A HYDRAULIC FILL PROJECT?

In the initial stage of a project the main milestones of intermediate realisation should be clear. This planning should indicate the required dredging capacity to produce the required sand volume within a certain timeframe. Other planning points for the timeframe are: for the design; for obtaining permits; and for acquiring ownership of land areas on which the project is to be realised. The outcomes of these initial findings will help determine the feasibility of the project.

Distribution and shaping of fill material by a bulldozer.

WHAT TECHNICAL ANALYSES ARE NECESSARY FOR THE FEASIBILITY STUDY?

Technical analyses include: the feasibility of the design, especially regarding soil conditions and material available in the borrow area, and insight into the volumes and quality of sand in these borrow areas and the dredgeability of these materials. For instance, suitable sand may be overlain with clay or peat or unsuitable fine sands, which have to be removed. The borrow area may be sheltered from waves or positioned offshore exposed to wave action, which is of consequence for the dredging method. Working with these physical circumstances will require an understanding of the capabilities of various dredging equipment.

The subsoil conditions in the fill area itself determine: the extra height of the fill to compensate for consolidation and creep settlements in case of soft underlying clay layers; the method of placement which may be in relatively thin layers; and/or the placement of sand layers in intermittent periods to avoid instability. Soft underlying clay layers may also have to be removed before sand fill is placed or vertical drains may be installed through the soft layers to accelerate consolidation and to strengthen the bearing capacity of the subsoil.

In case of removal, such material may be stored in depots on site or removed from the site and applied, if possible, for a beneficial use.

WHAT FINANCIAL ANALYSES SHOULD BE PART OF A FEASIBILITY STUDY?

Financial analyses must be conducted at an early stage of the project definition. The financial feasibility is determined by the costs and benefits of a project. Costs include the dredging and construction costs, possibly extra costs for opening up the area such as for access roads or canals, costs of land acquisition, exploitation costs and maintenance costs. Land reclamation works are often of such magnitude that long-term costs and benefits have to be considered. A feasibility study often requires the study of alternative designs for the project in a search to select the optimal design and appropriate dredging method.

In the initial stage of the project the realisation costs may have to be assessed using broad estimates. As the project evolves and becomes more detailed, more data become available and more accurate figures can be produced. In order to prevent disappointment, the feasibility must be judged at a distinctive decision moment such as after conceptual design and after preliminary design and the design may have to be adjusted accordingly.

Long-term benefits may be derived from port dues in the case of a harbour extension, landing fees for an airport, economic benefits in the case of new roads or railways, safety against loss of land as well as loss of life and goods in the case of a dike structure, and so on.

WHAT RISKS ARE PRESENT IN HYDRAULIC FILL PROJECTS?

An important feature of the feasibility study is an analysis of the project risks inherent in realising a project. The nature of these risks may be technical, financial, economic or political. Whether the client is a governmental agency or a public or private company may determine the legal position of the client and whether these risks can be insured. Whatever the case, the first approach should be to mitigate these risks.

WHAT ARE THE TECHNICAL RISKS OF A HYDRAULIC FILL PROJECT?

Technical risks can include uncertainties about the quality and volume of the fill, both required and available in the borrow area; about the nature of the subsoil upon which the fill is applied; about available equipment to realise the project, especially for larger projects; about slope stability; about adverse weather; about discharge water and other physical conditions; and about the project execution within the scheduled planning.

WHAT ARE THE FINANCIAL AND ECONOMIC RISKS?

Financial and economic risks include unexpected cost increases caused by adverse soil conditions, which may require different types of or additional equipment and/or a longer execution period, which will involve considerable extra costs. Also costs of arbitration, additional costs caused by inflation (fuel, wages, materials, ...) or an increase in royalties for the material from borrow areas, bankruptcy of either party, unstable currency, adverse profit margins or overly optimistic budgeting and a change in economic expectations.

Project planning forms the basis for financial planning and is an important tool to mitigate financial and economic risks. An estimate must be made of the costs as the project proceeds and must be set off against expected future project income. Such a financial analysis is also often required prior to project financing by financial institutes, relevant governmental agencies, investors and others.

Risks may also include a change in the market demand which could be of consequence for the phasing of the project, for instance, resulting in more or less port users than originally predicted or more or less capacity required per port user. This could also cause a change in the phasing when certain parts of the port infrastructure become available such as quay walls or surface areas to accommodate container ships. All risks can to a great extent be managed using the ongoing cost-benefit analysis with all relevant parameters as input.

WHAT ARE THE POLITICAL RISKS?

Political risks may also occur although they are difficult to predict and manage, for instance, a change in government, which may change demands and boundary conditions, or strikes or other political unrest requiring arbitration or resulting in an unstable currency.

HOW IMPORTANT IS THE TYPE OF CONTRACT TO A SUCCESSFUL HYDRAULIC FILL PROJECT?

Very important. The tasks that must be completed in every construction process relate to initiative (I), design (D), building processes (B), financing (F), long-term maintenance and management (M) and the exploitation of the project (E/O). The main players in the construction process are the client, the contractor, the advisor and/or consultant, the end-user and the financier. How the contract is structured impacts their roles.

A few main contract formats can be distinguished: traditional, integrated and partnership or Alliance contracts. In a traditional contract responsibilities are split between each party. In integrated contracts two or more functions are integrated starting with the design and the construction. In a partnership or an Alliance contract, various tasks, responsibilities and risks of the construction process are shared between client and contractor, according to predetermined divisions, aiming to arrive at the most optimal project.

When executing a Hydraulic Fill project, the chosen contract format will definitely influence the interaction, the risks and the responsibilities of each party.

FOR FURTHER READING AND INFORMATION

This Facts About is based on the newly published book, *Hydraulic Fill Manual for Dredging and Reclamation Works*, edited by Jan van 't Hoff and Art Nooy van der Kolff (2012) and published CRC Press/Taylor & Francis.

FSC MIX Paper FSC® C004611

This brochure is presented by the International Association of Dredging Companies whose members offer the highest quality and professionalism in dredging and maritime construction. The information presented here is part of an on-going effort to support clients and others in understanding the fundamental principles of dredging and maritime construction.