

## IMIA-WGP 50 (07)

### Engineering Insurance Exposure related to Wet Risks



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## **1. Introduction**

### **1.1 Goal and Scope of the Paper**

The goal of this paper is to help the Underwriter's understanding of wet-works construction, to build up awareness for the wide variety of perils construction of wet-works is exposed to, to help to perform professional risk analysis and underwriting and to draw attention to possible loss scenarios by some illustrative loss examples.

The paper explains in the first part various types of wet-works and the technical aspects of wet-works construction. In the second part, the paper describes a variety of exposures, individual underwriting considerations, typical loss scenarios as well as risk management, safety and security aspects. The paper closes with the description and illustration of typical losses and loss scenarios.

The risks involved in the construction of offshore projects are not dealt with by this paper.

### **1.2 History of Wet-works Construction**

The first ports seem to have been built by the Phoenicians around the 13<sup>th</sup> century B.C in particular the ports of Sidon and Tyr (in Lebanon) which were important commercial platforms. These ports were developed for commercial reasons but also to support navy units.

The next step in port development was the construction of the port of Alexandria in Egypt around the 3<sup>rd</sup> century B.C which was separated in two parts by a pier, each part being used according to the wind direction. It was also the site of the first lighthouse made of white marble.

Ports started to develop along the Mediterranean, like the port of Piraeus in Athens and the port of Ostia in Rome. One can also mention the port of Syracuse in Sicily and that of Carthage in Tunisia. Construction methods were very labour intensive and used rock material available locally. The Romans also used semi-circular arches to build jetties with a better resistance to waves.

The first embankments in Europe were also constructed in Roman times

After the end of the Roman Empire, ports continued to develop in the Mediterranean and on the Atlantic coast. The first polders were constructed in the 11th century.

It was only in the XIXth century that techniques started to change with the industrial revolution. The XXth century saw the implementation of large infrastructure projects involving wet works and land reclamation projects. Port development was extensive all over the world with the creation of specialized terminals (solid and liquid bulk, containers, passengers etc.).

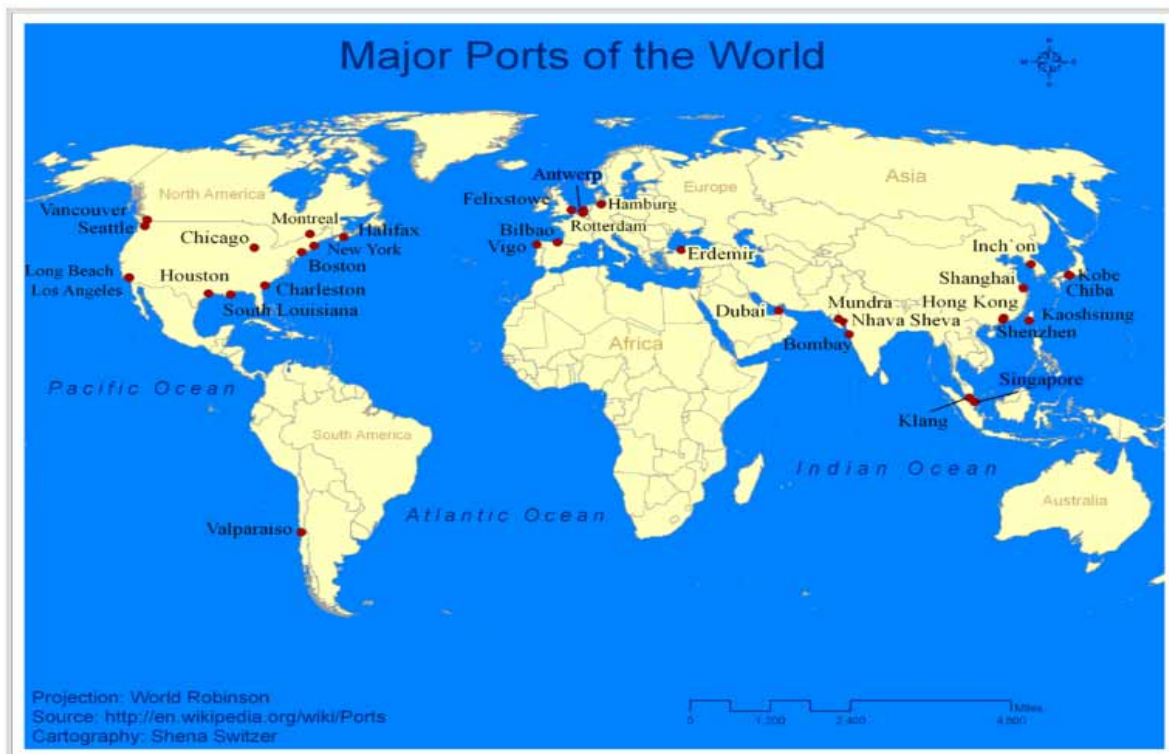
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### 1.3 Economical Aspects

The coastal zone has become increasingly important to the economic well-being of the countries world-wide. Recreation, tourism, residential and commercial development, ports and harbours are all expanding along the shoreline, and populations in coastal counties are growing faster than anywhere else in the developed countries. The United Nations estimated that by 2004, in excess of 75% of the world's population will live within the coastal zone. As example, in US:

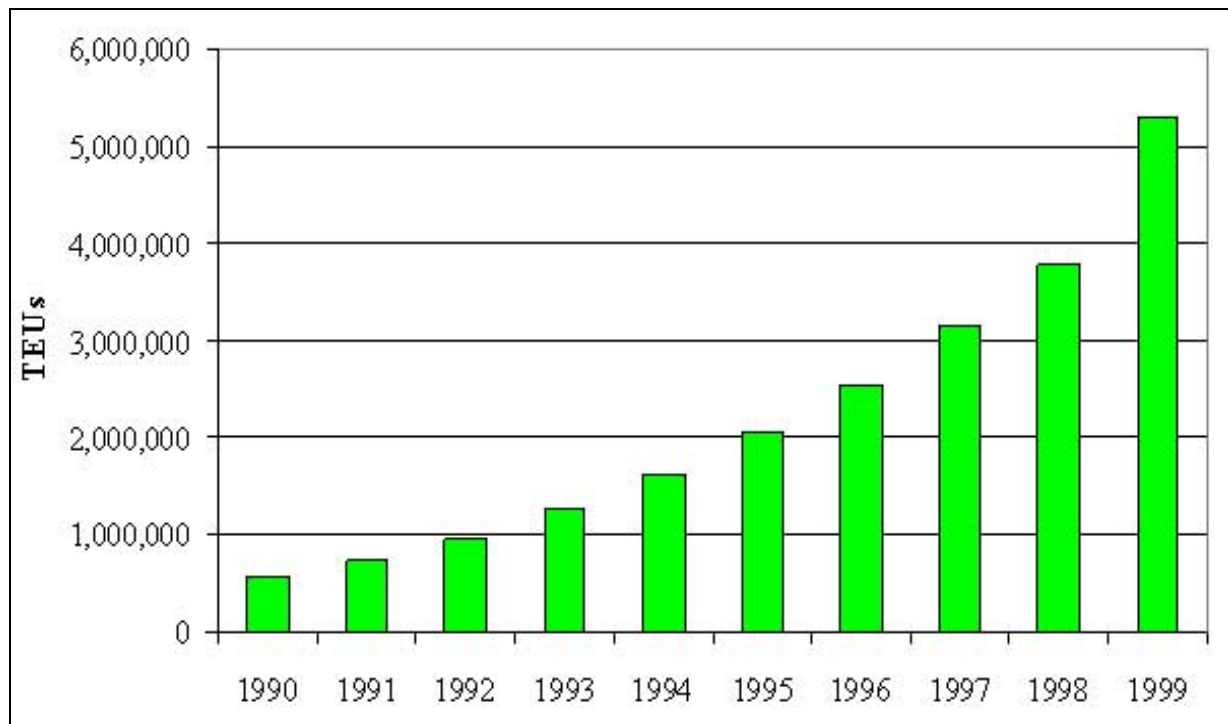
- one in every three jobs is now generated in a coastal county,
- 90 percent of foreign trade passes through U.S. ports,
- 33 percent of the GNP (gross national product) is produced in the coastal zone.
- More tourists from abroad visit beaches than national parks.
- Ninety percent of all foreign tourist dollars is spent in coastal states. This constitutes more foreign exchange than is derived from the export of manufactured goods.

