Construction health and safety in coastal and maritime engineering

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Cover photograph:
Jack-up platform working in exposed wave conditions in Sennen Cove (courtesy Seacore)

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It should be noted that the information given in this publication is based on a review of literature and guidance. This review does not purport to be exhaustive. It is essential that all those involved with construction works do not rely solely on information given in this publication but instead familiarise themselves with relevant source legislation and seek professional advice to ensure they execute their legal duties.

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Preface

Over £500 million is spent on coastal and maritime construction work in the UK every year. Approximately half of this expenditure relates to commercial projects including ports, harbours, docks and jetties while the other half is spent on coastal and flood defence work.

Coastal and maritime construction work is particularly hazardous due to the hostile and sometimes unpredictable nature of the environment in which it is carried out. At present, there is little specific health and safety-related guidance available to assist designers, planning supervisors, contractors and other stakeholders to ensure that work in this sector is undertaken in a safe manner. This guidance document has been produced following detailed consultation with a wide range of design engineers, clients and contractors. It addresses the safety management of coastal and maritime design and construction work, and identifies principles of good practice to be applied during each phase of coastal and maritime construction projects.

Best practice information on safe working practices in the coastal and maritime engineering sector has been assembled through examination of HSE statistical data and through detailed discussions with clients, consultants, contractors and suppliers, examining current operational procedures, accident records and perceptions of risk.

This document incorporates lessons learnt from previous experience in the coastal and maritime construction sectors, and contains guidance and recommendations for all stakeholders involved in the safety of construction work in the coastal and maritime environment.

Key areas covered by this guidance are:

- the regulatory environment
- causes of accidents in coastal and maritime construction
- key hazards in coastal and maritime engineering
- guidelines for good practice
    - i) good practice for generic areas of coastal and maritime construction
    - ii) good practice at each project stage.

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1. Introduction

1.1. BACKGROUND

Over £500 million is spent on coastal and maritime construction in the UK every year. Just under half of this expenditure relates to commercial projects including ports, harbours, docks and jetties, with the other half being spent on coastal and flood defence work.

Coastal and maritime construction work is particularly hazardous due to the hostile environment in which work is carried out. The volatility and unpredictability of conditions caused by storms, waves, currents and tides have resulted in a number of major accidents and fatalities in recent years. At present, there is little specific health and safety related guidance available to assist clients, designers, planning supervisors, contractors and other stakeholders to ensure that work in this sector is undertaken in a safe manner. This guidance document has been produced following detailed consultation with a wide range of design engineers, clients and contractors. It covers best practice in safety management of coastal and maritime design and construction work.

Best practice information on safe working practices in the coastal and maritime engineering sector has been assembled through examination of the Health and Safety Executive (HSE) statistical data and through detailed discussions with clients, consultants, contractors and suppliers, examining current operational procedures, accident records and perceptions of risk. This document incorporates lessons learnt from previous experience in the coastal and maritime construction sectors, and contains guidance and recommendations for all stakeholders involved in the safety of construction work in the coastal and maritime environment.

1.2. AIMS AND OBJECTIVES OF THIS PUBLICATION

1.2.1. The high level aim

The Construction (Design and Management) Regulations (CDM) Regulations, among other regulations, require both the designer and contractor to consider and assess construction risks. Without specific information and guidance on safe practice in the marine environment, it is not only difficult to undertake safety assessments but these assessments may be misguided and incorrect. The aim of this publication is to provide stakeholders with specific guidance on how to avoid, combat at source, mitigate and protect personnel from risks in coastal and maritime engineering works. Indeed, the significant health and safety hazards in coastal and maritime engineering make the identification and management of many of these safety hazards perhaps more important than for many land-based works. It is envisaged that real cost savings to the industry will be generated through avoidance of accidents and the consequent potential for reductions in fatalities and time off work.

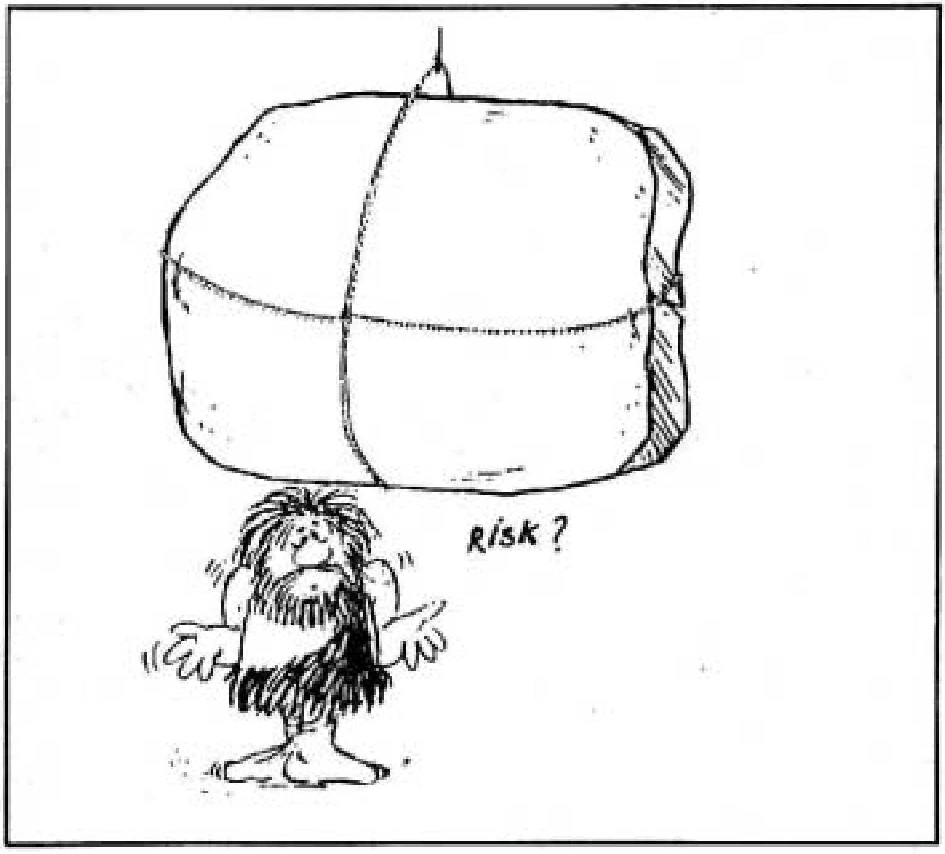


Figure 1.1. We can't manage the risk if we are unaware of unusual or particular hazards. (A key objective here is to help raise health and safety competence in the coastal and maritime sector) (courtesy Anon)

1.2.2. The detailed objectives

The objectives of the project set up to generate this document were to:

1. **identify and analyse the principal causes of accidents** in the coastal/maritime engineering sector and compare them with the rest of the construction industry
2. **highlight key safety issues** that affect the public during construction
3. **prepare relevant guidelines** of good practice to:

- *a)* assist **clients** to understand the real safety risk issues and promote best practice
- *b)* assist **design engineers** and **planners** in coastal/maritime engineering to improve awareness and competency levels to design out hazards and avoid foreseeable risks from the outset
- *c)* assist **contractors**, including both managers planning work and those operating on site, to:
  - **combat and remove health and safety risks** during construction in the coastal/maritime environment
  - **identify appropriate protective measures** where avoidance or removal of risk is not possible
- *d)* assist the **planning supervisors** to execute their duties and encourage others to focus attention on the principal hazards
- *e)* assist the **HSE** and **MCA** to understand the nature of the hazards in coastal/maritime engineering and the relative competence levels currently employed and to promote best practice
- *f)* assist **insurers** to understand the safety hazards and to promote best practice

4. **distil these guidelines** into a shorter document which could form:
   - *a)* a new Chapter of CIRIA C604 Work Sector Guidance for designers
   - *b)* a new chapter in CIP Construction Industry Publication guidance document '*Construction Health and Safety Manual*'.

Both these documents are currently used by all industry participants and benefit from specific sections on coastal/maritime work.

5. **disseminate** the information through publication and industry workshops/ seminars, to promote appropriate competencies and, if appropriate, to encourage a culture change on how safety risks are managed in the future.

These objectives meet the DTI *Construction Research and Innovation Programme* principal aims in terms of:

- economic savings – the project will promote a profitable and competitive industry by providing cost savings in terms of reduced accidents (time off work) and costs associated with fatalities
- social context – the project promotes respect and fair treatment for stakeholders and provides a safe and healthy work environment
- environmental costs – the project minimises the risk of pollution, which often results from accidents on the coast.

The objectives also meet HSE strategic research objectives in that they:

- promote engagement with key intermediaries and stakeholders to achieve a cultural change in the industry – in particular, promoting competence issues and partnership to those managing risks
- develop and promulgate guidance and standards that are clear to understand

- develop improved intelligence and knowledge based on health and safety performance and risk targeting
- assist designers to design out hazards at an early stage
- review current knowledge with respect to certain construction activities that have potential to create major hazards.

Once the performance of the coastal engineering industry has been benchmarked, the project objectives can be measured through the HSE tracking accident and fatality statistics in the coastal engineering sector in future years to assess how the safety record improves.

This publication draws together the main findings from this research.

1.3. DEFINITION OF CONSTRUCTION WORK COVERED BY THIS PUBLICATION

The scope of construction work covered by this publication includes:

Construction work carried out in, or adjacent to, tidal waters

The guidance is focused on *exposed* tidal waters rather than benign waters. The term ‘exposed’ refers to areas where wind, waves, currents, bed changes or a combination of these have a significant effect on the construction process. Where none of these effects are relevant or the water is more benign, then existing guidance on *working over water* should normally cover the majority of construction risks.

1.4. PROJECT PARTNERS

The project team was led by HR Wallingford and consisted of Project Partners involved in coastal and maritime civil engineering design and construction management.

The organisations involved are listed below. Each has extensive experience in coastal and maritime civil engineering which has enabled their own ‘lessons learnt’ and ideas to be brought to the project.

- **Association of Diving Contractors –** Involved in specialist support to the marine construction industry
- **CIRIA** – Research association ensuring that dissemination reaches a wider audience
- **Dean and Dyball** – One of the key contractors who instigated the original Construction Risk in Coastal Engineering project and is now applying best practice
- **Edmund Nuttall** – Key specialised coastal/maritime contractor and Environment Agency Framework Contractor working on a variety of coastal engineering projects in the UK
- **Environment Agency** – Key coastal engineering client keen to integrate best practice into their capital works programme

- **Halcrow –** Key Environment Agency framework consultant with extensive experience in the design and site supervision of coastal and marine engineering projects world-wide
- **Health and Safety Executive (Offshore Division)** – Key regulator who provided advice on existing data and experience from the offshore industry
- **HR Wallingford** – Research and consultancy organisation with extensive experience in the delivery of practical research guidance in this sector
- **Maritime and Coastguard Agency –** Responsible for regulation of vessels used in the marine construction industry
- **Mersey Docks and Harbour Board** – Major port project client keen to promote best practice
- **Mott MacDonald** – Consultant with extensive experience in the design and site supervision of coastal and maritime engineering projects world-wide
- **New Forest District Council** – Local authority client applying best practice previously developed at HR Wallingford
- **Posford Haskoning** – Consultant with extensive experience in the design and site supervision of coastal engineering projects world-wide and was involved in the original Construction Risk in Coastal Engineering project
- **Seacore** – Specialist piling contractor applying innovative techniques to reduce costs and improve safety aspects world-wide
- **Van Oord** – Key specialised contractor and Environment Agency Framework Contractor working on a variety of coastal engineering projects world-wide.

During the execution of the work, links were also made through existing contacts with:

- other clients involved in coastal/maritime projects
- other consultants involved in the planning and design of coastal/maritime projects
- other contractors involved in the construction of coastal/maritime projects
- insurers involved in the insurance of coastal/maritime projects.

These contacts are acknowledged in Chapter 9 of this report.

1.5. STEERING GROUP

The project steering group comprised:

Dominic Beer	Dean and Dyball
Malcolm Birkenshaw	Health and Safety Executive
Tim Bownes	Port of Liverpool
Ken Bunker	Mott MacDonald
Julian Cockett	Seacore
Stephen Cork	HR Wallingford
Ian Cruickshank	HR Wallingford
Simon Harwood	Marine Accident Investigation Branch
Jeremy Henry	Van Oord

Olav Lawrence	Dean and Dyball
Mick Newman	Posford Haskoning
Roger O'Kane	Association of Diving Contractors
Robin Raphael	Maritime and Coastguard Agency
Chris Refoy	Royal National Lifeboat Institution
Derek Ross	Edmund Nuttall
Andrew Scarth	Halcrow
Paul Sedgwick	Environment Agency
Siva Sivaloganathan	Mott MacDonald

1.6. STRUCTURE AND USE OF THIS PUBLICATION

The key sections of this publication are as follows:

Chapter 2 identifies the existing regulatory environment.	➔ **The law**
Chapter 3 reviews the causes of accidents in coastal and maritime construction and comments on the trends observed.	➔ **Statistics and consultation**
Chapter 4 describes some of the key natural hazards in the coastal environment and potential management options.	➔ **Generic H&S hazards**
Chapter 5 describes some of the key plant and machinery hazards and issues, and potential management options.	➔ **Key plant related H&S issues**
Chapter 6 provides focuses on the operatives and users of the coastal environment and potential management options.	➔ **Protecting the operative and public**
Chapter 7 provides guidance on issues to be considered during the feasibility, design, construction, maintenance and demolition phases.	➔ **Issues to consider at each project stage**

It should be noted that the information given in this publication is based on a review of literature and guidance. This review does not purport to be exhaustive. It is essential that all those involved with construction works do not rely solely on information given in this publication but instead familiarise themselves with relevant source legislation and seek professional advice to ensure they execute their legal duties.

2. The regulatory environment

2.1. REGULATORY AUTHORITIES

2.1.1. Introduction

This chapter sets out the arrangements for enforcement of health and safety in construction activities between the Health and Safety Executive (HSE), the Maritime and Coastguard Agency (MCA) and the Marine Accident Investigation Branch (MAIB). An agreement HSE (2003) sets out the roles and responsibilities for each organisation. Under this agreement, wherever there is reference to MCA having a responsibility it shall also be read that MAIB has the responsibility to investigate accidents. Wherever HSE has responsibility, this also includes accident investigation.

In principle, HSE has enforcement responsibility for construction work, even carried out on or from a ship. This is without prejudice to MCA's responsibility under the Merchant Shipping Act for the safety of the ship, the crew and others on board while the ship is used in navigation. Figures 2.1 and 2.2 illustrate the responsibilities of the two regulatory authorities, when applied to a dredger and a jack-up platform. Table 2.1 summarises these in more detail. The legislation, whilst different depending on whether it is HSE or MCA jurisdiction, is converging to risk-based approaches rather than prescriptive requirements.

Construction activities covered by the HSE/MAIB/MCA agreement include construction, repair or demolition of marine structures (e.g. bridges, piers, jetties, link spans and coastal and flood protection works, piling, dredging, lifting, and also the construction of 'non-marine' works which are adjacent to navigable waters, when the work involves support from vessels such as work boats or rescue craft).

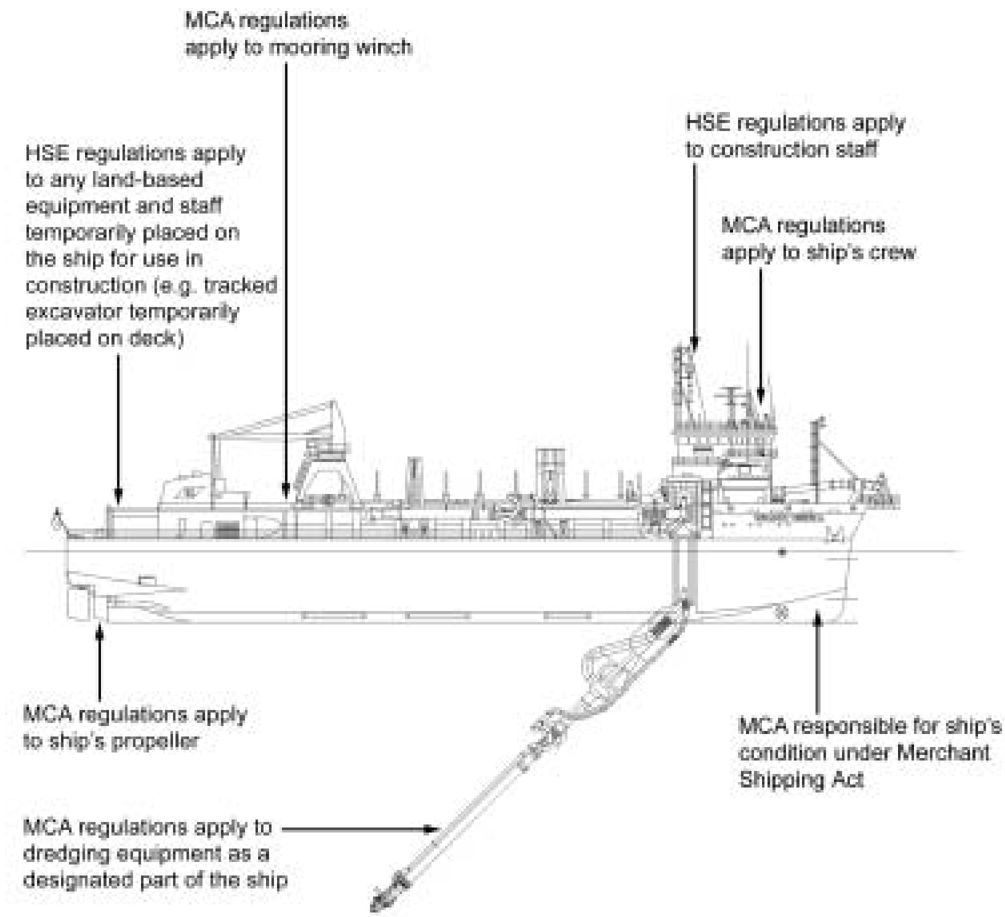


Figure 2.1. Examples of indicative responsibilities of regulatory authorities for dredger operations (UK inshore waters) [Note 1]

Note 1: The image refers to inshore waters. The Construction (Health Safety and Welfare) Regulations apply to all construction work including that within GB Territorial Waters. The regulations (CDM and CHSWR) are made under the Health and Safety at Work Act 1974 (HSWA). They are applied in Territorial Waters by virtue of the HSWA Application Outside Great Britain Order 2001 (AOGBO), but only to certain activities as specified in the Order. Dredging is not specified in the Order. However, if it was dredging as an activity 'in connection with' something else which is specified, such as the laying of a pipeline or power cable, then it would be included.