As international trade has expanded, the nation's economy has become dependent on increasing volumes of both exported and imported goods, which has intensified pressures on ports and port facilities. As the density of ship traffic in harbours increases, investment in breakwaters, navigational channels, and ship navigation facilities becomes a priority. Most harbours must be regularly dredged and often deepened to accommodate large cargo ships. At the same time, contaminants concentrated in the sediments that are deposited in many harbours, along with increasingly stringent dredging and disposal standards (as well as water quality criteria and concerns about wetlands), have made port maintenance and expansion a major economic and environmental issue.



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The amount of cargo handled at the Shanghai ports has increased at a phenomenal rate:



From a pure construction industry prospective, port sector remains a significant market. The private sector, which has driven recent port development, has rapidly matured and has organized itself into distinct specialized sub-sectors. Today, the port services industry is a US\$45-60 billion global business that includes several distinct specialized segments, as:

	Estimated Annual Revenues
Container Terminal Operations	\$30 to 40
Tug Assist Services	4 to 5
Maintenance Dredging	4 to 5
Information Technology	2 to 3
Environmental and Ship Safety Services	1 to 2
Other Port Services	4 to 5
<b>Total Available Market</b>	<b>\$45 to 60</b>

## 2. Understanding Wet-works Construction

### 2.1 Introduction

The aim of this chapter is to give an overview on the technical aspects for the design and construction of Sea-works. The information provided shall enable the reader to understand how Sea-works construction works.

#### 2.1.1 Wet-works Categories

Should Wet-works be defined as “works in connection with the water”, the big majority of projects could be considered as Wet-works since the foundations often meet water during the construction. It has been decided to admit that “**marine works** are known to insurers as wet risks” (“Construction Insurance, Insurance Institute of London p.51).

#### 2.1.2 Types of Marine-Works

##### Harbour

A **harbor** or **harbour**, or **haven**, is a place where ships may shelter from the weather or are stored. Harbours can be man-made or natural. A man-made harbour will have sea walls or breakwaters and may require dredging. A natural harbour is surrounded on most sides by land.

Harbours and ports are often confused. A port is a man-made coastal or river facility where boats and ships can load and unload. It may consist of quays, wharfs, jetties, piers and slipways with cranes or ramps. A port may have magazine buildings or warehouses for storage of goods and a transport system, such as railway, road transport or pipeline transport facilities for relaying goods inland.

##### Dock (maritime)

A **dock** (from Dutch 'dok') is a man-made feature involved in the handling of boats or ships. However the exact meaning varies between different variants of the English language.

In ‘British English’, a dock is an enclosed area of water used for loading, unloading, building or repairing ships. Such a dock may be created by building enclosing harbour walls into an existing natural water space, or by excavation within what would otherwise be dry land.

There are two specific elaborations of the dock:

- **Impounded docks** are a variant in which the water is impounded either by dock gates or by a lock, thus allowing ships to remain afloat at low tide in places with high tidal ranges.
- **Dry docks** are a variant, also with dock gates, which can be emptied of water to allow investigation and maintenance of the underwater parts of ships.

A **dockyard** consists of one or more docks, usually with other structures.

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In 'American' English, a dock is technically synonymous with pier or wharf - any human-made structure in the water intended for people to be on. However, in modern use, pier is generally used to refer to structures originally intended for industrial use, such as seafood processing or shipping, and more recently for cruise ships, and dock is used for most everything else, often with a qualifier, such as ferry dock, swimming dock, etc. However, pier is also commonly used to refer to wooden or metal structures that extend into the ocean from beaches and are used, for the most part, to accommodate fishing in the ocean without using a boat.

In 'American' English, the term for the water area between piers is 'slip'.

In cottage country in Canada and the United States, a dock is a wooden platform built over water with one end secured to the shore. The platform is used for boarding and off loading small boats.

### Wharf

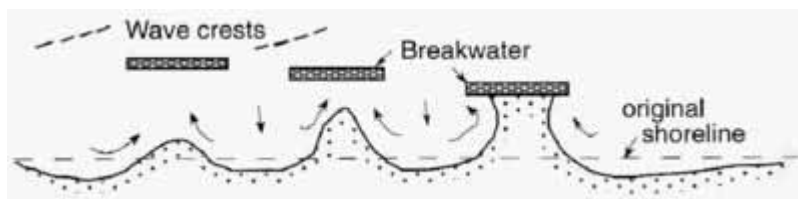
A wharf is a fixed platform, commonly on pilings, roughly parallel to and alongside navigable water, where ships are loaded and unloaded. They often serve as interim storage areas.

Smaller and more modern wharves are sometimes built on flotation devices (pontoons) to keep them at the same level to the ship even during changing tides.

The word comes from the Old English *whearf*, meaning "heap," and its plural is either *wharfs*, or, especially in American English, *wharves*; collectively a group of these is referred to as *wharfing* or *wharfage*.

### Breakwaters

Defence against coastal erosion



Schematic of shifting coastline with breakwaters

Offshore breakwaters reduce the intensity of wave action in inshore waters and thereby reduce coastal erosion. They are constructed some distance away from the coast or built with one end linked to the coast. The breakwaters may be small structures, placed one to three hundred feet offshore in relatively shallow water, designed to protect a gently sloping beach. Breakwaters may be either fixed or floating: the choice depends on normal water depth and tidal range.

When oncoming waves hit these breakwaters, their erosive power is concentrated on these structures some distance away from the coast. In this way, there is an area of slack water behind the breakwaters. Deposition occurring in these waters and beaches can be built up or extended in these waters. However, nearby unprotected sections of the beaches do not receive fresh supplies of eroded sediments and may gradually shrink due to erosion.

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Seawalls are subject to damage, and overtopping by big storms can lead to problems of drainage of water that gets behind them. The wall also serves to encourage erosion of beach deposits from the foot of the wall and can increase long shore sediment transport.

**Jetty**

The term jetty, derived from the French *jetée*, and therefore signifying something thrown out, is applied to a variety of structures employed in river, dock, and maritime works which are generally carried out in pairs from river banks, or in continuation of river channels at their outlets into deep water; or out into docks, and outside their entrances; or for forming basins along the sea-coast for ports in tideless seas

**Pier**

A pier is a raised walkway over water, supported by widely spread piles or pillars. The lighter structure of a pier allows tides and currents to flow almost unhindered, whereas the more solid foundations of a quay or the closely-spaced piles of a wharf can act as breakwaters, and are consequently more liable to silting. Piers have been built for several different purposes, and because these different purposes have distinct regional variances, the term *pier* tends to have different nuances of meaning in different parts of the world. Thus in North America and Australia, where many ports were, until recently, built on the multiple pier model, the term tends to imply a current or former cargo-handling facility. In Europe however, where ports have tended to use basins and river-side quays rather than piers, the term is principally associated with the image of a Victorian cast iron pleasure pier.

**2.2 Design of Marine-works****2.2.1 Determining Factors for the Design of Marine-works**

The design in many Marine engineering projects may be higher than in other civil engineering disciplines because the physical processes are so complex, often too complex for theoretical description. Also, because, the practice of Marine engineering, from concept to detailed layout, is still much of an art, practitioners should have a broad base of practical experience and should exercise sound judgment.

Significant engineering and geology, geomarine and hydrology engineering considerations when building Marine-works include:

Geology / Soil Conditions:

Detailed knowledge of the geology and soil conditions is crucial for the adequate design and construction of the Marine-works. The implied soil investigation programme has preferably to be developed by an expert who is familiar with the local conditions and the Marine environment.. When studying the detailed geological survey report, basis for the design of foundations and the body of Marine-works, special attention will be paid to:

- Bearing capacity and allowable stresses for shallow foundations
- Settlement of sand and other elastic settlements.
- Settlement of normally consolidated clays (soft clays often met in such projects)



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- Soil structure interaction
- Climate and Natural Perils:  
Flood, storm and earthquake exposure are to be considered when designing Marine-works.

Action of the sea:

Here again a special attention will be paid to the hydrographical and hydrodynamic surveys (Tides, currents. ...). As an example, the interactions of waves with the new structures supposed that oceanographic and engineering data collection is accomplished, including water level measurements. These data will be analyzed, and analytical results interpreted to define near shore bathymetry and coastal processes, and to design and to size the port works and protection against marine erosion. Often, a numerical and Physical modeling to estimate for example the sediment transport, the Wave refraction, diffraction, reflection, propagation and surf zone hydrodynamics is necessary. When general numerical methods for solving such flow equations are not sufficient, laboratory model tests can be necessary.