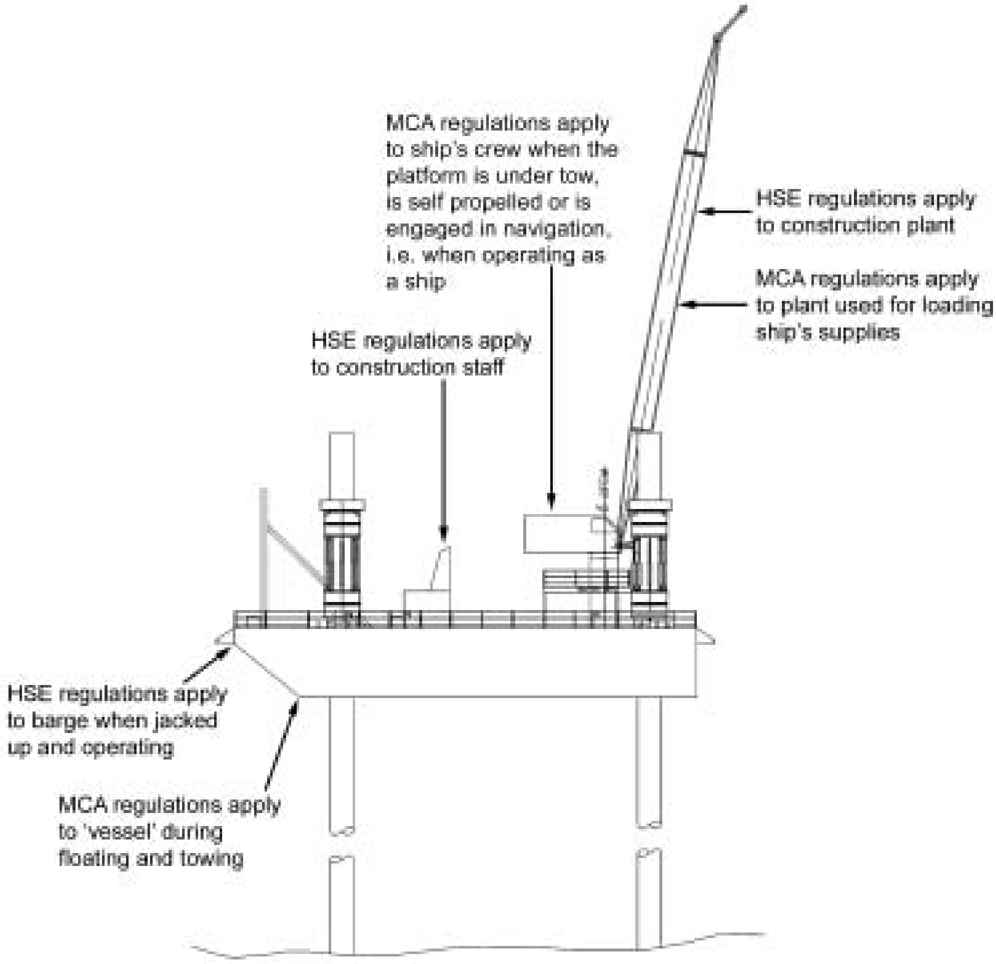


Figure 2.2. Examples of indicative responsibilities of regulatory authorities in coastal engineering for a jack-up barge (UK inshore waters)[Note 1]

Note 1: The image refers to inshore waters. The Construction (Health Safety and Welfare) Regulations apply to all construction work including that within GB Territorial Waters. The regulations (CDM and CHSWR) are made under the Health and Safety at Work Act 1974 (HSWA). They are applied in Territorial Waters by virtue of the HSWA Application Outside Great Britain Order 2001 (AOGBO), but only to certain activities as specified in the Order. Dredging is not specified in the Order. However, if it was dredging as an activity 'in connection with' something else which is specified, such as the laying of a pipeline or power cable, then it would be included.

Table 2.1. Schedule of health and safety enforcement and accident investigation for other activities in territorial waters and on the UK continental shelf

Work Activity [1]	Territorial Waters		UK Continental Shelf	
	UK Vessel	Non UK vessel	UK Vessel	Non UK vessel
Pipe-laying, pipeline repair and maintenance, pipeline removal, etc.	HSE/MCA/ MAIB	HSE	HSE/MCA/ MAIB	HSE
Loading, unloading, fuelling or provisioning of a vessel	HSE/MCA/ MAIB	HSE	HSE[2]/MCA/ MAIB	HSE
Diving in connection with installations, wells and pipelines	HSE	HSE	HSE	HSE
Diving not in connection with installations, etc.	HSE	HSE	MCA/MAIB	
Navigation	MCA/MAIB	MCA/MAIB	MCA/MAIB	–
Ship maintenance	MCA/MAIB/ HSE[3]	MCA/MAIB/ HSE[3,4]	MCA/MAIB	–
Cable-laying	MCA/MAIB	MCA/MAIB	MCA/MAIB	–
Dredging	MCA/MAIB	MCA/MAIB	MCA/MAIB	–
Pollution control	MCA/MAIB	MCA/MAIB	MCA/MAIB	–

1. Work activities *not covered* by offshore installations and wells (see full agreement for details).
2. HSE's responsibility extends only to loading, etc. of vessels engaged in pipe-laying, etc.
3. HSE's powers are limited to activities such as construction, repair, maintenance, cleaning, when not carried out by the crew of the vessel.
4. Excluding vessels exercising their right of transit through territorial waters.

Where overlaps occur in the table above, lead responsibility for enforcement and investigations will normally be as follows:

- all aspects of ship safety and operation, including construction and maintenance, manning and emergency arrangements – responsibility of MCA
- activities associated with pipe-laying, pipeline repair, removal, etc. – responsibility of HSE.

2.1.2. Responsibilities of the Health and Safety Executive

Under HSWA, the HSE is primarily responsible for enforcing legislation, including CDM, covering the occupational health and safety of shore-based workers engaged in a land-based work activity, and work equipment supplied by the shore, for example:

1. For workers and equipment (including cranes, etc. which are temporarily mounted on barges) employed on construction work on vessels on inland waters, coastal waters within GB Territorial Waters, where the primary purpose of the vessel is related to land-based works or undertakings. However, the Merchant Shipping and Fishing Vessels (Health and Safety at Work) Regulations 1997 (SI 1997/2962) which applied health and safety legislation to seagoing ships have been amended by the Merchant Shipping and Fishing Vessels (Health and Safety at Work) (Amendment) Regulations 2001 (SI 2001/54). The effect of the amendment is to apply merchant shipping health and safety legislation to non seagoing ships, thereby allowing effective enforcement by the Maritime and Coastguard Agency. However, HSE legislation still covers those workers involved in construction activities.
2. For workers and equipment carrying out cargo transfers between ships with one ship moored alongside another, when the cargo transfer involves the use of shore-based equipment and/or staff (including the use of loaders provided by shore-based contractors and cranes which are temporarily mounted on barges).
3. For all aspects of health and safety on vessels which are not capable of navigation.

2.1.3. Responsibilities of Maritime and Coastguard Agency

The MCA is an Executive Agency of the Department for Transport and has responsibility and accountability for the UK Merchant Shipping Regulations and their enforcement. It is responsible for the survey and certification of any ships (i.e. vessels used in navigation) engaged in coastal and other construction works, their compliance with merchant shipping legislation, the competency and occupational health and safety of the crew (i.e. not including workers who are normally shore based). The MCA is responsible for the safety enforcement in the following situations:

- The safety (construction, equipment, navigation) of all vessels (including floating cranes) which are used in navigation.
- The occupational health and safety of anyone on a vessel while it is being used in navigation; while the vessel is being used as an adjunct to construction works, MCA remain responsible for the occupational health and safety of the crew, but HSE would be responsible for the occupational health and safety of the construction workers.
- For cargo transfers between ships with one ship moored alongside another:
  i) in a port or in inland waters when the transfer is carried out solely by the ships' crews under the control of the master(s)
  ii) at anchor in territorial waters (even if shore-based personnel are involved) since the prime concerns are the safety of the ships and the risk of pollution; also the operations will be carried out under the control of the ships' master(s).

Figure 2.3 indicates the area responsibilities of the authorities.

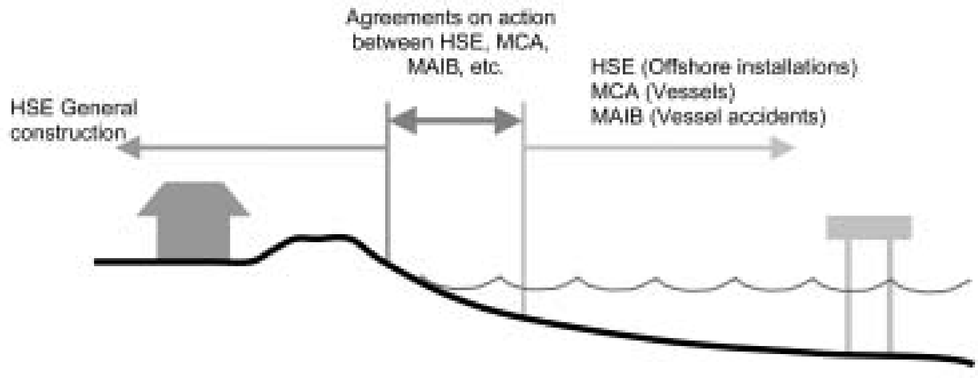


Figure 2.3. Indicative responsibilities of regulatory authorities in coastal and maritime engineering works

2.1.4. Responsibilities of Marine Accident Investigation Branch

The MAIB is responsible for investigating any 'navigation' accidents to or on ships engaged in coastal works, including safety vessels and floating cranes (i.e. except those investigated by HSE). Its purpose is to investigate accidents at sea so as to determine circumstances and causes with the aim of improving the safety of life at sea and the avoidance of accidents in the future. It is not the purpose to apportion liability, nor, except as far as necessary to achieve the fundamental purpose, to apportion blame.

2.1.5. Responsibilities of Ports Division of DfT

Ports Division has a statutory responsibility under the Coast Protection Act 1949 to ensure that coastal works and the siting of offshore installations create no hindrance to navigation. The Act was extended by the Continental Shelf Act 1989 to all parts of the UK continental shelf.

2.1.6. Enforcement

The MCA and HSE have similar powers of enforcement including, in particular, powers to issue improvement and prohibition notices where HSE inspectors or MCA surveyors observe matters of evident concern in areas for which they are not the lead authority. These should be reported without delay to the appropriate office of the other authority by telephone:

1. Where HSE inspectors or MCA surveyors observe matters of evident concern, in areas for which they are not the lead authority, and which pose a risk of serious injury, they may issue a prohibition notice. If they do so, they should notify the appropriate MCA or HSE office by telephone and send a copy of the Notice by fax at the earliest opportunity.

2. Where both organisations have an interest, improvement notices should normally be served by the lead authority after consultation with the other authority.

2.1.7. Accident investigation

The HSE inspectors have powers to investigate accidents to shore-based workers. Accidents to seamen or to ships would be investigated by MAIB. The lead responsibility would be allocated on a case-by-case basis on the same criteria as for the division of responsibilities between HSE and MCA. Where misuse of land-based equipment temporarily mounted on a vessel affected its safety, a joint investigation might be necessary.

2.2. RELEVANT KEY LEGISLATION

2.2.1. Introduction

A list of the key legislation that applies in the marine/coastal environment is given in Appendix 2. This section describes some of the key issues and complexities that occur in the coastal environment. However, the commentary and guidance set out in this section are no substitute for a thorough study of the regulations and their associated approved codes of practice. Much of this summary guidance is based on CIRIA (1999) (CIRIA 518).

All those involved in coastal and maritime construction should be aware of all the applicable regulations and should know the requirements of the regulations that specifically apply to their own role in the process. However, those legally responsible for the safety of these facilities must read and understand both the specific regulations and the guidance given in the associated approved code of practice. The person responsible under the relevant regulations is generally the managing director or chief executive officer of the employer, client (purchaser) or manufacturer. It is essential therefore that such persons have adequate knowledge of the requirements of the regulations and that they engage only those who are competent in the procurement, operation and maintenance of the facility.

2.2.2. Health and Safety at Work Act (1974)

The Health and Safety at Work Act 1974 (HSWA) covers almost all work situations, and places general duties on employers to provide protection for all people at work and some protection to the general public. The HSWA is of over-riding importance, and its requirements should be considered before reference to other Acts and regulations that may also be applicable (see also Appendix 2). The HSWA places a number of general duties on employers, including:

- the provision and maintenance of plant and systems of work that are safe

- the provision of information, instruction, training and supervision to ensure the safety of employees at work
- the maintenance of any place of work under the employer's control in a condition that is safe and without risk to health
- the provision of safe and risk-free access to and egress from any place of work under the employer's control
- ensuring that persons not in the employer's employment are not exposed to risks to their health and safety.

The HSWA also places duties on employees to take reasonable care of their own and others' health and safety.

Section 6 of HSWA places duties on designers, manufacturers, suppliers, erectors and installers to ensure that articles are, so far as is reasonably practicable, safe. They must also arrange any consequential tests and examinations, provide adequate information for safe use, and carry out necessary research to minimise risks to health and safety.

The HSWA provides for health and safety regulations to be made under Section 15, and for practical guidance on health and safety to be provided in the form of approved codes of practice under Section 16.

Failure to observe the provisions of approved codes of practice without following effective and suitable alternative procedures can be taken as evidence of contravention in criminal prosecutions. This obligation is absolute.

2.2.3. Merchant Shipping Act (1995)

The Merchant Shipping Act 1995 is an Act to consolidate the Merchant Shipping Acts 1894 to 1994 and other enactments relating to merchant shipping. It is in 13 Parts and covers the registration and operation of British ships and seamen. Part III – Masters and Seamen, contains a section on safety, health and welfare in terms of conditions for crew. Part IV – Safety, contains general guidance on safety and health on ships. The full text of the Act can be found on the HMSO web site at www.hmso.gov.uk/acts.

The Merchant Shipping and Maritime Security Act (1997) contains miscellaneous amendments of the Merchant Shipping Act (1995) as well as extension of powers to deal with emergencies at sea, pollution control and marine safety and maritime security. The full text of the Act can also be found on the HMSO web site.

2.2.4. Docks Regulations (1988)

The Docks Regulations 1988 apply to all operations carried out in ports within Great Britain. The essentially identical Docks Regulations (Northern Ireland) 1989 apply in Northern Ireland. Approved codes of practice for each version of the Regulations entitled *Safety in docks* were published at the same time. The codes of practice include useful appendices giving details of other relevant legislation, HSE guidance publications and relevant British Standards, although some of the legislation, publications and standards referred to have been superseded by later documents. It is important to ensure that the latest versions of the relevant publications and standards are used.

The Docks Regulations place duties on employers and employees, including vehicle drivers and equipment operators. Duties are also placed on owners of plant, but not on the master or crew of a ship when working on board without shore assistance, who are covered by a variety of merchant shipping legislation (see Section 2.2.3). However, operations involving ship's crew and dock workers working together are to comply with the Docks Regulations.

Operations must be planned and executed to ensure, so far as is reasonably practicable, that no person is exposed to danger. The term 'reasonably practicable' requires risk assessment to be carried out and the level of risk to be weighed against the effort needed to introduce remedial measures. The term 'practicable' means measures that are possible in the light of current knowledge and invention. Where more than one person controls operations, as in Ro-Ro operations involving ship's crew, stevedores and vehicle drivers, collaboration is required in setting up and agreeing strict procedures and systems of work. A reporting system is required for defects, so that timely repairs are carried out; the system of work should be reviewed and modified in the light of any defects.

The code of practice requires that appropriate arrangements are made for dealing with emergencies and other unexpected situations, and that appropriate instructions on these arrangements are given in advance.

Although the regulations do not apply specifically to ship's equipment, all dock operations are covered. Those making use of ship's equipment should plan and execute work safely, and the safety of the equipment should be checked, including the provision of certificates of test or examination.

For further advice of ship-to-shore linkspans and walkways refer to CIRIA (1999) (C518).

The Dock Regulation 13 requires lifting plant to be used only if it is of good design and construction, of adequate strength for the purpose required, of sound material and free from patent defect, properly installed or assembled, and properly maintained. It is implied that the lifting plant is provided in accordance with a relevant national or international standard and that it is subject to systematic preventive maintenance. Lifting plant should be subject to regular routine inspection by someone competent to assess its safety. The inspection should cover the operation of limit switches and overload indicators. In addition, lifting appliances should not be used in a manner likely to subject them to overturning, and lifting operations should be stopped when the wind exceeds the specified operating limit, and any additional braking system should then be brought into operation. A calibrated anemometer may need to be installed and an indicator or alarm fitted to warn the operator of excessive wind speeds. Rail-mounted walkways should provide the operator with a clear view of the area adjacent to the wheels, and the wheels should be fitted with guards.

The information provided in the approved code of practice is no longer up to date. New sets of regulations have been introduced that modify the Docks Regulations, and it is the responsibility of the user of the code of practice to ensure that the appropriate regulations and the relevant British or European Standards are being used. It is understood that a substantial revision of the approved code of practice and guidance *Safety in docks* is intended.

2.2.5. Management of Health and Safety at Work Regulations (1999)

The Management of Health and Safety at Work Regulations 1999 (MHSWR) cover general matters of health and safety, and operate alongside many other regulations. Normally, compliance with specific regulations will be sufficient to comply with those elements of MHSWR with which the specific regulations overlap. The regulations require every employer to assess the risks to employees and others who may be affected by the conduct of the undertaking, such as passengers or vehicle drivers embarking on or disembarking from a ship. A written record must be kept of the significant findings of the suitable and sufficient assessment of risks to health and safety. The significant findings should include hazards posing a serious risk, control measures and the extent to which they control the risk, and groups affected by significant risks or hazards. The assessment must be reviewed where there has been a significant change.

Appropriate written procedures to be followed in the event of serious and imminent danger, and for danger areas, must be established. These procedures must be implemented by sufficiently competent persons. The procedures should include the requirements of specific regulations. Competent persons and employees must have sufficient training and experience or knowledge of maritime and coastal engineering to implement the procedures. Employees must be provided with information on the risks to health and safety, the preventive and protective measures, the emergency procedures, and the identity of competent persons.

A key feature of these regulations and other Health and Safety legislation is the requirement for competent persons to be appointed. It is important to note that competency within construction of land-based works may not mean that they are competent to work on coastal and maritime projects.

2.2.6. Construction (Design and Management) Regulations (1994)

The Construction (Design and Management) Regulations 1994, generally known as the CDM Regulations, came into force on 31 March 1995. An approved code of practice was also published in 1995 and updated in 2002.

The regulations apply to *construction projects* which employ more than four workers, or last longer than 30 working days or 500 person-days. This includes any such work carried out in GB Territorial Waters. The Construction (Health, Safety and Welfare) Regulations 1996 (CHSWR) apply to all construction work including that within GB Territorial Waters.

Construction clients may appoint one or more competent persons to assist them to fulfil the requirements of the regulations. A competent person can be either an employee or a specialist organisation. Such persons should be given sufficient time and resources to carry out their duties. The appointment of these assistants does not absolve construction clients of their responsibilities under HSWA.

The regulations apply to construction work, including building and civil engineering work and alteration, cleaning, repair, maintenance, demolition or dismantling of a structure; site clearance, site investigation, excavation and laying foundations for a structure. They also apply to the installation, commissioning, cleaning, maintenance and repair of mechanical, electrical, hydraulic or similar services normally fixed within or to a structure including ship-to-shore linkspans and walkways. (Note: Where a linkspan or walkway is provided by a ship it will come under MCA's jurisdiction. Where they are provided from the shore they will come under HSE's jurisdiction.) A structure is any building, steel or reinforced concrete structure, dock, bridge or other similar structure; any formwork or scaffolding; and any fixed plant involving a risk of falling more than 2 m, but only in respect of installation, commissioning, maintenance and decommissioning and dismantling.

The client has specific duties under the CDM Regulations, one of which is to appoint a planning supervisor and a principal contractor. The client must be reasonably satisfied with the competence of these appointees and with the adequacy of resources allocated by the appointees to perform their duties. The client must provide health and safety information about the project, not permit construction work to start until an adequate construction health and safety plan is available, and hold the health and safety file and make it available to others. The client must also issue a notification of the project using Form F10.

The client is responsible for providing information about the site. In the case of marine structures, ship-to-shore linkspans and walkways this might include information on soil conditions, seabed levels, wave climate, ship operations and geometrical requirements.

On appointment, one of the designer's duties under the regulations is to advise clients of their duties.

Titles that provide guidance on the CDM Regulations are listed in the References, in Chapter 9 and Appendices 2 and 3. Particularly relevant guidance is provided in HSE information sheet 39, Construction (Design and Management) Regulations 1994. For the role of the client, view the HSE web site at www.hse.gov.uk/pubns.

A key feature of the CDM regulations and other Health and Safety legislation is the requirement for competent persons to be appointed. It is important to note that competency within design, construction, cleaning or demolition of land-based works may not mean that they are competent to work on coastal and maritime projects.

The CDM Regulations require the designer to weigh up many factors as they prepare their design whilst giving due consideration to health and safety. Only a competent designer, who understands the particular construction processes associated in coastal construction, will be able to address health and safety issues appropriately. Design decisions and competency principles as they might apply to coastal engineering are illustrated in Figure 2.4 and Box 2.1. Other issues to add on the right-hand side of Figure 2.4 might include operation and maintenance and whole life costs of the project. Further guidance is given in the Approved Code of Practice (CDM, ACOP).

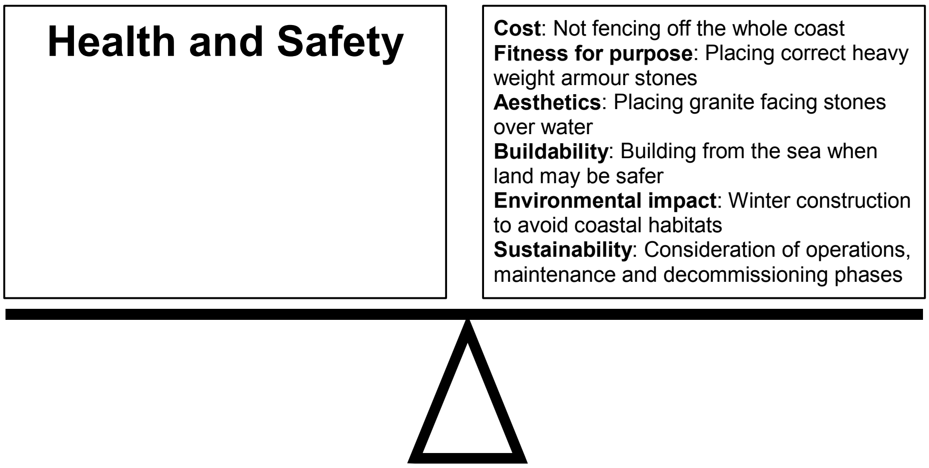


Figure 2.4. Example of decisions the designer or contractor might make when giving due consideration to health and safety in coastal engineering design (based on the category of issues given in the CDM ACOP)

2.2.7. Provision and Use of Work Equipment Regulations (1998)

The Provision and Use of Work Equipment Regulations 1998 (PUWER) implemented EU Directive 89/655/EEC (UWED) and covers health and safety requirements for the provision of safe work equipment and its safe use. The regulations came into effect in 1993, except for equipment that existed before this date, which were covered by a variety of old regulations. For existing equipment, the regulations came into effect in 1997. Existing work equipment sold second-hand since 1993 becomes 'new' equipment for the purposes of the regulations, and the requirements of Regulations 11 to 24 apply retrospectively.

Guidance on the regulations was published by HSE in 1992 in *Work equipment — guidance on regulations*. Many of the requirements of PUWER were already covered by earlier legislation and regulations, and several parallel regulations were enacted in 1992, such as MHSWR and the Workplace (Health, Safety and Welfare) Regulations. Where the various regulations set out duties that overlap, compliance with the more specific regulation will normally be sufficient to comply with the general requirement in other regulations.

The EU Directive 95/63/EC, the Amending Directive to the Use of Work Equipment Directive (AUWED), lays down wide-ranging requirements for the provision, management and use of mobile, self-propelled and remote-controlled work equipment, inspection of work equipment, provision and use of lifting equipment, and the management of lifting operations.

The provisions of PUWER 98 operate alongside the Dock Regulations 1988.

2.2.8. Lifting and pulling legislation

Lifting Operations and Lifting Equipment Regulations (1998) and Provision and Use of Work Equipment Regulations 1998 (PUWER 98)
The LOLER regulations cover ‘lifting equipment’. The PUWER regulations cover winches used for ‘pulling’. High-capacity winches are often employed in the pull out of pipelines and outfalls, positioning barges in offshore locations. They do not cover the vessel’s own lifting equipment, which are not used for construction activities, as these come under different legislation.

The Lifting Operations and Lifting Equipment Regulations 1998 (LOLER) implement the specific lifting aspects of AUWED, and apply over and above the general requirements of PUWER 98 to cover specific risks arising from lifting loads. There were numerous existing regulations covering lifting equipment, of which the most relevant to linkspans and walkways were the Docks Regulations 1988 (Regulations 13 to 17) and the Lifting Plant and Equipment (Records of Test and Examination) Regulations 1992. The lifting equipment aspects of all these regulations are amended or revoked by LOLER. Regulation 14 amends Regulation 13(4) and revokes Regulations 14,15,16(3)(4)(5)(7) and (8) and 17 of the Docks Regulations 1988.

One problem of the various existing regulations is that they do not provide a common definition of lifting equipment. The ports industry generally adopts the definitions in the Docks Regulations. The AUWED refers to ‘work equipment for lifting loads’ but gives no definition. Throughout LOLER ‘lifting equipment’ covers cranes and accessories, including slings, hooks and eyebolts.

Generally LOLER cover the proper planning of lifting operations so that they can be carried out safely, the safe use of lifting equipment, and the thorough examination of lifting equipment at suitable intervals by a competent person. The regulations in LOLER are relatively concise, and in order to fully implement AUWED they have been amplified by an approved code of practice giving comprehensive guidance, which also amplifies relevant clauses in PUWER 98.

The Management of Health and Safety at Work Regulations already require risk assessments of work activities to be carried out to identify risks arising from the use of lifting equipment and the appropriate precautions required to deal with these risks. The level of precaution will depend on the degree of risk assessed, and should reduce the risk to as low a level as is reasonably practicable. Particular hazards to be considered are equipment striking a person or object and the consequences of equipment failing.

The LOLER impose further requirements on employers, on persons controlling the lifting equipment, and on the operator of the lifting equipment or the method of operation of the lifting equipment.

The LOLER define lifting equipment as work equipment for lifting and lowering loads. The enforcement agency has confirmed that LOLER will not be applicable to the majority of linkspans and walkways where the lifting machinery is an integral part of the installation and only adjusts the vertical location of one component of the machine rather than raising or lowering a separately identifiable load. The general exclusion of linkspans and walkways applies both to those that are adjusted to a level then ‘spragged’ before vehicle or pedestrian loads are applied, and to those that are adjusted in level during use, because the primary function in both cases is not the lifting and lowering of loads.

All linkspans and walkways are considered to be work equipment, and are subject to the requirements of PUWER 98. (However, note that where a ship provides a linkspan or walkway it will come under MCA's jurisdiction.) New guidance on linkspans is given in BS 6349 Part 8.

The provisions of LOLER (1998) operate alongside the Docks Regulations 1988.

Figure 2.5. Winching operations (courtesy Van Oord)

Regulations for shipping

The PUWER and LOLER refer solely to the regulations introduced by HSE. Similar regulations applicable to shipping have not yet been introduced but are currently out to consultation. In the meantime the following continue to apply in relation to shipping:

- the Merchant Shipping (Guarding of Machinery and Safety of Electrical Equipment) Regulations 1988
- Regulation 10 of the Merchant Shipping (Safe Movement on Board Ship) Regulations 1988
- the Merchant Shipping (Hatches and Lifting Plant) Regulations 1988.

See previous comment about the application of HSE's PUWER to walkways and linkspans.

2.2.9. Diving at Work Regulations (1997)

The Diving at Work Regulations 1997 (DWR) and the ACOP for Inland/Inshore Diving operations apply if the activity occurs:

- inshore within United Kingdom Territorial Waters adjacent to Great Britain (generally 12 nautical miles from the low water line)
- inland in Great Britain including docks, harbours, rivers, culverts, canals, lakes, ponds and reservoirs.

Outside this scope, a diving operation is likely to be covered under the Approved Code of Practice (ACOP) covering Commercial Diving Projects Offshore.

For the purposes of this publication, all references are based on the assumption that the Inland/Inshore ACOP applies.

Regulation 4 states that:

> Every person who to any extent is responsible for, has control over or is engaged in a diving project or whose acts and omissions could adversely affect the health and safety of persons engaged in a such a project, shall take such measures as is reasonable for a person in his position to take to ensure that these regulations are complied with.

In a coastal and maritime environment this could include the employer, a port or harbour master, vessel master, main contractor, designer, specialist service supplier or any operator instructed to use plant or equipment in support of the diving or associated operation. Whilst the level of responsibility will vary from person to person, all should retain an interest in the diving operation and will need to maintain an element of liaison with the diving contractor and their appointed supervisor.

2.2.10. Other UK legislation in dockworks

There are also numerous by-laws and local requirements that can be applied by, for example, Port Authorities (ports), Harbour Authorities (coastal works), British Waterways (canals), and Local Authorities (inland lakes), depending on where the work is situated. Work in a water-filled quarry would also be subject to the Mines and Quarries Act. Different responsibilities apply to the different categories of personnel (see Box 2.1). The HSE (2002b) provides guidance on managing health and safety in dockwork.

Box 2.1. Categories of personnel working in port and harbour areas. Which category do we fall into? (from HSE, 2002b)

A statutory harbour authority

Most docks and ports are situated within a Statutory Harbour Authority (SHA) area. As an SHA, you will usually have powers to make 'bye-laws' on harbour activities, and powers to enforce them within the defined 'harbour area'. You may own land or premises and you may also be a 'dock company'.

A dock company

If you are a 'dock company' you may also be known as a harbour company, or a port operating company. You will usually manage the dock premises. You may employ dockworkers directly or via a contractor, and so you may also be a 'dock operator'. Alternatively, you may lease premises to a 'dock operator'.

A dock operator

If you are a 'dock operator' you will carry out dock operations, such as mooring, cargo handling and storage. You may do the work directly by employing dockworkers yourself, or you may employ stevedoring or berth-operating companies to do the work. You may lease out parts of the dock premises, such as berths, wharves, quays, etc. to a berth operator or stevedore.

A berth or terminal operator

If you are a 'berth operator' or 'terminal operator' you will carry out dock operations at specific berths or on a terminal. You may own the berths or terminal, or you may lease them. In some cases you will simply be allowed to use them by the SHA, dock company or dock operator. You may employ dockworkers and be a stevedoring company, or you may make use of stevedores or workers from other labour suppliers.

Labour contractors and labour suppliers

You will be a labour contractor or labour supplier if you are:

- a stevedoring company
  If you are a stevedoring company you will employ dockworkers. You may also own, lease or operate a berth, terminal or other dock facilities. Dockworkers may be 'direct labour' employees, 'contract labour' supplied by an employment agency or business, or working on a 'self-employed' or 'casual labour' basis.

- a recruitment or labour supply agency
  These include employment agencies and employment businesses. There is increasing use of such labour suppliers in dockwork.

Storage/warehousing and freight forwarding

You will be a company involved in storage/warehousing and freight forwarding if you provide temporary storage for goods before they are moved onwards. You may also prepare goods for further transit, for example by consolidating loads or packing them into freight containers.

Box 2.1. Categories of personnel working in port and harbour areas. Which category do we fall into? (from HSE, 2002b) continued

Ship owners and shipping agents

As a ship owner or shipping agent you will be involved in the transport of goods by sea. This may include the preparation of documentation, arranging for the actual transport of goods by ship, as well as arranging ancillary activities such as loading and unloading of goods.

Other employers and employees

Many other people work in dock areas, e.g. mooring crews, delivery drivers, customs and excise staff, representatives and quality assurance staff from customers and clients, etc.

2.2.11. Other international shipping legislation/conventions

There is extensive legislation that covers safety of shipping with the International Maritime Organisation (IMO) providing overall governance. For instance, there is a system of classifying ships based on various international maritime conventions (e.g. SOLAS, MARPOL, etc.). This is carried out by Classification Bodies, like Lloyds Register and Bureau Veritas through audits of the vessels. The ISM (Institute for Safety and Health Management) code is another registration scheme for vessels over 500 tonnes. The overall safety and sea worthiness of vessels of all Flag States within UK waters is the responsibility of the MCA.

2.2.12. Environmental legislation

Occupational health is governed both by health and safety legislation listed above and by environmental legislation. Further guidance on environmental legislation is given in CIRIA (2003).

3. Review of accidents in coastal and maritime construction

3.1. OVERVIEW

The review of accidents started with the perception from many stakeholders that coastal and maritime engineering presents a particularly hazardous environment for the construction industry. Simm and Cruickshank (1998) identified many of the commercial and technical hazards experienced by key stakeholders within the industry. However, this earlier review did not focus on health and safety issues. The current review seeks to examine what safety statistics exist and answer the following:

- Is there evidence to suggest that coastal construction has a better or worse accident rate compared to general land construction?
- Is there evidence to suggest that coastal construction has a better or worse accident rate than offshore operations?
- What are the main causes of accidents in coastal and maritime engineering?

Answers to the above can be used to help evaluate **cultural, organisational and humans factor competency issues** and to identify how these vary between the different sectors.

The causes of accidents were evaluated using:

- official data from the HSE RIDDOR database
- data supplied by contractors
- structured interviewing, drawing on expert opinions with respect to the key hazards and the differences between this sector and general and offshore construction.

3.2. THE BUSINESS CASE FOR BETTER HEALTH AND SAFETY MANAGEMENT IN COASTAL AND MARITIME ENGINEERING

Work-related accidents in the UK cost industry over £11 billion each year. The coastal and maritime engineering sector constitutes a significant industry and makes therefore a significant contribution to this cost.

Apart from the social benefits, avoiding work-related accidents improves the business case with other benefits such as:

- achieving a greater certainty of outcome
- improved planning and control, reduced delays
- more reliable cost and completion dates
- reduced overall costs.