International and Local Standards:

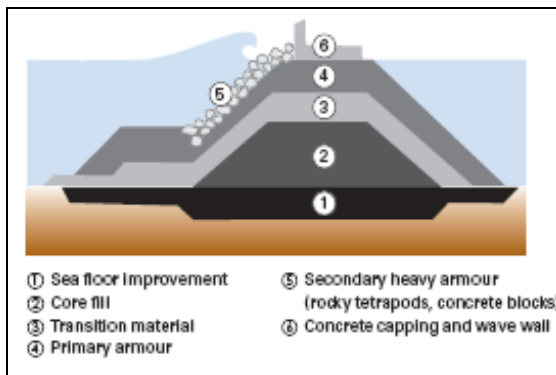
Marine-works have to be designed and built in line with internationally recognized standards like Eurocode. In a number of countries, local standards taking the local conditions into account are used.

Local Regulations and Laws (Marine traffic...)  
Existing / Third Party Property

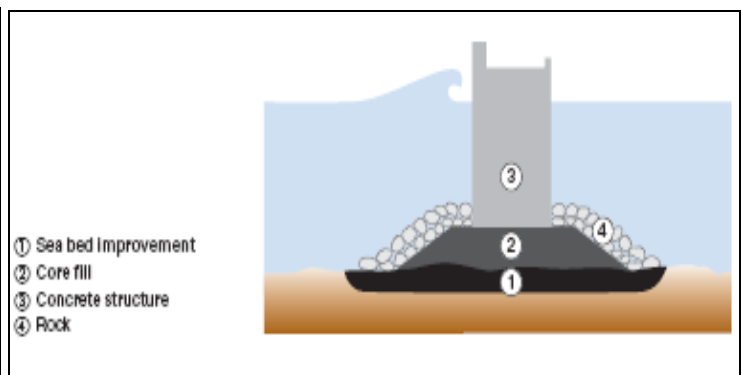
**2.2.2 Sea-works structure**

Types of breakwater structures:

A breakwater is constructed some distance away from the coast or built with one end linked to the coast. Breakwaters may be either fixed or floating: the choice depends on normal water depth and tidal range. A breakwater structure is designed to absorb the energy of the waves that hit it. This is done either by using mass (e.g. with caissons) or by using a revetment slope (e.g. with rock or concrete armour units).



Rubble mound breakwater cross-section  
Illustrations MR



Vertical wall breakwater

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Caisson breakwaters typically have vertical sides and are usually used where it is desirable to berth one or more vessels on the inner face of the breakwater. They use the mass of the caisson and the fill within it to resist the overturning forces applied by waves hitting them. They are relatively expensive to construct in shallow water, but in deeper sites they can offer a significant saving over revetment breakwaters.

Revetment breakwaters use the voids in the structure to dissipate the wave energy. Rock or concrete armour units on the outside of the structure absorb most of the energy, while gravels or sands are used to prevent the wave energy continuing through the breakwater core. The slopes of the revetment are typically between 1:1 and 1:2, depending upon the materials used. In shallow water revetment breakwaters are usually relatively cheap, but as water depth increases, the material requirements, and hence costs, increase significantly.

Various types of concrete shapes have been developed to afford some degree of interlocking (e.g. tetrapods, quadrapods, tribars, dolos...).



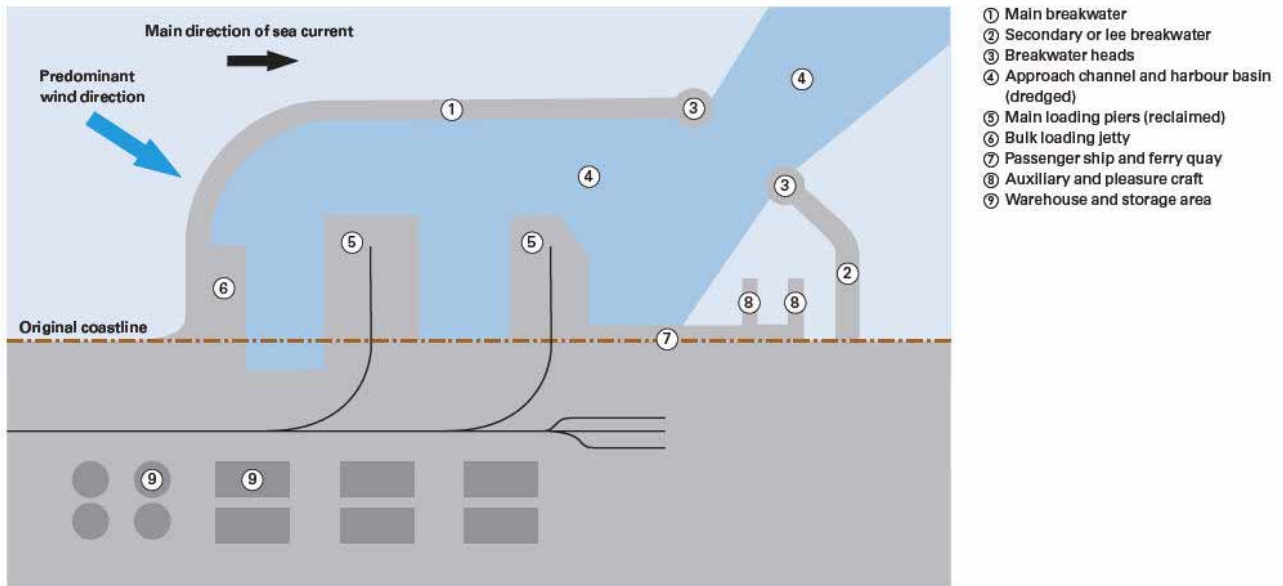
Floating caisson fabrication  
Illustrations MR



Placement of caissons

**Types of Jetty structures:**

The forms and construction of these jetties are as varied as their uses; for though they invariably extend out into water, and serve either for directing a current or for accommodating vessels, they are sometimes formed of high open timber-work, sometimes of low solid projections, and occasionally only differ from breakwaters in their object .



1 Principle features of a sea port  
 Illustration MR

**Types of Pier structures**

Piers can range in size and complexity from a simply lightweight wooden structure to major structures extended over a mile out to sea.

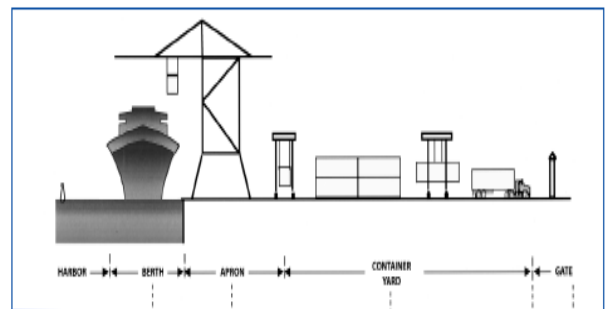
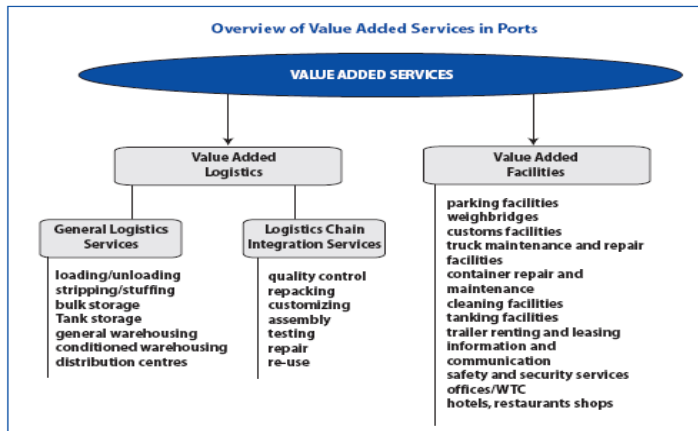
**2.3 Construction Costs**

Here is an example of breakdown of value of a Marine Project in the Middle-East:

Sr.	Description	Values in k USD
1	Site installation and temporary work	1,880
2	Workshops, stores, camps etc.	840
3	Dredging	30,814
4	Excavation	224
5	Filling (rock)	7,948
6	Breakwater	2,629
7	Quay Walls	25,679
8	Piers	NIL
9	Warehouse, silos, office buildings	Included
10	Road and railway facilities	1,753
11	Supply lines (gas, water, electricity, telephone etc.)	
	Technical installations (cranes, elevators etc.)	4,554
12	Other work	8,309
13	Contingencies + Day works	9,927
	<b>Total</b>	<b>94,557</b>

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The major contributor to the present value of Marine-works total direct costs is, invariably, the cost of its construction (Quay Walls, Breakwaters and Filling (rock)), but as often, in the present example, the Dredging represent more than the quarter of the value of the project. Many of the costs depend on the unique physical characteristics of the site and the project configuration and thus only limited generalisation is possible about the investment costs of Marine-works. In most low-income developing countries where Marine-works are constructed by foreign contractors with foreign plant and imported fuel, etc. , local costs probably don't amount to more than 50% of civil works costs. On the other hand, in middle income countries with their own sophisticated construction industry, (e.g., Brazil), most civil works costs are local. The technical installations, which represent only roughly 5% in the example here above, should increase in the next few years here due to the tendency to develop the services around the port equipments. (see graph thereafter). For budgeting purposes then many projects divide investment costs into local currency and foreign currency (typically denominated in US dollars) components. Marine-works projects may cost from a few million to billions of dollars.



**2.4 Quality Assurance**

**2.4.1 Testing**

In order to achieve the quality of Marine-works construction defined in the specifications, a detailed testing programme must be in place and complied with by all parties involved. The testing plan should entail predefined tests on site as well as in workshops.

The used material has to be tested with regard to their suitability for the construction. All the requirements like grading and strength have to be met in line with the design specifications.

Additionally, the bearing capacity of the subsoil (sub grade) has to be reported to the design engineer and the geologist. Parameters which form the basis for the design must be Re-confirmed by these tests. If the specifications cannot be met by the results achieved, the design must be adapted to the new parameters.

**Engineering Insurance Exposure related to Wet Risks****2.4.2 Monitoring**

A lot of damage can be avoided or diminished by applying a suitable monitoring system on the site. Preferably, the monitoring system should be designed and maintained by an independent engineer in order to avoid conflicts of interest.

**3. Typical Exposures**

The following exposures will be analysed in the paper according to the following structure:

- Definition of Exposure
- Typical Loss Scenarios
- Underwriting Considerations (Scope of cover, typical endorsements, etc.)
- Risk Management / Mitigation during Construction
- Safety and Security Aspects

**3.1 Natural Catastrophes***Typical Loss Scenarios of Natural Disasters:*

Various natural disasters such as earthquakes, windstorm and flooding, tidal waves and volcanic activity affect Marine-works construction. The most prominent natural disaster, both from the standpoint of frequency and damageability, is the water hazard.

**Earthquake:**

Depending on the construction area, earthquake is an important risk factor. The following points should be considered to assess the extent of the risk:

- Probability of the earthquake exposure in the area of the construction works
- Whether or not the construction location is on or near any known active faults
- Whether or not the construction location is near hypocenters of previous earthquakes

An earthquake of a certain magnitude can cause severe damage to the works under construction. The probability of such losses is lower than in the case of water damage, the severity, however, is usually very high. The exposure area with its return periods as well as topography and geology must be adequately considered not only in the design of the Marine-works as such, but also for its infrastructure like technical installations and buildings. For earthquake, long observation periods (e.g. 50 years) are necessary to get a somehow reliable picture of the possible exposure. The longer the observation period is the more reliable the statistics are. However, these data alone have little value unless they are used as design factors.

**Flood and Inundation, Windstorm:**

Most disasters are not entirely unexpected and therefore can, to varying degrees, be mitigated. It is widely recognized that the construction sector does not play a sufficiently integrated role in disaster risk management. It has to be kept in mind that knowledge and awareness of integrated approaches is poor, and the construction sector as a key stakeholder and potential

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resource is not being used sufficiently regarding disaster risk-management. For instance, the main sources of damage to breakwaters are the washing away of core material by normal wave action before completion of the armoring or even more damage and settlement of the completed lengths due to extreme storm.

*Underwriting Considerations and Risk Assessment Points:*

Underwriters must have evidence that the contractor has gathered sufficient statistical data with respect to hydrology, meteorology, earthquake and windstorm and - most important - that those have been considered in the design of the project.

It is important that underwriters require information relating to windstorm history, the return period applied for designing protection facilities. The local seasonal wind speeds must be considered with a reasonable return period (e.g. 25 years). The time schedule should be arranged in such a way that the most exposed works can be carried outside of windstorm seasons. In areas with substantial earthquake exposure the local and international earthquake building codes must be considered in the design of the construction.

The following insurance clauses are worthy of consideration:

- Warranty concerning safety measures with respect to precipitation, flood and inundation (MRe End. 110)
- Warranty concerning construction material (MRe End. 109)
- Special conditions concerning the erection/construction time Schedule (MRe End. 005)
- Exclusion of any kind of mobilization/demobilization costs and/or any other costs which arise for stand-by waiting on bad weather condition
- Warranty imposing Continuous Contract to weather office with 12 hours notice of Imminent storm
- Warranty concerning structures in Earthquake Zones (MRe End. 008)
- Normal Action of Sea/River: It is agreed and understood that otherwise subject to the terms, exclusions, provisions and conditions contained in the Policy or endorsed thereon, the Insurers shall not indemnify the Insured for loss or damage directly or indirectly caused to the contract works or Insured's property due to normal actions of sea or normal tidal actions which shall be deemed to mean the state of the sea or tidal water which must statistically be expected to occur once during :.... years observation period state of the or normal tidal action accompanied by wind speed not exceeding factor ..... on the Beaufort Scale.
- Exclusion for Dredging/Redredging  
It is agreed and understood that otherwise subject to the terms, exclusions, provisions and conditions contained in the Policy or endorsed thereon, the Insurers shall not indemnify the Insured for any cost incurred for dredging, redredging, overdredging or loss or damage resulting therefrom.

*Risk Management of the Risk Assessment Points mentioned above:*

One of the contractor's prime duties is to gather hydrological and meteorological data of the region going back to an observation period of at least 25 years. Weather conditions on the other hand ought to be observed daily and the project schedule should allow certain flexibility for adaptation in case of particularly adverse weather conditions like storm or cyclone. Good risk management practise also requests the contractor to study and work out possible worst case

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scenarios with respect to natural catastrophes and to have adequate counter measures planned and prepared in advance. In particular in typhoon and hurricane exposed areas it is highly recommended to maintain contact with a nearby meteorological station and to have an emergency plan established in case of a typhoon or hurricane approaching the project site.

**3.2 Faulty Design, Material and Workmanship***Definition of Exposure:*

Marine-works often consists of different types of structures. It is a complicated puzzle where a number of different design aspects play an important role. As mentioned in various parts of this paper, important design factors to be considered are

- Working load
- Hydrodynamics
- Geology
- Topography
- Exposures to natural perils like
  - o Earthquake
  - o Water
  - o Possibly storm,

just to mention a few of them: ...

*Typical Loss Scenarios and Underwriting Considerations:*

As with the design, faulty material as well as faulty workmanship can produce severe losses.

If it comes to a loss under the cover for faulty design, material and workmanship, the question about what will be the faulty part will immediately be raised. No doubt – depending on the interests involved by the various parties the definition will vary between the faulty grain of sand in the filling material and the Marine-body as a whole. Underwriters are well advised to define the faulty part in the policy wording in advance.

Recommended special clauses are outlined below:

 **Unprotected Core Clause:**

It is agreed and understood that otherwise subject to the terms, exclusions, provisions and conditions contained in the Policy or endorsed thereon that the maximum length of unprotected core shall not at any time exceed ... metres for all sections together, during the period from ... to ....In the event of loss or damage to unprotected core in excess of the above limit the Insured shall be considered as self-insured for the difference.

Limit of indemnity: ... any one occurrence and ... in the (annual) aggregate or to be agreed.

Deductible: ... % of the loss amount, minimum... any one occurrence or to be agreed.