For further information on the business case for better health and safety management see: www.hse.gov.uk. This site also contains up to date information on current legislation as well as guidelines for best practice in the construction industry.

3.3. HSE RECORDS

3.3.1. Construction and offshore statistics

The Health and Safety Executive do not hold specific accidents statistics for coastal and maritime engineering sectors. However, the Executive does categorise data into general construction and offshore sectors. The general construction sector covers all construction operations on land, whereas offshore covers offshore installations only. A comparison of accident statistics is given in Table 3.1.

Table 3.1. Severity of injury and type of accident in the general construction and offshore sectors 2000-2001

Type of injury	General construction[1]			Offshore[2]		
	Fatal	Major	Over-3-day	Fatal	Major	Over-3-day
Falls from a height	44%	37%	14%	33%	12%	12%
Struck by moving vehicle/machinery	17%	2%	1%	–	6%	2%
Struck by moving/ falling object	8%	18%	18%	33%	26%	24%
Slips, trips or falls on the same level	–	21%	19%	–	12%	13%
Injured while handling, lifting or carrying	–	8%	34%	–	6%	26%
Other	31%	14%	14%	33%	38%	23%
Total injuries	106	4268	9427	3	50	176

1. Revitalising Health and Safety in Construction, Discussion Document DDE20, 2002, Health and Safety Executive, pp. 43-45.
2. Hazardous Installations Directorate, Offshore Injury and Incident Statistics 2000/2001 (Provisional Data), Health and Safety Executive, Hazardous Installations Directorate, Offshore Division, Table 6.

The above data appear to show that more accidents occur in general construction. However, the general construction sector is much larger than offshore. When the same data is presented as rates of accidents per 100 000 workers (Table 3.2) the data shows that the sectors are generally similar.

Table 3.2. Summary of injury rates (per 100 000 workers) in the general construction and offshore sectors 1993-2001

Severity of injury	General construction[1]			Offshore[2]		
	Fatal	Major	Over-3-day	Fatal	Major	Over-3-day
Year						
1993-94	5.7	214.4	1127.4	2.9	254.4	1102.3
1994-95	5.1	221.2	1139.4	3.7	250.0	878.8
1995-96	5.0	224.0	1030.3	17.2	231.0	1199.9
1996-97	5.6	403.0	1078.6	7.4	163.9	1124.6
1997-98	4.6	382.3	966.3	13.0	321.7	1265.2
1998-99	3.8	402.7	863.4	3.9	290.2	960.8
1999-00	4.7	395.9	917.0	10.5	278.9	1015.8
2000-01	6.0	383.1	841.5	12.9	214.3	754.4
Average	5.1	328.3	995.5	8.9	250.6	1037.7

1. Revitalising Health and Safety in Construction, Discussion Document DDE20, 2002, Health and Safety Executive, p. 41.
2. Hazardous Installations Directorate, Offshore Injury and Incident Statistics 2000/2001 (Provisional Data), Health and Safety Executive, Hazardous Installations Directorate, Offshore Division, Table 2.
3. Non-fatal injury statistics from 1996/97 for general construction cannot be compared directly with earlier years due to the introduction of revised injury reporting requirements (RIDDOR 95) in 1996.

3.3.2. Diving statistics

Table 3.3 presents accident statistics for inshore/offshore diving activities over the period 1996-2003 in terms of total injuries.

Table 3.3. Comparison of offshore and inland/inshore diving operations[1]

Year	Inland/Inshore*					Offshore				
	Fatal	Major	Over 3 Days	Disease	Dangerous occurrences	Fatal	Major	Over 3 Days	Disease	Dangerous occurrences
1996-1997	1	3	2	5	4	1	0	10	8	14
1997-1998	1	0	7	7	8	0	1	4	7	14
1998-1999	0	1	5	9	5	0	2	4	3	19
1999-2000	0	1	6	5	10	1	0	11	2	18
2000-2001	1	1	2	11	9	0	1	4	2	24
2001-2002	0	1	2	11	1	0	2	3	8	24
2002-2003[2]	1	0	3	4	5	0	0	1	4	19
Average	0.6	1.0	3.9	7.4	6.0	0.3	0.9	5.3	4.9	18.9

1. From HSE tabled at the Diving Industry Committee meeting 26 June 2003.
2. Provisional.

*Includes the training of sports divers

The inland/inshore diving industry appears to have a similar number of incidents to the offshore industry although there is evidence to suggest that:

- There is a greater degree of dangerous occurrences in the offshore diving industry. However, it may that the offshore industry is more proactive in reporting these occurrences.
- There is a greater degree of health problems resulting from disease in inland/inshore operations. This may be as a result of greater degrees of pollution of inland/inshore environments.

However, it should be noted that the offshore industry is a smaller industry and the incident rate is likely to be higher in the offshore industry.

3.4. CONTRACTOR'S RECORDS

One contractor's analysis of marine-related accidents is given in Box 3.1. This analysis suggests that accidents statistics in coastal engineering are similar to those experienced in general construction. However, this analysis does not convey whether competency levels on these operations are any different to general construction.

Box 3.1. Summary of one contractor's marine-related accidents data

One contractor examined reportable accidents over the last five years and identified those on projects that come under the coastal/maritime category. Brief details of these accidents are given below:

1998

- *Struck by a rock as it was being positioned*
- *Struck on foot by a falling steel beam*
- *Stumbled and fell over a 750 mm high wall*
- *Struck hand on the end of a truck-mixer chute*

Box 3.1. Summary of one contractor's marine-related accidents data (continued)

- *Struck by a load being lifted by crane*
- *Stumbled while walking down a slight batter*
- *Trapped hand while lifting drawbar onto towing hitch*
- *Injured hand while freeing jammed rock drill*
- *Injured back while lifting a steel plate*
- *Fell 5 m into cage of reinforcement*
- *Concrete debris in eye whilst breaking out.*

Total number of accidents = 47
Number of 'tidal water' accidents = 11

1999

- *Slipped on algae when walking down concrete steps from promenade to beach*
- *Struck by pile helmet as it toppled*
- *Stepped off ladder onto compacted sub-base*
- *Tripped on 3m x 1m steel mesh*
- *Slipped on scaffold board which was bridging a pool of muddy water*
- *Tripped on tying wire*
- *Fell approx. 2.5 m from untied ladder*
- *Stumbled while walking along a trench invert*
- *Slipped on walkway and struck hand against handrail*
- *Trapped between projecting H-pile and slewing crane.*

Total number of accidents = 62
Number of 'tidal water' accidents = 10

2000

- *Dropped metal pipe onto foot*
- *Crushed finger while manually handling grout pump*
- *Fell when shutter gave way.*

Total number of accidents [excluding overseas] = 49
Number of 'tidal water' accidents = 3

2001

- *Injured while erecting a Heras fencing panel*
- *Spilled hot tar over right arm and chest*
- *Sprained back while pushing against ground anchor to prevent it dragging*
- *Struck hand with a large sledgehammer*
- *Struck finger with large sledgehammer*
- *Struck by shutter being lifted by crane.*

Total number of accidents [excluding overseas] = 46
Number of 'tidal water' accidents = 6

2002

- *Struck by falling dust suppression unit*
- *Slipped while climbing into the cab of tractor*
- *Fingers trapped by a load being lifted by crane*
- *Tripped and fell over fencing*
- *Struck by debris from concrete crusher.*

Box 3.1. Summary of one contractor's marine-related accidents data (continued)

Total number of accidents [excluding overseas] = 45
Number of 'tidal water' accidents = 5

The number of these accidents expressed as a percentage of all reportable accidents was 23%, 16%, 6%, 13% and 11% respectively for the years 1998-2002. This is an average of 14%.

The contractor then investigated the proportion of total work that comes under this category [based on value] and the respective figures are 16%, 21%, 18%, 11% and 14% – an average of 16%.

The small sample shows that for this contractor there does not appear to be a higher level of accidents within the coastal engineering sector. Also, the brief description of each accident, indicates that they are generally the types of accident that could have occurred on any construction project. The accident statistics may hide the fact that there is generally an increased competence level of operators in coastal engineering.

The contractor acknowledged that there are specific hazards associated with coastal/maritime work that are difficult to manage. The contractor also stated that there were 35 accidents that perhaps could have been avoided.

Accident statistics from other contractors operating principally marine plant are given in Table 3.4 and Table 3.5. This shows that the 'over-three-day' incident rate is similar to the construction average with major accidents higher than the construction average. However, the latter is based on only a small number of incidents.

Table 3.4. Data from one marine contractor's safety statistics

Year	Fatal	Major	Over 3 days	Dangerous occurrences	Members of the public	Average/no. of employees	Incidence rate/ 100 000 employees
1997	0	1	0	0	0	200	500
1998	0	3	1	0	0	269	1480
1999	0	0	2	1	0	141	2130
2000	0	3	3	0	0	207	2890
2001	0	2	4	0	0	177	3380
2002	0	1	1	0	0	230	870
Average	0.0	1.7	1.8	0.2	0.0	204	1875
Average/100 000 employees	0	833.3	882.4	–	–	–	–
General construction average	5.1	328.3	995.5	–	–	–	–

Table 3.5. Data from one specialist marine piling contractor's safety statistics

Year	Fatal	Major	Over 3 days	Dangerous occurrences	Members of the public	Average/no. of employees	Incidence rate/ 100 000 employees
2000	0	0	3	–	–	98	3061
2001	0	0	2	–	–	108	1852
2002	0	0	1	–	–	114	877
Average	0	0	2	–	–	107	1930
Average/100 000 employees	0.0	0.0	1875				
General construction average	5.1	328.3	995.5	–	–	–	–

Table 3.6. Causes of accidents from one specialist marine piling contractor's safety statistics

Cause	Number (3 years data)	% of total
Falls from height	3	4
Falls at ground level	3	4
Falls into water	0	0
Stepping on objects	1	1
Striking against objects	9	13
Falling objects	8	11
Handling objects	17	24
Contact with hot surfaces	3	4
Machinery	4	6
Hand tools	5	7
Electric	0	0
Contact with substances	9	13
Other	9	13
Total	71	100

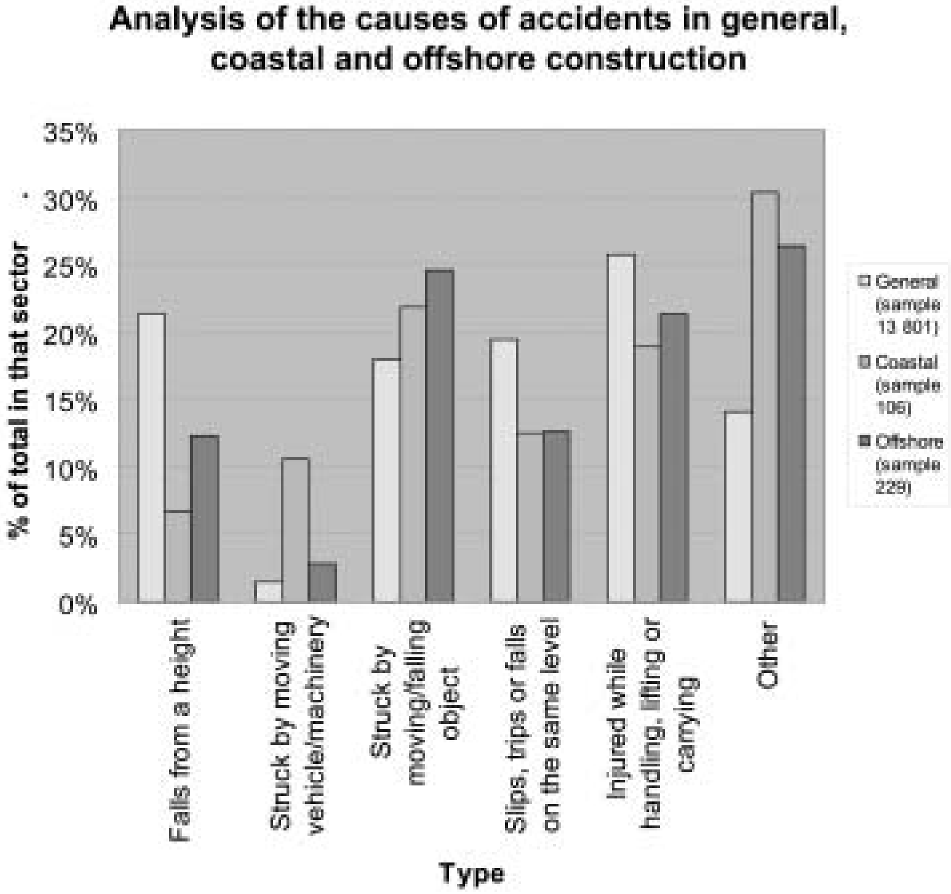


Figure 3.1. Analysis of the type of accidents in general, coastal and offshore engineering/construction sectors

Figure 3.1 summarises the information provided in Table 3.1, Box 3.1 and Table 3.6. While the sample is very small for the coastal engineering sector (106) and should be treated with caution therefore, it provides a useful insight into the kinds of accidents in the coastal and maritime sectors and the differences between this sector and general land-based and offshore. In particular it is noted:

- **Falls from heights appear to be lower in the coastal sector than either general or the offshore sector.** This may be because in the coastal sector, as for example a beach recharge or outfall construction project, less work is undertaken at height. It should be noted that falls from heights constitute the majority of deaths in both the general construction and offshore industry.
- **There are a greater number of accidents in the coastal sector where operatives are struck by plant or machinery.** This may be because the working areas can be cramped especially on construction platforms such as jack-ups, barges and in inter-tidal areas.
- **There were no 'falls into water' in the 106 accidents analysed.** It may be that falling into water hazards are effectively mitigated or eliminated at source.

- **There is a significant number of 'other' accident types in coastal engineering.** Analysis of these accidents shows no major trend towards any particular hazard. However, it appears that there is a wider range of accident types than in general construction and this could be as a result of an unfamiliar environment.

3.5. CLIENT FEEDBACK

3.5.1. The Environment Agency

The Environment Agency uses its framework contractors and specialist subcontractors to undertake coastal defence works. In total there are probably only a dozen companies undertaking coastal engineering work for the Environment Agency. Agency staff consulted considered that this helps to maintain high competence levels within the contractors they use. It is the Agency's stated policy objective to achieve a position of zero reportable construction incidents and to be considered to demonstrate best practice as a client.

The Environment Agency employs both proactive and reactive systems in managing health and safety risk, which is co-ordinated through a national health and safety advisor. Its proactive systems include:

- health and safety pre-qualification processes for prospective contractors (including company procedures and staff competency levels)
- vetting of method statements
- site visits by the EA health and safety advisor
- site meetings (where Health and Safety is a key agenda item)
- quarterly reviews, which include the recording of H&S key performance indicators as one of the measures for assessing contractors' performance and used in the future allocation of work
- post project evaluation (with Health and Safety being a key performance indicator within the evaluation).

On the reactive side, the Environment Agency maintains a database of information on health and safety information relating to its staff, contractors and the public. The purpose of the database is to ensure that accident records (including near misses) are investigated and lessons are learnt thereby improving the Agency's ability to examine why incidents occur and provide better protection and a safer working environment. Unfortunately, the database had not been operational for sufficient duration to make use of the data.

Anecdotal evidence suggests that the Agency's health and safety record is better than the construction norm. It was suggested that the main reason for this was that there was a general absence of construction work associated with construction at height and the corresponding risks associated with that work.

The Agency is also endorsing the Construction Skills Certificate Scheme and will require all contractors' staff to have attained the necessary level of certification.

3.5.2. Port operator

The port operator contacted owns and operates two major commercial ports. Its experience identified that the commercial port operations themselves were much more hazardous than the construction operations. This is explained further in Box 3.2.

Box 3.2. Summary of one port operator's accidents data

One port operator's safety department examined the accident statistics for the past six years for two major commercial ports. In that time, the two ports had had **4 reportable construction accidents** and since then have spent around £100 million in capital expenditure. Two of these accidents occurred in the marine environment but were not the result of a marine-related risk, i.e. they could just as easily have occurred on land. However, the port's accident data may mask the true picture, as they would not record the contractor's accident data, as contractors are separately responsible for submitting the RIDDOR forms to HSE.

In the same period the operator had had approximately **60 reportable operational accidents** involving the operator's employees. Again, in the same period, there had been many more reportable incidents involving tenants, berth users and operations contractors but the operator had limited information on this, as it is not their responsibility to report such incidents. Although this included **4 deaths during operations**, it was actually significantly better than the industry average, but still a completely unacceptable record.

The operator stated that many of the incidents (including at least two of the deaths) were a result of people not following the safe system of work or indulging in 'horseplay' but the corrective action for all types of operational incident usually included an 'engineering' solution. There can be no doubt that some of these incidents could have been avoided in the first place had the link between the initial design through construction and into operations been stronger.

The port operator is a key player in an organisation called Port Safety and Skills Ltd. and it has recently been involved in the launch of a Safer Ports Initiative, supported by HSE. The engineering and construction activities have been highlighted as an example of good practice and it is trying to use that to influence its operational activities.

3.6. CULTURAL, ORGANISATIONAL AND POLICY FACTORS

A series of structured interviews were held with marine contractors and other stakeholders to draw out cultural, organisational and policy factors that contribute to safety practice in coastal engineering. These structured interviews covered the following principal topics, focusing on the differences between land-based construction and coastal/maritime construction:

- perceived areas of special risk in marine construction
- training/instructions/competence of the workforce
- safety records
- preparation of risk assessments and method statements.