*Risk Management and Mitigation:*

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Due consideration of all elements necessary for the sound design and execution of the wet works project is the basis for eliminating most of such losses. As outlined in the next chapter, this can only be achieved if experienced and qualified parties are involved in the design and execution of the wet-works project. In addition, it is most important that a broad and structured testing and monitoring programme be in place (see 2.5 Quality Assurance). Insurers and reinsurers can add by frequent risk surveys, where these points are carefully observed and discussed with the insured parties.

**3.3 Contractors and other Parties involved***Definition of Exposure:*

Any kind of civil engineering project, whether initiated by a private party or a public body, involves a number of different parties from the first idea on the drawing board to the actual completion and entry into service.

Even in a very small project at least two parties are usually involved. This becomes much more complicated in large scale projects. Many different parties – quite often even from different cultures – need to communicate and to interact with one aim in mind: To successfully complete given tasks and objectives within specifications and budget:

- Parties to a project: Principal (public or private)
- Contractor and sub-contractors
- Suppliers and sub-suppliers
- Engineering consultant
- Architect
- Financial institutions
- Authorities (including Port Authorities in charge of the operation of existing facility if any)
- Insurers and reinsurers
- Independent Engineer and/or Technical Controller

The successful completion of a project highly depends on the competence of the individual parties and the communication amongst them. All of those involved in the planning and execution of the project must be qualified for the particular type and scope of works. Regarding the heavy civil works themselves, it has to be carried on by specialized company with sound reference in similar projects. Another important element is the communication between the parties involved. This applies not only for large-scale projects, it is equally important for small projects. Missing communication often results in misunderstandings with severe consequences for the project and the insurers.

*Typical Loss Scenarios:*

A very important element is the experience of the contractor in a particular environment. Soil conditions, exposure to natural perils, political environment etc., varies greatly from country to country or even from region to region. Contractors and consultants must be aware of the environment they are exposed to and take all the necessary steps to adequately consider the local factors during planning and execution of the works. Difficult conditions must also be taken



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into consideration in the budget. The result for insurers can be disastrous if these factors are not properly checked in the underwriting process.

*Underwriting Considerations:*

In particular with complicated projects the underwriter is well advised to carefully check the qualifications and experience of the parties insured. In addition, the “loss history” of a contractor provides an important element in the risk assessment process.

The successful completion of the works highly depends on the number and qualifications of the contractors workers and supervisory staff. This is for insurers one of the very important points to be observed. Well trained – also in site safety matters - and dedicated staff is one of the key factors for a successful and loss-free project. The necessary information can be gathered in a structured and standardized way by using the construction insurance questionnaire.

*Risk Management:*

Experienced and well-trained staff, familiarity with the environment as well as good relations between the parties involved are key factors for a successful project. Insurers play insofar an important role as they need – in particular in large-scale projects – to stay in regular contact with the parties insured and contribute with their experience to the risk management process. Insurers must also check that communication channels and schedules for regular meetings are established and executed.

**3.4 Third Party Liability aspects***Definition of Exposure:*

With this cover extension (wording based on Munich Re English Standard CAR/EAR Wording Section II) Insurers agree to indemnify the Insured against such sums which the Insured shall become legally liable to pay as damages consequent upon:

- a) accidental bodily injury to or illness of third parties (whether fatal or not)
- b) accidental loss of or damage to property belonging to third parties

occurring in direct connection with the erection, construction or testing of the items insured under the Material Damage section and happening on or in the immediate vicinity of the site during the Period of Cover.

*Underwriting Considerations including typical Loss Scenarios:*

The country factor should not be under-estimated.

For projects situated in litigious countries like USA, the underwriter has to take into account the aggravated exposure. In developing areas as well, the public is gradually becoming aware of their rights and frequency of TPL claims increase rapidly as well as the amount claimed.

Recommended special clauses are outlined below:

- Navigation distance for public traffic to work site minimum 200m

**Engineering Insurance Exposure related to Wet Risks****3.5 Geology / Hydrology and Soil Conditions***Definition of Exposure:*

Geology/hydrology and soil conditions are decisive factors for the dams design specifications as well as for its financial design. The project must not be either over-designed resulting in waste of money or under-designed leading into endless troubles during construction and later on during operation.

Soil quality can vary from stable such as rock or gravel to soft/unstable such as clay and sand. It is the contractor's/principals' responsibility to adequately investigate the subsoil conditions by means of soil sampling as well as field and laboratory testing. Professional contractors/principals usually cooperate with experienced geologists, which can perform sound soil investigations. Local know-how of geologists is as well required to understand long term pattern of soil development/movement. Hydrological investigations are done in the same course of actions. Trying to save money on these preliminary surveys may prove to be very costly later on during the construction phase.

*Typical Loss Scenarios:*

- Soil settlement may be the result of inadequate design (not allowing for the weights and loads to be transferred properly in soil) or of faulty workmanship (inadequate compacting), or of seismological activity or hydrological factors.
- Instability problems such as shear failure of the embankment on soft subsoil, slopes sliding (inadequate underpinning/anchoring)
- Loss of fill

*Underwriting Considerations:*

An important piece of information for underwriting is whether the contractor has a comprehensive geological report in his possession, carried out by experienced soil engineers. The underwriter shall request and receive a copy of the findings/conclusions of the soil investigation and hydrodynamic survey, which are the basis for Marine-works design. If the underwriter does not have the required background to evaluate the available information, he is advised to seek assistance from risk engineering/consulting experts. Unavailability of geological reports or use of existing reports for other similar projects in the neighbourhood should be alarming for the underwriter and cautious underwriting must be exercised. As stated elsewhere in the text, the frequency and the chosen location of bore holes drilled is decisive for the reliability of the results.

Recommended special clauses are outlined below:

- The special warranty for projects in regions with medium or high EQ exposure (MRE 008)
- Exclusion of loss or damage arising out of unforeseen soil conditions
- Differential Soil Settlement:  
It is agreed and understood that otherwise subject to the terms, exclusions, provisions and conditions contained in the Policy or endorsed thereon this insurance shall not indemnify the

**Engineering Insurance Exposure related to Wet Risks**

Insured for additional material necessary beyond the designed profile due to changes in the seabed as well as the costs of rectifying, jacking up or re-levelling of constructed or erected walls or material, both from any cause whatsoever. Deductible: ... % of the loss amount, minimum ...any one occurrence or t. b. agreed.

**Loss of Fill Exclusion:**

It is agreed and understood that otherwise subject to the terms, exclusions, provisions and conditions contained in the Policy or endorsed thereon this insurance shall not indemnify the Insured for the loss of fill from any cause whatsoever. Deductible:...% of the loss amount, minimum...any one occurrence or t. b. agreed.

*Risk Management:*

Contractor's own risk management initiatives shall be evident to the insurers. He should make available to the insurers the following information:

- Are there soil engineers specifically appointed for the project?
- Is there a regular monitoring system of earth movements established on site?
- Is there a regular and standardized communication between the soil engineer(s) and the design engineer(s) established?

Depending on the size and the complexity of the project, insurers may consider appointing an independent expert, who would undertake to visit the project regularly, i.e. it is recommended twice a year but it could also be quarterly, especially if Advance Loss of Profit cover is attached to the CAR coverage. This expert shall be capable to identify the risks, classify them depending on the relevance to the project as well as recommend improvements for mitigating the impact, if the risk occurs. Moreover, he should monitor implementation of his recommendations.

### **3.6 Other Environmental Impacts**

*Definition of Exposure:*

There is a growing awareness that wet-works development has major environmental impacts. Some of the major environmental impacts of marine-works projects include damage to sensitive ecosystems, permanent disruption of local economic activities (i.e. fishing) ...

Since environmental impacts from wet-works developments are quite common, such projects usually call for comprehensive environmental assessment studies carried out by professionals, who work closely and support the main engineering team.

*Typical Loss Scenarios:*

Careless construction camp design and management can lead to serious environmental degradation including sewage and garbage pollution, infrastructure loading, etc.

- Equipment Servicing and Fuelling:**  
Experience shows that without a fuelling and servicing protocol as part of the project's Environmental Management Plan chronic oil product pollution often takes place.
- Site Preparation and Clearing:**  
These activities may involve drying of areas, demolition of existing buildings or civil works,

**Engineering Insurance Exposure related to Wet Risks**

temporary rerouting of utilities, topsoil stripping and diversion or re-channelling of waterways, which brings risks of erosion of exposed ground or stored topsoil, and increased water runoff and salvation of watercourses.