The structured interviews highlighted that:

- Almost all contractors consulted believed that there was generally a **higher level of competency** on maritime and coastal engineering projects than for general land-based construction. They considered that this high level of competence helped to keep the number of accidents lower and that this may be the reason why accident statistics do not show an increased accident rate for maritime and coastal engineering projects, which are potentially more dangerous.
- In addition, the experienced maritime/coastal engineering contractor will have planned and understood the full scope and risks of the project at the time of tender, and this can generally be recognised in the tender submission, even though this may place the contractor at a disadvantage, if price alone is the driving consideration (Figure 3.2).

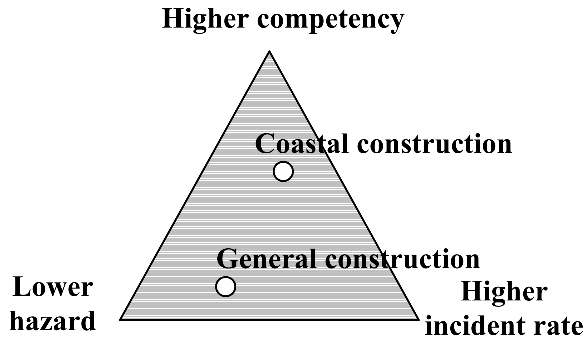


Figure 3.2. Illustration of hypothesis on competency levels in land-based and coastal/maritime engineering

- Safety is often 'engineered in' at an early stage in a project because of the close involvement of engineers in the methodology of constructing the works. Typically, in maritime/coastal construction large elements and large forces are in play, be it stability of dock walls or other structures in the water, floating construction plant and other marine craft, temporary works and access structures and others. These demand the attention and skills of the engineer to provide appropriate and safe solutions to the problems of construction in such an environment.
- Almost all of the consultees use **direct labour**, rather than perhaps the more usual practice in land-based civil engineering of using subcontractors or labour/staff hired for the project. The contractors considered that maritime/coastal work was more specialised typically than that associated with general land-based construction and therefore a higher level of competency was required. The use of direct labour was the only way to realistically achieve this increased competence. Where subcontractors were employed, these tended to be specialised contractors who were well used to working in this environment. The contractors did not accept that the use of management contractors was appropriate in coastal/maritime engineering.

- If the contractors' workload did not entirely consist of coastal or maritime works, then when a coastal engineering project was awarded, the **core coastal/maritime engineering team** remobilised from the various site teams to work on the project. The core team then trained any new staff to ensure that competency levels remained high throughout the site team. One contractor stated that the average age of their specialist core team was 43, suggesting that experience was a key element of the competency resource.
- Competence of staff was demonstrated using skills training schemes such as the NVQ, Construction Skills Certificate Scheme (CSCS) run by CITB or other apprenticeship schemes. However, many found that standard training schemes did not address their specialised coastal/maritime engineering training needs and that they had to carry out more targeted health and safety training focused towards coastal/maritime engineering themselves. One contractor partnered with one training organisation to **ensure that the safety training was targeted** towards its needs and not the needs of general construction. This training was backed up by annual appraisals. One contractor stated that it required all staff working away from shore to undertake a one day sea survival training course STCW 95 Approved or OPITO Training Approved.
- Most contractors tried to employ the normal approach of **removing the risk at source** wherever possible, e.g. removing marine plant risks by working from land, removing wave height risk by using a jack-up barge rather than a floating barge where possible, clearly fencing off water edges.
- Consistent with land-based construction, a **combination of measures** was used to maintain competence such as formal off the job training, on the job training and tool box talks. Also consistent with land-based engineering, method statements and risk assessments were prepared to ensure that the work was undertaken in a planned and safe manner.
- One specialised contractor stated that its **management structure** was different to a normal land-based construction site and that it had more senior and more highly skilled staff with little to no unskilled staff (Figure 3.3). It stated that this higher level of competence helped manage safety on its sites.

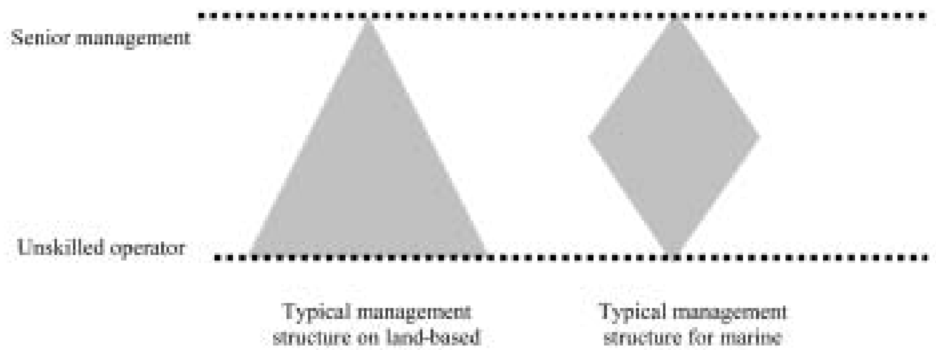


Figure 3.3. Typical management structure on land-based and coastal engineering projects

- One specialised marine contractor stated that it tended **to source operators from other similar industries** such as the fishing industry who were used to working in maritime environments.
- One specialised marine contractor stated that on its jack-up platform it tended to work in close knit **small teams**, who each know each other's roles, responsibilities and competencies. It believed that this working relationship helped manage health and safety.
- A number of contractors stated that apart from the more obvious risks, coastal working often involved working in remote areas with long stretches of coastline and only a few operators spread over significant distances. Therefore, the **risk management approach needed to recognise the different working environment** such as hazards associated with lone working and remote access.
- A number of contractors commented on the fact that many marine contractors are **foreign owned and often operated by foreign personnel** resulting in greater variety in health and safety practices. On the positive side the maritime industry benefits from greater cross-fertilisation of ideas but has the disadvantage that cultural differences, differences in legislation and its implementation and communication problems can affect health and safety. A bad example of different cultural attitudes to health and safety is given in Figure 3.4.

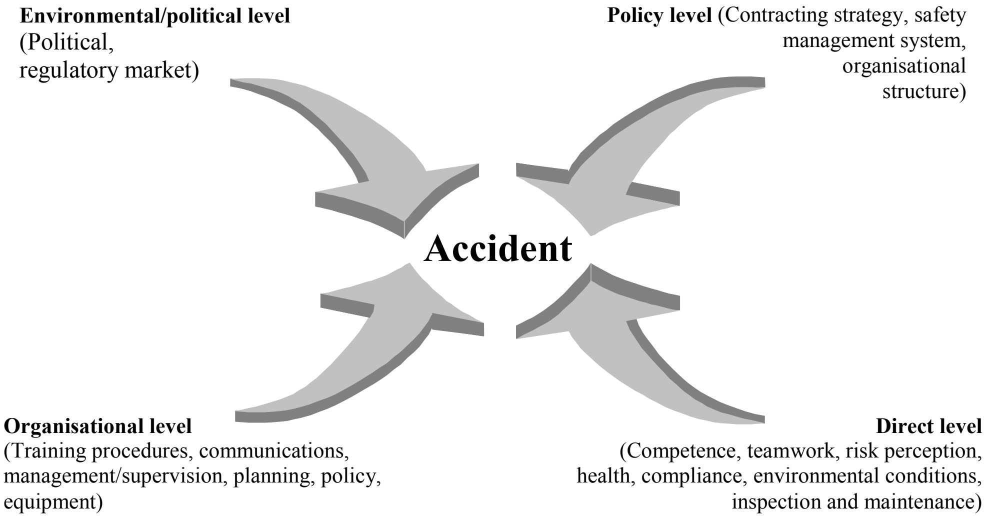
Figure 3.4. Example of different 'cultural' attitudes to health and safety
Photo shows swimmer (below surface) who takes a breath and dives down several metres with a wire brush held in his mouth to then brush the rust off the sheet piles for as long as he can hold his breath before returning to the surface to catch his breath again. The whole wall was treated in this way (courtesy Alan Brampton)

3.7. SUMMARY AND CONCLUSIONS

Given the potentially more hazardous environment, it is noticeable that coastal and maritime engineering appears to have similar levels of incident rate to general construction. A general conclusion would be that better organised staff who are more highly trained and have experience in the coastal/maritime sector tend to have fewer accidents. However, all those consulted acknowledged that in addition to the natural hazard issues present in coastal and maritime engineering, many organisational, cultural and other factors influenced health and safety management in coastal and maritime engineering. This is illustrated further in Box 3.3.

Box 3.3. Influence levels on health and safety in coastal and maritime engineering

The following diagram illustrates how accident causes occur at a number of levels and do not just rest with the individual.



These are illustrated with reference to coastal engineering:

- **Environmental/political level,** e.g. lack of clarity as to whether HSE or MCA are the regulator and whether proscriptive or risk-based legislation applies
- **Policy level,** e.g. lack of a clear policy that life-jackets should be worn
- **Organisational level,** e.g. no life-jackets available for the new shift
- **Direct level,** e.g. taking off a life-jacket.

An example is given in Box 3.4.

Box 3.4. Influence levels on health and safety in coastal and maritime engineering (based on an example by Bomel)

A new quay wall was being constructed using a jack-up barge. Before the barge was jacked up a rigger was asked to climb up a ladder to carry out a regular task not normally undertaken by him and it was near the end of his shift. The rigger needed to adopt an awkward position which made his harness uncomfortable. Therefore to get the job done the rigger unclipped his harness. Then a large wave impacted on the platform and the rigger lost his balance and fell incurring serious injuries.

What led to this accident may appear straightforward. The rigger should not have unclipped his harness and by doing so he was to blame. However, closer inspection of the circumstances indicates that failings existed on all levels:

- The rigger was tired because it was the end of his shift.
- He was inexperienced at such work and yet the work was unsupervised.
- There was no company procedure for training of new staff in the use of the harness (it tended to happen on the job).
- Staff had complained to management in the past about some harnesses being uncomfortable.
- Management had not removed these and no one had told the rigger about the differences between harnesses.
- The task was not undertaken with the normal rigger as it had been delayed by bad weather. The planning of the job hadn't taken into account that different staff may have to do this regular task.
- The harbour authority was putting pressure on the contractor to jack up the platform as the mooring lines were causing a problem to shipping.

4. Key hazards and other risk issues in coastal and maritime engineering

This chapter aims to identify and describe key sources of hazards in coastal and maritime engineering (see Figure 4.1). Much of this work is based on Simm and Cruickshank (1998) and further information on these issues can be found in that publication.

The key sources of hazards derive from:

- the uncertain sea (wind, waves, currents, water levels)
- the physical dynamic environment (impacts due to the above)
- the users of the coastal environment (the lack of containment of the site)
- the selection and use of equipment in these environments
- impact on the operators (inadequate welfare provisions).

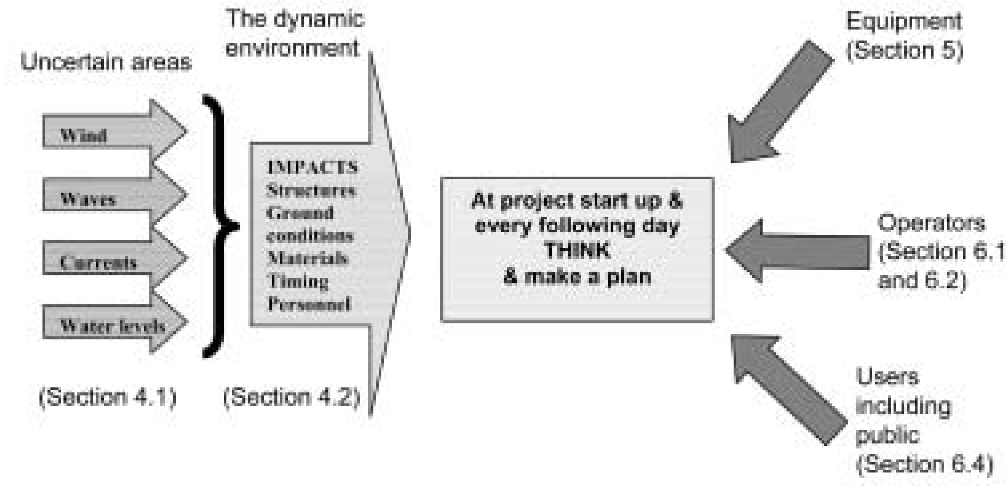


Figure 4.1. Generic hazards (left) and other factors (right) that affect health and safety in the coastal construction environment (based on CIRIA, 2003)

4.1. THE UNCERTAIN SEA

The coastal/maritime environment can be highly volatile and at times unpredictable, presenting a major challenge to those engaged in construction work (Figure 4.2). Conditions can also change very suddenly. This section describes the basic parameters that can influence the planning and execution of construction works in such environments, namely:

- wind climate
- wave climate
- currents
- water levels
- joint probabilities of the above.

Figure 4.2. Storm damage to coastal protection site

These basic parameters are discussed briefly below and further details are available from CIRIA (1996), CIRIA/CUR Rock Manual (1991) and Simm and Cruickshank (1998).

It is important to recognise that waves and tidal action in particular can introduce irregular and varied directional forces. For example at peninsulas where estuaries meet tidal currents, wave patterns are not predictable and the direction of flow can change at any depth and time, making operations in such areas particularly hazardous.

Contractors need to be fully informed on the weather climate at the site. Basic data on prevailing conditions can be obtained from a number of sources as shown in Box 4.1.

Box 4.1. Useful sources of weather climate data

Useful data for inclusion in the health and safety plan can be found as follows:

- **Wind** – European Wind Atlas; BS6399; UK Met Office Models
- **Waves** – UK Wave Atlas*; UK Meteorological Office Model*; Nomographs*; Numerical models; Online site specific weather service supplied by Met Office and others
- **Currents** – Admiralty Charts and Tables; Admiralty Pilot Books; Current Maps; Tidal Flow Models
- **Tides** – Admiralty Tide Tables; Tide Table Software; Surge Maps; Published Data from Research Stations (such as POL).

* Caution as waves inshore can be very different to those defined offshore

In addition, recent developments have allowed for real-time forecasting of weather conditions, giving contractors three–five day forecasts which can be site specific and allow for forward planning of weather dependent operations such as towage and positioning of caisson units, heavy lifts using floating cranes, etc. For further details see www.met-office.gov.uk and www.ecmwf.int.

4.1.1. Wind climate

For marine operations, the wind strength is described in terms of the Beaufort Scale (see Box 4.2).

Apart from the influence that the wind climate can have on the wave climate (see Section 4.1.2), winds can also have an important effect on floating craft and on the operation of certain items of contractor plant. The effect of strong and rapidly varying wind speeds and local pressures can cause significant motions of marine craft, which have consequential effects on safety. In addition, wind can have a significant effect on lifting operations, both on shore and, more particularly, on floating crane barges and cranes on jack-up platforms.

Around most of the UK coast, sequential wind records in digital format are available from about 1970 onwards. It should be noted that the coastal environment is much more exposed than many land sites and this has a direct consequence in wind speeds over the water being higher than speeds over land for any given weather condition. Simm and Cruickshank (1998) suggested that the increase is of the order of 10%. Further advice on managing issues in the maritime/coastal construction environment is also given in that publication.

Box 4.2. Beaufort Scale: Equivalent wind speeds and specifications for use on land and sea

Beaufort force	m s^{-1}	knots	mph	Description	Specifications for use on land	Specifications for use on sea
0	0.0 – 0.2	0 – 1	0 – 1	Calm	Calm; smoke rises vertically.	Sea like a mirror.
1	0.3 – 1.5	1 – 3	1 – 3	Light Air	Direction of wind shown by smoke drift, but not by wind vanes.	Ripples with the appearance of scales are formed, but without foam crests.
2	1.6 – 3.3	4 – 6	4 – 7	Light Breeze	Wind felt on face; leaves rustle; ordinary vanes moved by wind.	Small wavelets, still short, but more pronounced. Crests have a glassy appearance and do not break.
3	3.4 – 5.4	7 – 10	8 – 12	Gentle Breeze	Leaves and small twigs in constant motion; wind extends light flag.	Large wavelets. Crests begin to break. Foam of glassy appearance. Perhaps scattered white horses.
4	5.5 – 7.9	11 – 16	13 – 18	Moderate Breeze	Raises dust and loose paper; small branches are moved.	Small waves, becoming larger; fairly frequent white horses.
5	8.0 – 10.7	17 – 21	19 – 24	Fresh Breeze	Small trees in leaf begin to sway; crested wavelets form on inland waters.	Moderate waves, taking a more pronounced long form; many white horses are formed. Chance of some spray.
6	10.8 – 13.8	22 – 27	25 – 31	Strong Breeze	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.	Large waves begin to form; the white foam crests are more extensive everywhere. Probably some spray.
7	13.9 – 17.1	28 – 33	32 – 38	Near Gale	Whole trees in motion; inconvenience felt when walking against the wind.	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind.
8	17.2 – 20.7	34 – 40	39 – 46	Gale	Breaks twigs off trees; generally impedes progress.	Moderately high waves of greater length; edges of crests begin to break into spindrift. The foam is blown in well-marked streaks along the direction of the wind.
9	20.8 – 24.4	41 – 47	47 – 54	Severe Gale	Slight structural damage occurs (chimney-pots and slates removed).	High waves. Dense streaks of foam along the direction of the wind. Crests of waves begin to topple, tumble and roll over. Spray may affect visibility.
10	24.5 – 28.4	48 – 55	55 – 63	Storm	Seldom experienced inland; trees uprooted; considerable structural damage occurs.	Very high waves with long over- hanging crests. The resulting foam, in great patches, is blown in dense white streaks along the direction of the wind. On the whole the surface of the sea takes on a white appearance. The 'tumbling' of the sea becomes heavy and shock like. Visibility affected.
11	28.5 – 32.6	56 – 63	63 – 72	Violent Storm	Very rarely experienced; accompanied by widespread damage.	Exceptionally high waves (small and medium-size ships might be for a time lost to view behind the waves). The sea is completely covered with long white patches of foam lying along the direction of the wind. Everywhere the edges of the wave crests are blown into froth. Visibility affected.
12	≥32.7	≥ 64	≥ 73	Hurricane	--	The air is filled with foam and spray. Sea completely white with driving spray; visibility very seriously affected.