- Earthworks:  
The removal and placement of earth can bring further risks of soil erosion.
- Concrete plant :  
On larger projects a temporary concrete production plant is often constructed.
- Waste Management  
Construction crews, which on larger projects can exceed 500 people at any one time, may generate significant amounts of solid & liquid waste per day. Uncontrolled and untreated, these wastes are major sources of pollution, disrupting the ecosystem and contributing to local health problems.

*Underwriting Considerations:*

It is of utmost importance that the underwriter excludes from the TPL coverage environmental liability (this should be treated separately by specialized underwriters), seepage and gradual pollution.

TPL coverage must be restricted to accidental pollution only.

*Risk Management:*

Direct impacts of wet-works projects can be significantly reduced and sometimes eliminated through the application of environmentally sound construction and operations management practices. For such actions to occur, the following two basic conditions need to be in place:

- a knowledgeable construction and operations management team, which is sensitive to environmental issues; and
- an enabling environment where regulatory agencies and government planners look for and encourage sound resource use.

**3.7 Camps and Stores***Definition of Exposure and typical Loss Scenarios:*

Depending on size of the project several camps & stores facilities may be required.

These units are temporary facilities used during the construction period and are usually covered with the same insurance programme purchased for the project as such.

These temporary facilities are usually low cost constructions, e.g. containers, wooden structures etc. and are exposed to the following perils:

- Flood:  
Careless situation of camps and storage units, e.g. nearby unprotected areas, increases the flood exposure significantly.

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- Fire:  
The temporary scope of these facilities limits the fire-fighting facilities to the use of some fire extinguishers only. Bearing also in mind that in Marine-works projects outside city limits such facilities remain unattended after the working hours, it is easy to understand why the risk aggravates.
- Theft:  
The content of these units (tools and tackles, computers, fax machines, etc.) is surely very attractive and relatively easy to steal.

*Underwriting Considerations:*

The underwriter shall obtain information regarding the exact location and value of the facilities insured.

It is recommended to incorporate the following special clauses:

- Special warranty for camps & stores (MRe 107)
- Special warranty for fire-fighting facilities (MRe 112)
- Special warranty regarding Theft pre-requiring fencing of the areas where camps and stores are placed as well as 24 hour guarding of the project with emphasis on these facilities.

*Risk Monitoring:*

As part of a general risk monitoring plan for the entire project, emphasis shall also be given on regular inspection of the camps and stores insured with subsequent improvement suggestions, when required.

**3.8 Contractors' Plant and Machinery***Definition of Exposure and typical Loss Scenarios:*

As in almost all types of construction projects, construction machinery used in a wet-works construction project represents a considerable capital investment.

Floating dredging equipment, mobile construction machinery (self-propelled or not), stationary units (like Fixed sand bypassing systems, processing plants, conveyor belts, crushers, etc.), mobile or stationary producing and powering equipment and machinery (e.g. for generating energy or compressed air) are the main headings under the construction machinery.

In general, the causes of losses and damages to construction machinery can be divided into three main categories:

- a) Acts of God (natural hazards)
- b) Operating errors
- c) Material failure

Acts of God are certainly unforeseeable for the contractor as long as he has taken the appropriate normal precautions. Typical Acts of God are flood and inundation, storm, earthquake and lightning.

## Engineering Insurance Exposure related to Wet Risks

Loss or damage resulting from human error and negligence can in principle be reduced by adequate training of personnel. For the contractor, however, the possibility of an unskilled employee making a mistake cannot be avoided. Damage resulting from such causes is covered by construction machinery insurance. Typical examples here are collision of vehicles on the construction site and tipping of cranes.

The risk of theft or vandalism can be reduced by appropriate precautions such as locking up equipment, fencing the machinery park site or patrolling the construction site. But as the contractor cannot avert the danger completely and is also dependent on his employees' care in this respect, this peril is covered by construction machinery insurance in most countries.

### *Underwriting Considerations and Risk Assessment:*

When construction machinery is to be insured, the insurer has to get an exact idea of the risk and be personally aware of the peculiarities of that particular risk.

Contrary to the project works as such, Contractors' Plant and Machinery is usually insured on an annual basis with annual premium (Munich Re or Swiss Re Endorsement for Contractors' Plant and Equipment). It is important for insurers to insist on a complete list of all items used on the site with their respective new replacement values.

It is recommended to incorporate the following special clauses:

- MRe 108 Construction Plant, Equipment and Machinery endorsement where applicable
- Any floating and other equipment such as caissons, barges and the like and liabilities thereon
- Loss or damage to pulling wires, anchors, chains and buoy.

## 4. Probable Maximum Loss (PML) Considerations

IMIA describes the PML as follows:

*“The Probable Maximum Loss (PML) is an estimate of the maximum loss which could be sustained by the Insurers as a result of any one occurrence considered by the underwriter to be within the realms of probability. This ignores such coincidences and catastrophes as may be possibilities, but which remain highly improbable.”*

The Underwriter may also refer to the IMIA Paper WGP 19 (02) “PML Assessment of Civil Engineering Projects”.

As mentioned previously for the cost in § 2.3, MPL depends on the unique physical characteristics of the site and the project configuration and thus only limited generalisation is possible about the MPL calculation of Marine-works

Nevertheless, performance data suggests that Marine-works projects often incur substantial cost overruns in construction. While, datasets from the World Bank, Inter-American Development Bank and Asian Development Bank reveal average cost overruns in the range of from 20-45% in nominal terms there is considerable variability in and amongst the samples.

## 5. Typical Loss Examples

### 5.1 Appendix No. 1

#### 5.1.1 Risk description:

A harbour in Asia being part of a multi billion industrial project which may be taken as a representative illustration for any other storm exposed harbour construction in any other part of the world

Harbour Structures and buildings as well as the adjacent shore sections were protected by unreinforced heavy tetrapods of 50 tons each. Depending on the design of the tetrapods and the number of interlocked layers the values may be 5 m to 15 m USD/km. Tetrapods are usually produced in high quality mass concrete which is adequate for their purpose. Only in very rare cases there is a reinforcement required only to cater for special handling procedures. At a later stage reinforcement might mean corrosion problems and a reduced life expectancy. As a consequence the shearing strength of unreinforced tetrapods is limited.

Tetrapods are chosen in the shallow sea where the depth rarely exceeds 8 – 10 m. They are usually placed in various layers according to a predefined placement order on a specially prepared stone bed which is roughly horizontal or on slopes of stone packing in front of concrete structures. Usually there is no special treatment of the underground such as removal of sediments, replacement by graded material and subsequent underwater compaction.



Tetrapods in front of a quay wall

Consequently there is a certain risk of sliding.

The risk of shearing off during placement is generally eliminated by using straps or ropes instead of hooks. The most important exposure for the tetrapods is storm which causes waves beyond

## Engineering Insurance Exposure related to Wet Risks

the design speed, i.e. what is considered to be beyond normal action of the sea. This exposure is of particular relevance during the placement of the tetrapods, as in this phase they do not yet interlock according to the design, have freedom to move and may be dislodged due to the action of waves.

### 5.1.2 The incident:

During the construction period a storm caused waves the height and/or intensity of which exceeded the normal action of the sea. A considerable number of tetrapods were displaced and, to a lesser extent, had arms sheared off and had to be replaced.



Broken tetrapods

### 5.1.3 The settlement:

There was an exclusion of abnormal action of the sea in the policy, however as often is the case, it was not possible to clearly determine the wind speed and wave heights during the time the loss occurred.



Casting of tetrapods





Transport of tetrapods

In this case the costs did not get out of hand as the production equipment, formwork etc. was still on site. This loss was indemnified with 2 m USD

#### **5.1.4 Conclusion:**

In certain cases the placement of caissons should not be performed during known regular storm seasons or in case of storm warning.

Normal action of the sea should be clearly defined in the policy, e.g. by agreeing on a certain critical value of the wind speed and wave height. In case these are agreed there should be adequate measuring appliances which must be operational at all times and allow for unambiguous measurements.

## **5.2 Appendix No. 2**

### **5.2.1 Risk description:**

An outfall structure in the container terminal of an Asian harbour: To facilitate internal reclamation to proceed in parallel with construction of quayside structures, the reclamation interface was constructed early on in the programme. Drainage outfall structures were pre-cast as open four cell box culverts. The adopted method of construction involved excavating a trench in the seabed and replacing marine deposits with graded material and a top sand layer. The outfall units were subsequently floated into position and placed on to a prepared foundation bed.