4.1.2. Wave climate

Waves provide probably the single most important hydraulic parameter in coastal/maritime engineering construction (Figure 4.3). Wave conditions are described in a number of technical terms as described in Box 4.3.

Their impact on construction activities is wide ranging and can:

- affect deliveries reaching the site (e.g. preventing barges leaving port, causing them to run for cover, delaying them in transit, preventing them from unloading)
- damage plant (due to beaching, overturning, striking the works, etc.)
- damage temporary works
- result in personal injuries to operatives through wave impact
- compromise effective rescue procedures
- damage completed works where permanent protection is not yet in place
- draw down beach levels which can affect both the works and deliveries.

The impact of waves is dependent on factors, such as:

- wave height
- wave period – long-period waves tend to cause more problems for vessel movements and greater overtopping and run up
- wave length – a function of water depth and wave height
- likely extreme values of the above factors over a period of one season, one year or more
- wave direction
- storm duration
- storm persistence and sequencing.

Figure 4.3. Jack-up platform working in exposed wave conditions in Sennen Cove (courtesy Seacore)

Box 4.3. Common wave definitions often used in coastal engineering

- **Wave height** is the distance from the crest to the trough of a wave.
- **Significant wave height, ($H_{(1/3)}$ or H_s)** is the average height of the highest one-third of all waves occurring in a particular time period.
- **Maximum wave height (H_{max}).** In any wave record, there will also be a maximum wave height, H_{max}. Prediction of H_{max} for a given period of time has great value in the design of structures such as flood barriers, harbour installations and drilling platforms. It is necessary to emphasise the essentially random nature of H_{max}. For instance, although the wave $H_{max(25\ years)}$ will occur on average once every 25 years, this does not mean such a wave will automatically occur every 25 years.
- **Wave period (T)** is the time a wave takes to pass a fixed point.
- **Mean wave period (T_m)** is average wave period. In many cases it is identical to another term the zero up crossing period (T_z).
- **Peak wave period (T_p)** is the period at which the peak energy occurs. For many sites a reasonable estimation is $T_m = 0.8T_p$ but can commonly vary from 0.65 to 0.9.
- **Swell** waves are waves generated at some distance from the site. They have longer periods than wind-generated sea waves and tend to cause more problems for marine operations. Swell does not exist on totally enclosed waters, however these waves can penetrate into enclosed waters even through small harbour entrances.
- **Wind** waves are waves generated closer to the site. These have shorter periods (i.e. more choppy in nature) and tend to cause less problems for marine operations than swell waves.

Ship-generated waves

In addition to wind-generated waves, consideration must be given to the possible impact of waves generated by passing ships. This can be particularly important in the case of high-speed catamaran ferries, where large bow waves can be generated which may arrive at a site some considerable time (which may be up to 20 minutes) after a vessel has passed.

Wave overtopping

In addition, consideration should be given to wave overtopping hazards. Overtopping can occur on a regular basis as a foreseeable gentle ‘splash’ or on a rarer and often more dangerous and violent basis as a result of ‘freak’ wave(s). Forces that arise from violent overtopping can be well over 200 kN/m^2. Research is currently underway to examine overtopping so that better understanding and predictions of violent overtopping can be assessed.

4.1.3. Tidal currents

Except in the case of construction using caissons or pitching and driving piles in strong currents, the impact of currents on construction risk is generally limited mainly because they are more predictable, especially around the UK coast. However, in some cases, for example at river or loch entrances or sections of narrow waterways, currents can be high and sometimes unpredictable due to the influence of surges. This is particularly important when considering submerged construction activities using remote operated vehicles or (ROVs) or divers.

Currents can:

- knock personnel over
- affect the ability of a vessel to hold position offshore
- affect the ability of a vessel to safely approach the site especially in restricted water depth
- affect the rescue procedures and ability of rescue craft to operate
- affect the ability to place materials within tolerance
- affect the ability to pitch piles and require immediate pile bracing after driving
- erode partially completed works
- apply loading on temporary works
- affect the incident wave conditions.

Currents can be described over a given time-scale by a time–mean magnitude, direction, and spatial and turbulent variability. Tidal currents, like astronomical tidal levels are predictable but can be particularly influenced by less predictable components such as wind, river discharge and surge effects. When wind and wave influences are important in current generation, it is rare for the resulting, albeit less predictable, currents to be a governing construction consideration when compared with the direct wind and wave effects.

Waves, water levels and currents can interact to change the conditions of each.

4.1.4. Water levels

Water levels are important in a number of ways as they may:

- define what works can be carried out in the dry and the access time available to those works
- prevent deliveries from reaching the site
- flood the works where excavations or cofferdams are used
- affect the wave and current climate that reaches the site
- affect ground water levels and pore water pressures behind quays and retaining structures.

There are various components of water level which need to be considered. These are described in Box 4.4. As well as astronomical tides there are several meteorological components of water level. For construction works these residual components comprise:

- storm surges
- wind set-up
- wave set-up
- seiches.

The major effect determining water level at any one instant, around the UK at least, is the astronomical tide which can be predicted accurately well in advance. Meteorological and seismic effects are not predictable more than, at best, a few days in advance, and even then the predictions are very uncertain. It is these aspects that can pose a risk to the construction works.

⇒ Good practice: Water levels

- It is important that a detailed knowledge of predicted water levels is available on the site to plan operations to suit.
- Basic information can be obtained from the Admiralty Tide Tables, software or on the web which give daily times and heights of high and low water.
- It may be necessary to calculate adjustments from the published data, which refers to selected ports, to be site specific for the project location.

Box 4.4. Components of water levels

Tides

The basic driving forces of tidal movements are astronomical and therefore entirely predictable, which enables accurate prediction of tidal levels and currents. There can be considerable amplification of tidal levels in shallow seas and estuaries. The predictive character of tides can be useful when timing of critical operations and manoeuvring during construction is needed.

Storm surges

Local minima of atmospheric pressures (depressions) cause a corresponding rise of water levels (similarly, high pressures cause reduced water levels). Mean air pressures at sea level are 1013 millibars (mbar) approximately. In the storm zones of higher latitudes variations from 970 to 1040 mbar are common, while in tropical storms pressures may drop to 900 mbar.

Due to dynamic effects, however, the rise in water level can be amplified significantly. When the depression moves quickly, the elevation of the water level moves correspondingly as a storm surge.

A storm surge behaves as a long wave with a wave length approximately equal to the width of the centre of the depression. The height of these long waves may increase considerably due to shoaling. For example, along the coasts of the southern North Sea, storm surges with a height of 3 m have been recorded. In practice, the term 'storm surge level' is sometimes used loosely to include the astronomical tidal component and other meteorological effects. Care should be exercised when quoting or using surge data to acknowledge whether or not it includes wind set-up, wave set-up and seiches.

Wind set-up

Shear stress exerted by wind on the water surface causes a slope in the water as a result of which wind set-up and set-down occur at downwind and upwind boundaries, respectively.

Box 4.4. Components of water levels (continued)

Wave set-up

Wave set-up is caused by energy dissipation due to shoaling of the incoming waves. For small-amplitude sinusoidal waves, the wave set-up can be roughly approximated by linear wave theory.

Seiche

A seiche in a body of water is a standing wave oscillation of the water surface with the natural frequency of oscillation for that water body. It is normally observed in completely enclosed water bodies such as lakes and inland seas. Thus, when a long wave traverses the water body it is reflected from the end and the interference with the original wave results in a standing wave pattern. However, if a body of water such as a bay or estuary is open at one end, reflection may still occur at the open end and produce standing waves.

Mean water level

For coastal waters in open communication with the sea, the mean water level (MWL) can often effectively be taken as a site-specific constant, being related to the mean sea level (MSL) of the oceans. In some areas, for example the eastern Mediterranean, the mean sea level varies slightly with the time of year, in a predictable way.

Most countries have a national datum level, which is often approximately equal to the MSL (for example Ordnance Datum in the UK). Chart Datum conversely, as used by the British Admiralty, represents the Lowest Astronomical Tide, which varies significantly from one place to another.

Still water level

Still water level is defined as the average sea surface elevation over an area at any instant. It excludes localised variations due to waves and wave set-up, but includes tidal elevations and surges.

Changing the operation to work in the dry through the use of limpet dams or caissons (Figure 4.4) can remove the hazards associated with changing water levels. Care should still be taken to ensure inundation does not occur due to excessive water levels, waves, ground water or other means.

4.1.5. Joint probability of waves and water levels

Overtopping and damage to construction works are usually associated with times of both large waves and high water levels. Therefore it can be important to consider both parameters in the design of temporary works. High currents can also occur at these times. Further advice is given in Simm and Cruickshank (1998).

Figure 4.4. Limpet dam (courtesy John Martin Construction)

4.2. DYNAMIC PHYSICAL ENVIRONMENT

The previous section discussed how the 'uncertain sea' affects construction works. This section shows how the presence of the sea interacts with physical and other factors to affect the buildability of coastal works. It illustrates with examples the inherent problems in constructing in the coastal environment and, in particular, discusses the following:

- ground conditions and changes in seabed and beach profiles
- uncertainty of condition of existing structures
- access and working space
- temporary instability of the works
- ordnance
- subsea services
- timing of the works
- contaminated sediments
- interaction of the above.

4.2.1. The surf zone

Working in the surf zone can be particularly hazardous. The issues to consider include:

- Breaking waves can capsize small vessels especially if power is lost. The vessel can then turn broadside and be at its most vulnerable. For larger vessels, using spuds and anchors to hold position can mitigate this risk. Strong tidal cross-currents can cause additional problems.
- A manned safety boat in the surf zone is a major hazard and its use should be carefully planned.
- There is limited tug access (i.e. restricted to shallow draught tug which means limited power to act in emergencies). Operations often rely on manoeuvring with ropes using winches, two sea moorings and two land moorings.
- The underkeel clearance is less and vessels can ground in a larger swell. There may be additional obstructions resulting from operations (i.e. rock placement). Correct vessel selection is important when working in this area.
- Access into intertidal zone (e.g. to unload rocks) becomes more difficult when the tidal range is small.
- Weather reports from established sources are useful but in the surf zone waves are all important. Local knowledge is useful and an inshore forecast can be obtained from specialists sources.
- Man overboard procedure and emergency evacuation will be different in the surf zone (Figure 4.5).

Figure 4.5. Rescue in the surf zone once things go wrong is particularly hazardous

4.2.2. Ground conditions and changes in seabed and beach profiles

Unlike most civil engineering works, the ‘ground’ surface (seabed and beach) in coastal engineering can be highly mobile, changing from day to day and from season to season. These changes can be caused by:

- long-term trends within the coastal region
- sea-state fluctuations
- summer/winter or storm/swell fluctuations in the position of a coastal bar
- scour/accretion due to presence of plant, temporary works or partly completed permanent works
- wind variations
- dredging adjacent to the shore.

These changes can affect the construction works in a variety of ways as they alter:

- the exposure to wave attack
- the ‘dry time’ available at the works and for land access to and from the works
- draught available for marine plant at the works and in the access route to and from the works
- the nature of the surface layers affecting the works and access (e.g. sand layer removed to expose soft clay)
- the stability of the permanent works
- the stability and design criteria used in the design of the temporary works.

Examples where seabed changes have caused construction problems are given in Box 4.5.

Box 4.5. Example of seabed changes causing an accident

At Crumbles marina, Eastbourne, a 20 000 t barge was beached in the same location five times. However, by the sixth occasion, the beach at the end of the breakwater being constructed had scoured away, leaving a hole. When the barge ‘sat down’ on the lower beach, attempting to cantilever over the hole, the barge ‘broke its back’ and extensive damage was caused.

As with all construction projects, coastal engineering projects will always benefit from good quality site investigations appropriate to the project. Ground condition issues most frequently affect coastal engineering construction. Some are detailed below.

Settlement

Direct settlement of soft ground under loading can be of unacceptable proportions. Ideally, this should be a matter for design. In practice, natural variability of the ground or lack of knowledge of the founding materials may well mean some hazard is left to be determined at the construction stage.

Quicksand, particularly on open flat sandbank areas, can be especially hazardous.

Variability in founding levels for structures

The required founding level may be dictated, for example, by the requirement to reach:

- a certain geological stratum (e.g. chalk or clay underlying beach material)
- soil of a particular resistance to loading (e.g. resistance to pile-driving loads)
- soil of a particular density (e.g. granular soils of sufficient density, indicated by SPT or CPT values, that will not liquefy under earthquake loading).

Natural variability between boreholes or trial pits, even with the best methods of interpretation (e.g. interpolation using seismic traces) will still leave uncertainty here. Indeed, the action of the sea between the design survey and construction can actually affect shallow underlying material. For example, the motion of the beach material under wave action can abrade clay or soft chalk platforms underlying the beach surface.

Obstacles and hard ground

Obstacles and hard ground can affect excavations to required depths, such as in navigational channel dredging projects, or steel piles requiring to be driven to a certain level. Obstacles frequently encountered include old, temporary or abandoned permanent works and sunken vessels. In such cases, obtaining detailed local knowledge or a discussion with the relevant authorities such as the Harbour Master can often reveal much information.

Soft ground

Soft ground may also create problems due to a requirement for flatter back slopes to excavations and by the lack of a firm platform for the operation of plant. Unconsolidated material can result in quicksand developing especially on flat estuarial areas. This is especially the case where dense sand material overlies soft material.

Instability of cliffs

Significant practical problems and safety issues arise when working at the base of cliffs.

It should be noted that the risks of dealing with such unforeseen ground conditions are magnified in the marine environment, due to the effects of constant marine action at the base of the cliffs.

Changing soil properties

Soil properties may change from one tide to the next as wave and current loading may liquefy or mobilise seabed and beach material. Therefore, ground which is stable for an excavator one day may alter and become unstable at the next low tide (Figure 4.6).

Figure 4.6. Excavator on a rising tide in an outfall trench. Problem caused by bank collapse. Despite appearances the machine was recovered before inundation by the rising tide (courtesy May Gurney)

Contaminated ground conditions

Contaminated sediments often exist around port and industrial areas. Like land-based construction ground and sediment, contamination can affect human health. These issues are discussed in more detail in CIRIA (2003).

⇒ Good practice: Uncertainty in soil conditions

Provide a Health and Safety Plan and File which gives:

- a summary of historical profiles and trends in beach/bed levels (Figure 4.7)
- model study results to assess the affect of bed changes on the works
- a comprehensive topographic/hydrographic survey of the work area for the safety of the design and construction operations. This should be supplemented with a geophysical survey and geotechnical site investigation (boreholes/probes) wherever possible
- risk identification of:
  i) potential settlement
  ii) potential for quicksand
- information on hard, soft ground and buried structures
- information on cliff instability
- an assessment of potential for change in seabed materials. Seabed conditions can change significantly, both in level and properties, on a daily basis. The contractor should assess the impact of these changes on structures, personnel and access to and egress from the site
- an assessment risk of contaminated bed materials.

Figure 4.7. Jack-up platform collapsing. Investigation concluded that the jack-up leg possibly penetrated historical borehole (courtesy Tony Edmundson)

4.2.3. Uncertainty of condition of existing structures

This can cause three main categories of hazard.

1. Hazards similar to those arising from the uncertainty in regard to ground, where the existing structure is being modified in some way as part of the works.
2. Hazards arising from failure of 'support' where a structure is effectively forming part of the contractor's temporary works. This frequently occurring situation arises where an existing structure is used to support plant and equipment, and the load which it can safely sustain is difficult to quantify. As in many situations, where such structures make the difference between working in the wet or in the dry, there is great incentive for contractors to use them and accept the hazard (even if unclear about its consequences). The hazard may be defined as that of

either collapse, or the structure becoming unusable, under the range of combinations of loads which might be experienced during the course of the contract arising from either the operation of plant, temporary structures or from the weather.

3. Hazards of the unknown extent of collision damage due to impacts arising from reduced navigational control of floating plant.

⇒ Good practice: Existing structures

- Obtain 'as-built' drawing of existing structures if possible.
- Carry out a condition survey of existing structure, with particular attention to foundation conditions, undermining or scour and impact/collision damage.
- Carry out structural calculation of loads and stresses from temporary plant/loadings and how these might change if bed levels or wave, water levels and current conditions change.

4.2.4. Access and working space

Available land access routes are normally well defined prior to commencing construction. However, narrow streets leading to the site, a limited number of access points and tidal restrictions may compromise access. In addition, access restrictions may be imposed on a contractor for reasons relating to the public, and public access, recreational and leisure considerations and tourism issues.

Available working space may change with the tide and may be limited especially at high tide. Movement of beach material to create local berms can increase tidal access. Moreover, working areas can be very long and narrow (sometimes several kilometres long), and, like road maintenance projects, can make supervision of health and safety difficult to manage.

Marine access may be well defined, but is subject to all the vagaries of the weather affecting draught, navigability, etc. and the risks of seabed debris fouling or damaging craft.

Marine access may also be subject to receipt of permissions, the carrying out of surveys prior to and after construction, and concluding appropriate compensation agreements with commercial interests, notably fishing and aquaculture interests. Failure to achieve any of these can lead to significant costs and time delays.

Tidal working can also put pressure on operators to finish work before the incoming tide prevents work being completed. This pressure can, if not checked, lead to the disregard of health and safety measures.

An example of access problems and their impact on health and safety is given in Box 4.6.

⇒ Good practice: Access

- Maximise working space to provide a safe working environment.
- Consider emergency access and egress from the site in storm conditions.

Box 4.6. Case study – Minsmere, near Sizewell. Example of balancing safety and environmental requirements in coastal engineering

On a repair to a small outfall at Minsmere in Suffolk, the only access to the site involved a 3.5 km journey along the beach. The area directly behind the construction area on the beach was a protected habitat and the environmental restrictions meant that the plant and equipment could only track on the intertidal part of the foreshore and could not use the area behind (i.e. between the sea and the posts shown on the photograph). The site was remote (see lorry tracking along the beach in the figure below).

During high tide and storm conditions, the site area was very remote, exposed and site personnel and plant were vulnerable to wave action. It was observed that the safety of personnel was compromised by the environmental constraints. A risk assessment was undertaken to redress this balance and concluded that the potential environmental impact was greater than the risk to health and safety under normal operation but that the dunes could be used in emergency situations. The mitigation measures employed involved emergency access and use of the dune area behind if necessary under these emergency conditions. The contractor also put into place a weather forecasting system to ensure that potential risk could be monitored.

Box 4.6. Case study – Minsmere, near Sizewell. Example of balancing safety and environmental requirements in coastal engineering (continued)

Discussion:
The CDM regulations under Regulation 13 require the designer to determine what is reasonably practicable to remove, reduce and protect against risk to health and safety. In determining what is reasonably practicable the designer should weigh the mitigation measures against cost, fitness for purpose, aesthetics, buildability or environmental impacts.

4.2.5. Temporary instability of the works

Unless it is economic to provide cofferdam arrangements (rarely the case with seawalls), excavations may often have to be left open and works left exposed between successive low waters allowing the ingress of the tide at high water.

Scour under, or in front of, temporary works/plant can cause major delay and cost impacts. These impacts can include:

- land-based plant becoming temporarily bogged down on a beach. If trapped by the rising tide the damage to the machine can be severe and in the worst case may involve a write-off
- consequential environmental damage through diesel/oil spill from machines which are inundated
- damage due to undermining of vessels temporarily beached on what was originally a flat beach or seabed
- erosion around or accretion against piled cofferdams, potentially causing failure.

The designer generally focuses on the extreme wind, wave, water level and current conditions appropriate to the design of the permanent works but should also take into account the wave conditions that will affect the works during partly completed conditions. The temporary instability of the works during the construction (e.g. before primary armour is placed on a breakwater) can result in catastrophic failures and risk to personnel (Box 4.7). It is essential that adequate consideration be given to the critical stages during the construction, when the works may be susceptible to damage from relatively mild wind, wave, water level and current conditions.

The temporary instability of the caissons was a fundamental risk for the contractor on one caisson project. Here, the contractor managed this risk by carrying out numerical wave modelling to establish a management system which used UK Meteorological Office offshore wind and wave predictions to give local wave predictions at the site. The site team used the system to assist making decisions as to when to commence, accelerate or terminate operations and to make safety decisions during critical operations.

Temporary instability of rock storage areas is another potential hazard. Often these mounds are dumped by marine plant or lorries prior to placing in the works. As the rock in these storage areas has not been ‘placed’ to any specification then the rocks are unstable and likely to move and trap construction workers or the public climbing on them.

Where there is the possibility of temporary instability, this should be designed out of the construction process.

⇒ Good practice: Temporary instability

- Design out temporary stability problems where possible. Where not possible and the stability is affected by seabed movements, wind or waves, use a real-time weather system to plan the works.
- Take measures to exclude the public from the vicinity of stockpiles.

Box 4.7. Example of temporary instability

There are safety considerations with dredging new channels and berths, particularly at the toe of underwater slopes. Figure 1 shows the site of a new berth, where piling started at the top of the slope (Figure 2). Dredging for deepening the channel commenced soon afterwards. The dredger can be seen in the left of Figure 2.

Figure 1 – New berth area

Figure 2 – Piling at top of slope

After the piling rig had moved off and dredging was continuing, a slip occurred in the underwater slope (Figure 3). Subsequently a further slip occurred (Figure 4).

Figure 3 – First slip

Figure 4 – First and second slip

Box 4.7. Example of temporary instability (continued)

When dredging underwater slopes, it is essential to consider not only the final dredged condition but also the method and speed of working. In this case it is likely that rapid dredging by large plant has caused changes to pore water pressures affecting the stability in the short term.

4.2.6. Ordnance

A significant amount of unexploded ordnance lies in the waters surrounding the UK as well as other parts of the world. The ordnance has either been deliberately dumped in specific locations, when sea dumping was a recognised and accepted means of disposal, or as a direct result of military/wartime activity. Another potential source of explosives arises from possible charges which have been left unexploded in rock from quarrying or underwater rock removal sites. The end result is that unexploded ordnance presents a risk to certain maritime activities.

In addition to unexploded ordnance, there is a vast amount of scrap metal and non-hazardous waste that has also been deposited in the water. This can be mis-identified as ordnance with the resultant delays to projects.

Ordnance is designed to function in a pre-determined way. However, much of the ordnance to be found subsea has been dropped in an armed condition or has been fired and failed to function. In many cases the ordnance has deteriorated and safety features can no longer perform the function for which they were designed. There is, therefore, a risk that unexploded ordnance can be caused to explode by direct impact or shock. Typically dredging, pile driving and other maritime intrusive engineering may provide sufficient energy to cause an item to function.

Where practicable/feasible a threat assessment and underwater survey should be carried out to ascertain the presence or otherwise of unexploded ordnance in an area. If a proactive approach is not possible, reactive measures need to be explored. The guidelines given in Box 4.8 have been prepared specifically to provide advice and recommendations as to the measures to be undertaken in the event that ordnance items are encountered.

Some companies can provide Explosive Ordnance Safety and Awareness Briefings to all personnel working on a site as part of the overall site induction training and health and safety seminars. They can also provide services to deal with or remove ordnance which may reduce downtime on site.

The assessment process is an imperfect science and clients find it difficult to find a balance between undertaking additional studies and managing the residual risk.

Figure 4.8. Ordnance found at Hurst Spit (courtesy Westminster Dredging)

Box 4.8. Recommended procedures for assessing risk and dealing with ordnance

There is always a risk of discovering unexploded ordnance and its absence should never be assumed!

Information regarding the possible/probable presence of ordnance and the results of any surveys, previous clearance operations, etc. should be included in any Pre-Tender H&S Plan provided by the client. However, this information is usually extremely generic (e.g. 'unexploded ordnance may be present...' and places the onus on the contractor to manage the situation.

When considering work in this area the client and the designer should consider whether a risk assessment should be carried out. In this respect they should consider whether:

- ordnance has been found in the past
- the region is likely to have had ordnance, i.e. was it an urban area or military installation which may have been targeted during previous conflicts.

If there is a potential risk then the following main steps should be implemented:

- Obtain the services of a specialist company to carry out a thorough survey of the area and if required, locate and remove any suspect items identified by the survey.

Box 4.8. Recommended procedures for assessing risk and dealing with ordnance (continued)

- It is unlikely that a survey will be 100% accurate, so it is important to have emergency procedures in place to deal with any unexploded ordnance dug up during the works. This would include:
  - i) stop work
  - ii) evacuate area to a safe distance
  - iii) call the Police on 999 to notify the nearest bomb disposal unit
  - iv) ensure nobody re-enters the area until told to do so by the authorities.
- The procedures put in place for a particular project will be based on the results of a risk assessment that should consider issues such as locality of military firing ranges, previous survey results, previous ordnance finds, local knowledge, etc.
- Typically, on the discovery of an item of ordnance, or suspect object, the location of the object should be marked and the immediate area evacuated in accordance with the size of the object. A grenade-size object 100 mm long, 50-75 m diameter projectile will typically have a lethal range of 25 m and a 100 mm diameter projectile will typically have a lethal range of 50 m. These figures are for an object on the surface with no protection, buildings, etc. for the site personnel.
- Where possible, a digital photograph should be taken and emailed to a specialist company. When a photograph is taken, a cigarette package or similar object with a known size should be used to indicate the size of the suspect object, together with a description of the object. If a camera is not available, as much information as possible should be presented to the disposal company. Typical are length, diameter, overall shape, any fins or other features, material and general state.
- The object should not be touched or moved until it has been identified.

  If in any doubt, call in a specialist firm.

⇒ Good practice: Ordnance

- Assess potential risk using a desk assessment (see box above).
- Consider using an experienced ordnance survey, clearance and disposal company to undertake explosive ordnance threat assessment.
- If considered appropriate undertake land and marine surveys.
- Develop an emergency procedure for dealing with ordnance.
- Undertake explosive ordnance safety and awareness briefings to all personnel working on a site as part of the overall site induction training and health and safety seminars.
- Talk to the contractor about the residual risk and the best options for managing or assessing it further.

4.2.7. Subsea services

The existence of subsea pipelines and cables, especially electricity cables, oil and gas pipelines can pose hazards for coastal and maritime engineering, especially as it is more difficult to undertake intrusive and positive identification of the pipeline position below the seabed than it is for land-based operations.

Marine geophysical survey techniques can usually be used to locate such services. Sonar or multi-beam bathymetric surveys can map pipelines lying on the seabed. A magnetometer survey can be utilised to determine the position of buried steel pipelines. If a depth of burial is required, or if the pipeline is constructed of non ferrous material then a seismic technique using a pinger or boomer sound source will be required.

Detecting cables can be more difficult due to their smaller size. A surface laid cable should be detectable with a high resolution sonar survey. Buried cables may be located with a magnetometer if the cable carries electrical current or has steel armouring. Otherwise specialised cable tracking techniques would need to be employed. For further information, it is recommended that the user contact a specialist marine survey company to advise on the best option to use.

⇒ Good practice: Subsea services

- Thoroughly investigate subsea services in the vicinity of the construction site from historical records and through the use of geophysical techniques such as magnetometer surveys.
- Crown Estates hold records of all permitted subsea services, although the exact position may not be defined the records will give an indication of the presence of subsea services in the vicinity.

4.2.8. Timing of the works

Coastal engineering tender documents issued by clients may have a contract duration specified, but rarely is an exact commencement date for the works given. The typical requirement for three months validity for tenders reflects a corresponding uncertainty in the commencement date. As a result, the weather statistics during the contract may reflect a more stormy or less stormy period than anticipated (especially if the contract is only to be of six to nine months duration).

Uncertainty about the commencement date may be controllable by the client. Often lack of confidence in the availability and timing of funding is cited as a reason for not fixing the commencement date.

Sometimes commencement dates are expressed in the ‘as soon as possible’ category. Valid reasons for this may relate to the urgency of the project. However, ‘urgency’ can arise for a number of reasons. For example, this may arise due to: the need to make use of particular plant as soon as available; risk of failure of existing works; risk of loss of funds for the project (e.g. due to the approach of the end of the financial year for public sector clients) and political urgency.

Sometimes the contract is timed to run through the winter period. While there may be valid reasons for this, such as environmental concerns, concerns about damaging trade or tourism over the summer period, or more ready availability of plant and labour, fixing the timing in the winter period automatically increases the hazards to construction. However, there may be marginal benefits in carrying out the work during the winter period in terms of hazards to the public since there may be fewer people around the site in this period.

If the contract timing can be made as flexible as possible then the contractor can maximise plant efficiently and avoid undesirable weather seasons.

⇒ Good practice: Timing of the works

Undertake a risk assessment to assess the safest time of year to construct the work. There may often be a conflict between the safest time to carry out the construction and other issues, such as allowing access to the site for tourism and pleasure during the summer periods or environmental issues such as bird migration periods. The CDM regulations require the designer to balance a number of issues including environmental, cost and safety considerations.

5. Plant and operational issues

Plant used in coastal construction works fall into three categories:

1. Land-based plant, including earth-moving plant
2. Marine plant
3. Other specialist plant.

The various types of plant and their limitations are discussed below.

It is important to understand that much of this equipment is not specifically designed to operate under the conditions it is likely to meet in a coastal/maritime project. This ‘misuse’ means that the safety margins built into the plant by the manufacturers, applicable to the normal field of operation, will to some degree be eroded. Some equipment has been specially modified to help it meet these exceptional conditions, but often still remains at greater risk than in its original design environment.

5.1. LAND-BASED PLANT

Land-based plant is used extensively for construction of coastal works, both in transporting materials to and around construction sites, and in placing materials into their final position. The relatively large tidal range around the UK coast makes this possible for beach-based schemes, where work can be carried out using land-based plant in the intertidal area. Land-based plant can also be used for construction where the original levels are below low water, by making use of end-tipping of material to secure a working platform or by operating the plant from other temporary platforms or floating equipment (barges, pontoons, etc.).

Most conventional land-based contractors equipment can be employed on the shore-based aspects of coastal and maritime works (Figures 5.1 to 5.3). Normal safety risk assessment applies to the use of this equipment, but some items of plant and their use require specific site-based consideration. An example of this is the use of dump trucks on beaches. This particular equipment is susceptible to variable ground conditions and can easily overturn if a patch of soft sand is hit.

Figure 5.1. Use of conventional land-based equipment in sea defence work (courtesy Edmund Nuttall)

Figure 5.2. Land-based equipment used for placing armour units with jack-up barge behind (Note limited access and working area) (courtesy Edmund Nuttall)

Figure 5.3. Crane caught by the tide, West Bay, Dorset (courtesy West Dorset Council)

5.1.1. Earth-moving plant for rock materials, beach nourishment and flood embankments

Relevant plant for rock materials and beach nourishment includes most types of earth-moving equipment. The more popular types are those which can operate readily on a beach, or near or on a breakwater (Figure 5.4).

Hydraulic excavators are generally tracked rather than wheeled and may be fitted with a hydraulic bucket, Bofors grab or orange-peel grab.

For moving smaller rock around on site, articulated steel-bodied dump trucks are popular, being able to accommodate rapidly changing ground levels. However, rigid dump trucks are also used, particularly for large pieces of rock armour. Hydraulic excavators fitted with grabs often load such material.

Conventional earth-moving plant are used in the construction of embankments, and are similar to those described above but with the addition of bulldozers and rollers. There may also be the need to use craneage for long-reach activities, such as the installation of sheet-pile cut off walls (see also ‘hard defences’ below), or draglines for trimming slopes.

Figure 5.4. Example of earth-moving plant working in a dynamic environment (courtesy Van Oord)

5.1.2. Plant for hard defences

As well as earth-moving equipment, the construction of hard defences requires additional heavy plant in the form of cranes, which are required to lift or suspend objects such as:

- piles and piling hammers or vibrators for steel sheet piling
- precast concrete elements such as precast concrete beams, steps and armour units. (Lighter elements can be lifted by hydraulic machinery as long as the required reach is not too large)
- formwork for in situ concrete during fixing in place
- concrete skips (where not pumping in situ concrete).

5.1.3. Plant for construction of marine-piled jetties and dolphins

Installation of the tubular steel piles for these structures typically uses heavy piling hammers located either on A-frames on large floating pontoons, or suspended from ringer cranes mounted on jack-up barges (see also Section 5.2 on Marine plant). Construction often requires the use of some form of temporary steel 'leader' framework to hold the pile in position until it has been driven sufficiently far into the bed to achieve an acceptable degree of rigidity. Driving such piles into the seabed often requires pre-drilling and the large diameter drills required also need craneage to move them around.

Figure 5.5. Cromer Lifeboat Station under construction, illustrates problem of sea breaking on formwork support under a NW Force 8 (courtesy May Gurney)

Marine construction work often makes extensive use of precast concrete pilecaps, beams and slab elements in order to reduce the cost and safety issues associated with over-water formwork (Figure 5.5). However, some in situ concrete production is inevitable, unless the deck or the deck joints are fabricated out of steelwork and rely on welded or bolted connections. Commonly, steel deck frames are restricted to small areas, such as in mooring or berthing dolphins. Larger areas are normally formed with concrete and have some kind of in situ concrete topping. The in situ concrete can be provided from a floating batching plant. If mixed on land, the wet concrete will be shipped out in skips or rotating mixer drums and placed in its final position using marine cranes or land-based cranes located on already complete/ partially complete parts of the structure. Pumping of concrete may also be feasible, but only over relatively short distances.

5.2. MARINE PLANT

Like land-based plant, marine plant is also used for both transport and placing. They are subject to access limitations dictated by the water depth available for navigation, a depth which is constrained by both variations in water level and by wave action.

International legislation covers the safety of marine plant with the International Maritime Organisation (IMO) providing the overarching governance.

A number of the problems that arise with marine plant originate from the fact that, while each captain is responsible for the safety of their own vessel as a first priority, they may be inexperienced in managing it in the inshore environment. The particular wave, current and water depth phenomena of that environment have an ability to punish even small errors both quickly and severely. However, inexperience of this environment can be mitigated by employing a captain or beachmaster with the necessary experience of operating in these conditions. This beach master is charged with the responsibility of ensuring that operations are carried out in a safe and workmanlike manner, and that no skipper inadvertently puts either their own or another vessel at jeopardy. Accident rates both in terms of death and injury, as well as damage to equipment, are significantly lower on contracts where this strategy has been employed.

Marine plant can be divided into six main categories:

1. work boats
2. ships (including any self-propelled module)
3. non self-propelled barges and pontoons (i.e. anything which requires tug assistance to manoeuvre)
4. marine craneage
5. jack-up platforms
6. safety/rescue boats.

5.2.1. Work boats

A work boat is a general term which applies to boats used to undertake a wide range of functions including the support of marine construction work. Many are standard in design but there are many variations.

Tugs are specialised push/pull vessels, ranging from small vessels designed for use in harbours and inland waterways to much larger ocean-going vessels. A common factor to nearly all tugs is that they are deep hulled for their size, and often require more draught than the equipment they are moving.