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### 5.2.2 The incident:

In order to cater for settlement of the prepared fill material each culvert outfall unit was set to a pre-elevation. The settlement of the structure had been calculated at approx. 300 mm but in reality this turned out to be 600 mm. Relifting, backfilling the space between lower slab and the sand bed and repositioning was discarded as being too difficult. Instead it was decided to demolish the soffit slab and simply extend the vertical walls to each cell before recasting the soffit slab to the design level. A claim was submitted for this modification work but was declined by insurers on account of the settlements being neither sudden nor unforeseen but merely incorrectly calculated.

In order to execute these modifications in the dry the contractor's method involved sealing each cell within the outfall unit and pumping out water from within each cell one by one. It should be noted that in order for negative buoyancy to remain, only one cell at any given time was to be drained. However, after removing the soffit and walls between the individual cells, a high tide occurred which reduced the safety factor and this, in combination with a pump inadvertently left running overnight within one of the flooded cells, the outfall element became buoyant. With water pressure acting on one end of the outfall structure; the landward side at this stage was being drained, the structure floated and displaced at one end, tilting and slipping on the underlying sand bed and coming to rest out of position but without being damaged itself.



Tilted outfall structure

### 5.2.3 The settlement:

Whilst the claim for repositioning after excessive settlements had been correctly declined, the tilting and sliding of the outfall structure was caused by human failure and/or faulty workmanship. The structure had to be split into two elements and floated separately into the correct position after repairing and preparing the backfill underneath, using divers.

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The claim was indemnified with approx. 1 m USD.

**5.2.4 Conclusion:**

A clear method statement should be presented before works are executed and ways should be found to guarantee its correct implementation. Preparation of method statements should consider all external factors which are present and which might potentially influence the works to be undertaken. In this example, repositioning has to be declined if it is found that movement was due to gradual influences, whilst the same has to be indemnified if caused accidentally. In this case the human error had to be considered as a break in the original chain of causation or as a supervening event.

**5.3 Appendix No. 3****5.3.1 Risk description:**

Construction of a commercial harbour in Europe: The works included the construction of a 1.400 m long concrete held quay wall of 40 m height. The wall was expected to be fully built within a protected, dry area and therefore, no action of the sea was feared.

The owner and the contractor were covered by a CAR policy. The total sum insured was around € 140 m

Apparently, at a certain point during the construction period, the owner decided to change the schedule and started opening the harbour, while the retention wall was still being built. The construction company did not notify the insurer/reinsurers about these changes and therefore, nobody was aware of the change in risk.

**5.3.2 The incident:**

In order to build the retention wall, a ditch was open alongside as the construction made progress. Once the owner decided to start dredging the harbour, the ditch was protected by two clay embankment dams or cofferdams.

At the time of the loss, 350 m of the wall were finished with top coping and pinning and exposed to the water behind the dike because the dredging had already started. Tide movements gradually hollow out the underwater part of the first cofferdam until it broke. Soon afterwards, the second cofferdam, not being able to resist the water pressure, yielded letting the water flood the ditch.

The water stream broke into the ditch and quickly reached the other ditch end, bounced and returned in the direction it had come, in a progressive wave mode. As a result of this, the part of the wall which was still not reinforced by pinning and earth was stretched and cracked (see pictures in power point presentation attached).



Retention wall and flooded ditch



View of ditch and broken cofferdam



Deformed section of retention wall





Deformed section of the retaining wall



Cracks in the retention wall

### **5.3.3 The settlement:**

The original amount claimed was € 35 m.

The cause of the loss was a rupture of the cofferdam due to a design error and the action of the sea. No specific “*normal action of the sea*” exclusion was attached to the policy since it was initially understood that the quay was going to be built fully onshore.

Despite an obvious material change of risk, it was very difficult to reject this claim. Considering the legal environment, litigation for a case with no sufficiently accurate original project descriptions would have been hazardous and most probably unsuccessful.

### **5.3.4 Conclusion:**

Harbour and sea works are intricate and as such difficult to assess and price. The size of the accepted share should reflect these uncertainties. In addition, never consider works in a harbour as dry, even if the main part of the construction is going to be executed on earth. An exclusion of “*normal action of the sea*” should always be inserted.

For complex CAR/EAR facultative business an adequate Risk Management organization should be set up. Systematic risk surveys – followed by the corresponding adaptation of the terms and conditions – would have helped the insurer / reinsurer to detect the material change of risk in time and to react accordingly.

## **5.4 Appendix No. 4**

### **5.4.1 Risk description:**

A port in South America built, owned and operated by an industrial company. The owner had extended the port and constructed an additional quay consisting of a mole the surface of which was broadened by a vertical bored pile wall which was anchored to the mole, the space between bored pile wall and mole being backfilled with heavy rock boulders. The water depth had been approx. 20 m

### **5.4.2 The incident:**

Some time after construction the bored pile wall tilted to the outward side, anchors broke and the quay had to be closed down, cargo cranes and other equipment had to be removed.

### **5.4.3 The Claim:**

A claim of more than 10 m USD was made for the repair works and the BI. As probe drillings revealed, the mole had been constructed after cleaning the seabed but without removing soft material and replacing it by graded and adequately compacted material. As a consequence the mole settled differently than the bored pile wall. Moreover the bored pile wall had been embedded insufficiently in the underground and did not have the required stability.

## Engineering Insurance Exposure related to Wet Risks

### 5.4.4 The settlement:

The claim was declined by insurers as the root cause had been faulty design and/or faulty workmanship in the construction period. As the claim had been submitted under the subsequent property policy and construction works had been planned and executed by the insured himself this was considered as gross negligence.

### 5.4.5 Conclusion:

Sea ground must be properly investigated and removed if inadequate. In this case it should be replaced by graded and properly compacted material, e.g. by vibroflotation or the structure should be founded on the well prepared bed rock.

Faulty design and faulty workmanship may cause failures during the maintenance period or even at a later stage during the operational phase. Certain types of design errors or bad workmanship committed by the insured himself may be considered in the operational phase as gross negligence.

## 5.5 Appendix No. 5

### 5.5.1 Risk description:

Øresund Fixed Link Denmark:

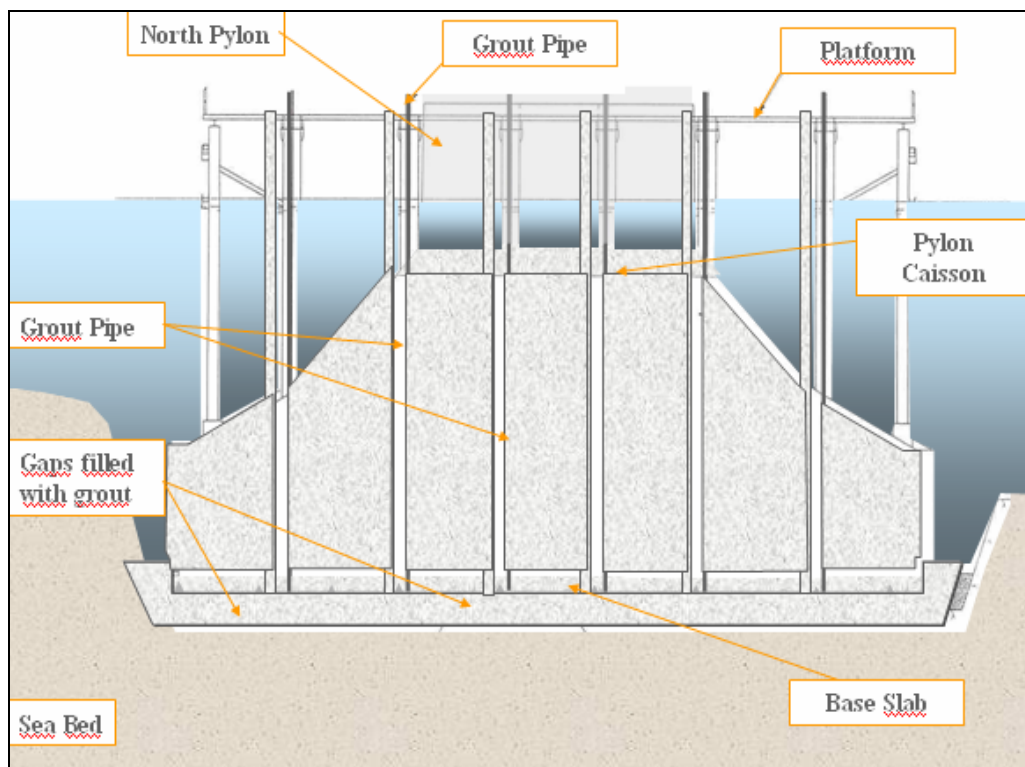
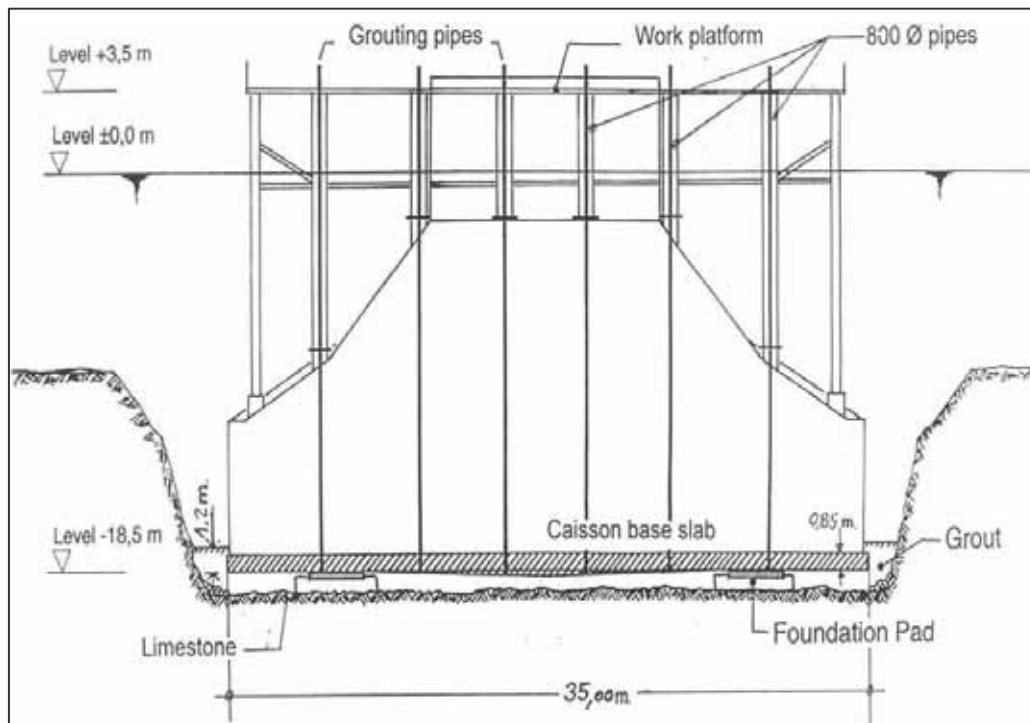


Part of the Link:  
Cable stayed bridge supported by two pylons each 203.5 m a.s.l. – span between both pylons 490 m.

The foundations for the pylons consist of pre-fabricated concrete caissons grouted in the limestone, approx. 18 m below the surface of the sea. The caissons were floated out to their locations, suspended between pontoons, then lowered into the sea and positioned on three supporting pads located on the bottom of a pit which was excavated in the limestone seabed.

Engineering Insurance Exposure related to Wet Risks

Following the placement of the caisson the cavity between the underside of the caisson base and the bottom of the limestone pit were to be grouted.



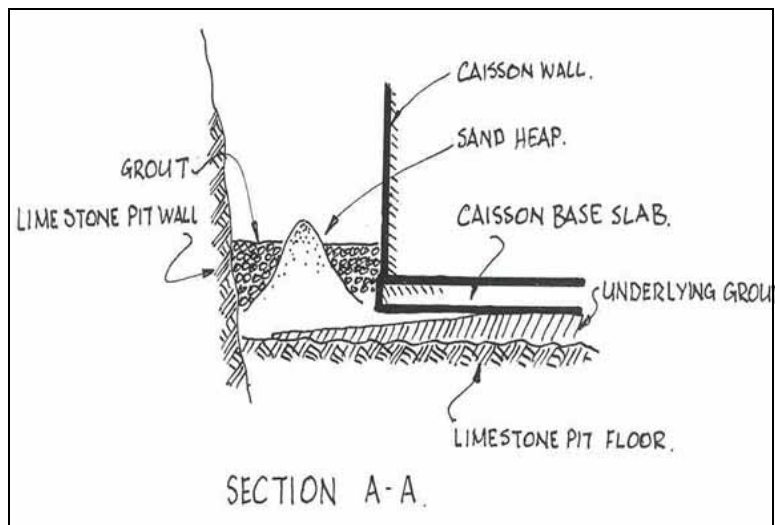


## Engineering Insurance Exposure related to Wet Risks

### 5.5.2 The incident:

In April 1997 base grouting had to be stopped for 8 hrs due to bad weather. At that time 50% of grout had been placed.

Before recommencing the grouting a diver was dispatched in order to ensure that no sea weed was being mixed with the grout material. He made a video film of this inspection which was viewed only two days later. After restarting grouting and while viewing this video a heap of sand was observed on top of the grout between the pit wall and the caisson slab at the West pylon. At that time 95 % of grout had been placed.



After careful investigation it was concluded that no sand had been washed into the trench from the sea bed but that the grout had de-mixed or had been washed out and therefore the sand stemmed from the grout. Additional core drillings confirmed that there was sand at various locations below the base slab. It was feared that the grout was likely to be inadequate for its intended purpose.

### 5.5.3 The settlement:

#### Cause of the loss

The loss consisted in defective grout, no damage had occurred to the insured works.

Possible causes for the erosion of the grout were

- defect in workmanship
- defect in design
- adverse weather conditions
- seaborne traffic

The root cause of the de-mixing or erosion of the grout could not be unambiguously determined. Adverse weather conditions could not be proven to be the cause.

Initial repair works included backfilling of grout on the outside of the caisson and drillings within the caissons cells. The final repair was based on additional investigations and the confirmed

**Engineering Insurance Exposure related to Wet Risks**

nature of the problem and extent of defect. Jet grouting and pressure conductivity systems were applied.

Repair costs, i.e. jet grouting costs were claimed.

The claim amount of approx. 30 m USD was later revised to 15, then to 12 m USD.

The policy exclusions applicable in this case were

- normal action of the sea,
- defective workmanship (accidental damage covered).

Based on the investigations and the policy exclusions the claim was declined. Due to the complicated legal situation (English wording, Swedish Law, Danish jurisdiction) and uncertainties in respect of the root cause a commercial settlement amounting to 650.000,00 USD was negotiated on a "strictly without prejudice" basis.

**5.5.4 Conclusion:**

The exclusion of adverse weather conditions (normal action of the sea clause) often proves insufficient. It requires additional definitions, quantification and a mutual understanding on how to measure the sea activity.

Even a professional policy has often to be interpreted in the context of language, law and jurisdiction which may render a univocal understanding of the policy liability very difficult if not impossible.

Often there is a combination of various causes contributing to a loss. Defects in design and defective workmanship very often are important and decisive factors to losses in wet works. Usually the allocation of repair costs to the individual causes requires comprehensive investigations and extensive negotiations as well.

For additional interesting claims examples please also refer to [http://www.imia.com/interesting\\_claims.php](http://www.imia.com/interesting_claims.php)

## **6. References and Internet Links**

### **6.1 Literature**

Contractors' Plant and Equipment Insurance in International Markets - Swiss Reinsurance Company, Zurich – 1998

Contractors' All Risk Insurance - Swiss Reinsurance Company, Zurich – 1998

Engineering Insurance and Reinsurance - Swiss Reinsurance Company, Zurich – 1997

PML Assessment of Civil Engineering Risks - IMIA Working Group Paper WGP 19 (02) – 2002 on [www.imia.com](http://www.imia.com)

### **6.2 Internet Links**

[www.bceom.fr/2\\_Metiers/ingenierie-maritime\\_new\\_Ang.html](http://www.bceom.fr/2_Metiers/ingenierie-maritime_new_Ang.html)

<http://rru.worldbank.org/Toolkits/PortReform/>

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