Multicats, powerful motorised barge/pontoons complete with a hold and engine room, bridge, clear working deck and some form of mechanical lifting equipment, are frequently employed in most marine/harbour works. Work boats can be used as a shuttle vessel, tug, ferry or floating working platform. They tend to be extremely flexible and can carry out work which would otherwise tie up major items of marine plant.

A code of practice has been developed by a number of organisations to assess and set standards of safety and protection for all on board. Moth (1998) provides an easy to use guide to this code of practice for vessels under 24 m in length. The ‘Code of Practice for the Safety of Small Work Boats and Pilot Boats’ does not apply to vessels operating on inland waters where such waters form part of a river or are completely self-contained such as a lake or reservoir. In such circumstances, further advice should be sought from the river and/or water authority or the local authority regarding any local requirements that might apply.

A new ‘Code of Practice for Small Commercial Craft’ is currently under preparation by the MCA. This new code has been developed for application to UK vessels of up to 24 metres Load Line length that are engaged at sea in activities on a commercial basis, that carry cargo and/or not more than 12 passengers, or provide a service in which neither cargo nor passengers are carried, or are UK pilot boats. This new code of practice will supersede the following four Codes of Practice:

1. The Safety of Small Commercial Motor Vessels (Yellow Code).
2. The Safety of Small Commercial Sailing Vessels (Blue Code).
3. The Safety of Small Work Boats and Pilot Boats (Brown Code).
4. The Safety of Small Vessels in Commercial Use for Sport or Pleasure Operating from a Nominated Departure Point (NDP) (Red Code).

Publication of this new code was scheduled for the autumn of 2004 (see www.mcga.gov.uk for latest information). Current legislation covers the certification of work boats to operate in different waters. These categories are described in Box 5.1 (MCA (2003)).

Box 5.1. Categorisation of waters and areas of operation

The following four categories are based on Class IV, V, and Class VI Passenger Ships and determine which waters are not regarded as 'sea' for the purposes of the regulations made under Section 85 of the Merchant Shipping Act 1995.

Category A
Narrow rivers and canals where the depth of water is generally less than 1.5 metres.

Category B
Wider canals where the depth of water is generally more than 1.5 metres and where the significant wave height could not be expected to exceed 0.6 metres at any time.

Category C
Tidal rivers and estuaries and large, deep lakes and lochs where the significant wave height could not be expected to exceed 1.2 metres at any time.

Category D
Tidal rivers and estuaries where the significant wave height could not be expected to exceed 2 metres at any time.

All other areas are **'at Sea'** (See also Box 5.2).

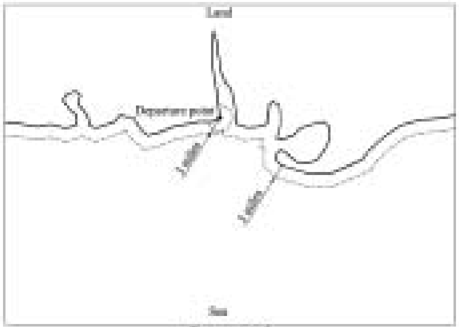
Moth (1998) provides guidance based on the legislation on the protection of personnel on work boats with respect to the following areas:

- deckhouses
- bulwarks, guard rails and handrails
- safety harnesses
- life-saving apparatus
- surface of working decks
- retrieval of persons from the water
- personal clothing
- noise.

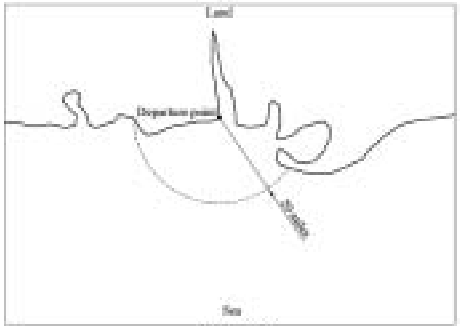
A summary of the life-saving equipment appliances required for work boats is given in Table 5.1. Further guidance should be sought on the detail of the legal requirements from the MCA publications.

Box 5.2. Work boats – Categories of certification at sea (Moth, 1998)

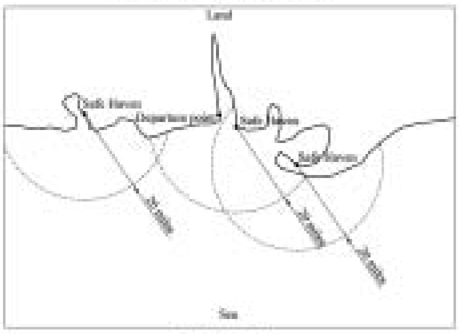
A vessel may be considered for issue of a work boat certificate allowing it to operate at sea within one of the following areas. The categories basically define the type of work boat.



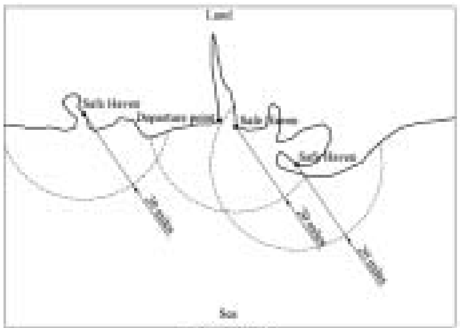
Category 6
within 3 miles of land and not more than 3 miles from either the point of departure to sea or the seaward boundary of protected water



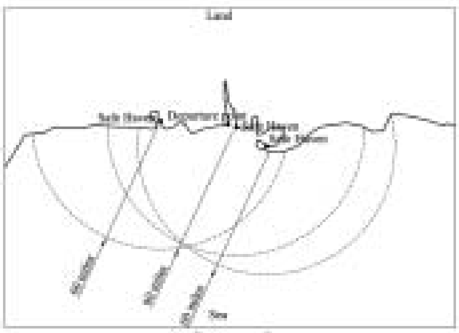
Category 5
up to 20 miles from a nominated departure point, in favourable weather and in daylight



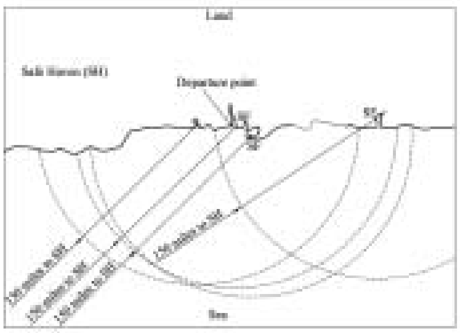
Category 4
up to 20 miles from a safe haven, in favourable weather and in daylight



Category 3
up to 20 miles from a safe haven



Category 2
up to 60 miles from a safe haven



Category 1
up to 150 miles from a safe haven

Table 5.1 Indicative summary of life-saving appliances for required work boats (from Moth, 1998)

Category of open sea operation for work boats	6	4 and 5	3	2	1
Nautical miles	<3 m	<20 m (Daylight and favourable weather)	<20 m	>20 and <60 m	>60 and <150 m
Life-raft	Yes	Yes	Yes	Yes	Yes
Lifebuoys	2	2/4*	2/4*	2/4*	2/4*
Lifebuoy light	1	1 or 2	1 or 2	1 or 2	1 or 2
Buoyant line	1	1 or 2	1 or 2	1 or 2	1 or 2
Life-jacket	100%	100%	100%	100%	100%
Parachute flares	None	None	4	4	6
Red Hand flares	2	2	6	6	6
Smoke signals	2**	2**	2**	2**	2*** (buoyant)
Thermal protective aids	100%	100%	100%	100%	100%
Immersion suits	None	None	None	None	None
Means to recover persons from water	1	1	1	1	1
Portable VHF	1	1	1	1	1
406 MHz EPIRB	None	None	None	None	1
SART	None	None	None	None	1
General alarm	None	None	None	Yes	Yes
Life-saving signal	Yes	Yes	Yes	Yes	Yes
Training manual	Yes	Yes	Yes	Yes	Yes
Instructions for onboard maintenance	Yes	Yes	Yes	Yes	Yes

* <15 pers 2, >15 pers 4
** Buoyant or hand-held
*** Buoyant

5.2.2. *Dredgers*

Dredgers are used for excavating the seabed and either dumping the material at sea or pumping it ashore, for land reclamation or beach nourishment (Figure 5.6).

Their hulls are derived from ocean-going ship design, which are meant to operate in harbours or the open sea. They are built on the assumption that they will operate with sufficient water under their keels. Further information on dredgers and their use is given in Bray *et al*. (1997) and in the Beach Management Manual (CIRIA 1996).

Side stone dumpers are specialist vessels designed to place smaller armour stone very accurately underwater (Figures 5.7 and 5.8). To this end they are equipped with very sophisticated navigation and manoeuvring equipment. This ability is largely wasted if they are used simply to dump large rocks on a beach for re-handling. Apart from a few small vessels carrying under 1000 t at a time their draught requirements are from 3.5 m upwards.

Figure 5.6. Back-hoe dredger at work close to existing seawall (courtesy Edmund Nuttall)

Figure 5.7. Side stone dumper (courtesy Van Oord)

Figure 5.8. Side stone dumper (courtesy Van Oord)

Split hopper barges are specialist vessels used to place dredged material. The vessels are used in much the same way as side stone dumpers.

5.2.3. Non self-propelled barges and pontoons

For shallow water work, dredging can also be carried out with a spud-leg motorised barge equipped with a slew ring mounted backacter. This equipment, used with a split hopper barge, is well suited to shallow or confined waters to which a conventional dredger cannot get. The spud legs make them particularly stable during operations.

Barges are broadly boat-shaped, but often need a tug to move them around although some are self-propelled (Figure 5.9). Many are adapted for dumping materials at sea in conjunction with static dredgers, and are also commonly used to deliver beach nourishment or for rock dumping. Other uses of barges include acting as platforms for piling frames and light equipment, floating stockpiles, and materials delivery. Towed equipment needs more sea room than self-propelled vessels, particularly under windy conditions, and may be draught limited by their tug.

Simple pontoons are also extensively used on marine construction sites as transport for temporary and permanent materials and as working platforms for lifting and/or pile driving. Uniflotes or equivalent can also be joined together to make platforms of any size and shape to fit around or between construction works.

Figure 5.9. Barge run aground on East Anglian coast (courtesy Environment Agency)

Pontoons are basically floating steel boxes used as floating platforms for a wide variety of uses. Some are fitted with 'spuds' to hold them in position without the need for anchors (spuds should be distinguished from jack-up legs – spuds are a positioning tool and cannot be used to lift the equipment above the water). Sizes of pontoons vary enormously from Uniflotes, working either singly or in assemblies, to a 20 000 t rock barge. Some are dedicated to permanent equipment such as large cranes; most are modified for some degree of dedication even if only on a job-by-job basis.

Some pontoons are designed to sit on the seabed or beach. However, care should be taken as a small error in procedure can lead to very expensive repairs or even a write-off. 'Beaching' has therefore become unpopular with insurers and as a result is now much less popular.

The only pontoon specifically built for carrying rock operating in European waters is a 22 000 t unit; all others used are modified from other purposes. Some, mostly continental, units are designed for inshore work, but not for the severe conditions so often found in UK waters.

Figure 5.10. Barge used for placing rock armour sea defences (courtesy Edmund Nuttall)

The majority of serious accidents to non self-propelled equipment occur when they are trying to ride out bad weather close to a lee shore and they suffer some form of failure of their anchoring system. It is good practice therefore to have sufficient towing units on station, which can either take them to shelter, or give them extra sea room in the event of an on-shore storm.

Provisions for edge barriers preventing plant from going over the edge when operating on the barge need to be considered and managed (see Figures 5.10 and 5.11).

Winch operations can be particularly hazardous for both powered and/or non powered plant and need to be carefully monitored to ensure that anchors and lines are not overloaded and that they are not fouled by other vessels or fishery equipment (Figure 5.12). There is limited guidance on the use of winches in this environment although the CIP Construction Manual covers some issues. A summary guide for good practice is given in the box below and Section 2.2.8.

⇒ Good practice: Winch operation

- The winch capacity should never exceed the self working load (SWL) of the rope. The winch should stall well before the SWL is reached.
- Ropes should be in a good condition.
- Personnel should not stand in the line of wires under tension.
- Loads should be applied steadily to avoid potential damage from ‘snatching’.

Figure 5.11. *Transhipment of rock*
The Lapis barge (centre) later suffered repairable damage after running aground during a construction project (courtesy Stema Shipping).

Figure 5.12. *Multi-purpose barge* Manta *under winch control. Winches can be hazardous and careful control is required (courtesy Van Oord)*

Pipeline pulling operations contain many of the risks describe above. Additional risks include risks associated with bottom pulled pipelines where post pull release of temporary buoyancy tanks may pose a risk to the diver and craft when they reach the surface.

5.2.4. Jack-up plant

Jack-up platforms are pontoons fitted with legs and lifting gear which bear on the bottom and allow them to be lifted above the water to work. In other words they manoeuvre as marine plant and work using the ‘land’ to support them. In general they can carry a much higher deck loading when jacked up than when afloat. They are at their most vulnerable when manoeuvring and jacking up as they are normally reliant on tugs or anchors to move, and it is rarely possible to inspect the seabed in sufficient detail to be certain that it is capable of taking the load of the legs. There have been a number of accidents caused by failure as a leg is being loaded up leading to tilting, leg breakage and consequent overturning: more rarely, this can happen in service when the bed becomes overstressed with time. Another known form of failure arises from the legs not being long enough to keep the pontoon above storm waves, and it is quite literally lifted off them.

However, in general, they have a good safety record, and can be confidently used in situations where other types of pontoon would be a severe hazard (Figure 5.13).

Figure 5.13. Jack-up platform used for marine piling close inshore (courtesy Edmund Nuttall)

Figure 5.14. View of jack-up platform. Note that different legislation applies to different parts of the platform, see also Figure 2.2 (courtesy Seacore)

5.2.5. Marine craneage

Marine craneage can be defined as custom-built floating lifting plant such as shearlegs, e.g. Smit Taklift type vessels, or conventional cranes mounted on pontoon barges or jack-up platforms (Figure 5.14).

As the marine craneage operates from a pontoon or a jack-up barge the operational safety issues are discussed in the relevant sections above (see also Box 5.3 and Figure 5.15).

Box 5.3. Example of risk mitigation measures for lifting operations employed by one contractor

On coastal construction wave conditions as well as wind speed may well affect the safe working limits of craneage. One marine contractor uses combined wind and wave height look-up charts to help safely manage the risk as illustrated below. More detailed approaches could also include wave period.

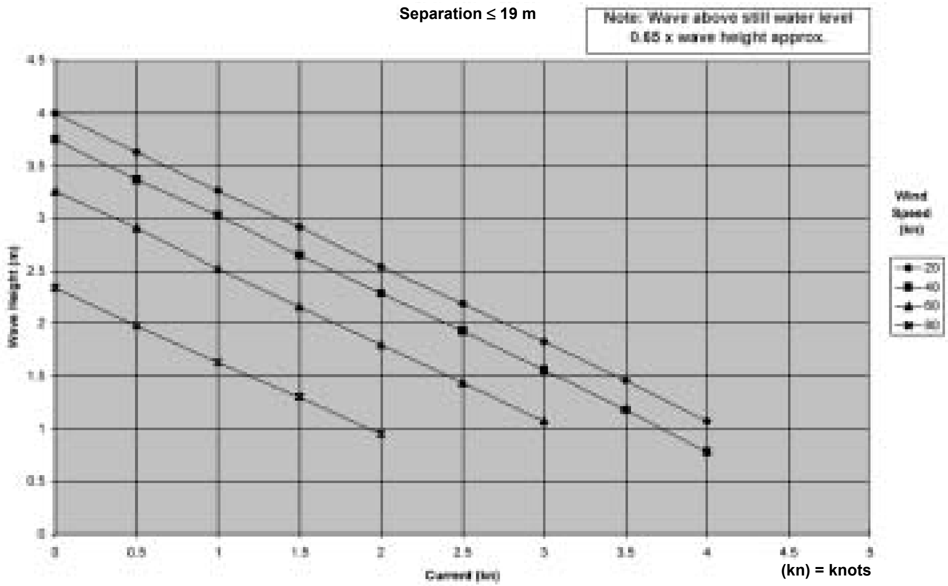


Figure 5.15. Jack-up failure (courtesy Anon)

5.2.6. Safety boat/rescue boat

Safety boats can include:

- guard vessels in the vicinity of the works
- standby boats in the vicinity of the works.

A *rescue* boat is different and is a boat only put into action when an incident has occurred (e.g. RNLI vessels are rescue boats).

Many contractors considered that safety boats often provided a false sense of security. Their benefit in calm sea conditions was considered marginal while they often could not be launched or operate safely in severe swell conditions when they would provide the most benefit. Their very existence may put the safety boat operatives in an unsafe environment. Those consulted considered that a risk assessment should be undertaken and, where possible, mitigation measures should be put in to avoid operatives falling in the water in the first place rather than providing a safety boat.

Selecting the most appropriate boat is very important. The RNLI may be able to provide guidance on selection. Issues to consider are given below.

- In open waters the choice is open. Often a fast pilot cutter is the most viable option as it has a low freeboard and offers some protection from the elements to the crew if they are on standby.
- In the surf zone a RHIB is the only viable alternative. However, it is not usually viable to have a RHIB in the water on standby as there may be more of a risk of losing crew than a man overboard from the works. Instead it may be more appropriate to have a RHIB on a very quick launching davit if working from a jack-up or land structure (jetty).

It may be possible to provide a mooring if working from a floating vessel. The difference is that the tide makes mooring against a land structure more difficult and can result in damage to the boat.

Often an experienced crew can be recruited from local fishermen. Their local knowledge of land and sea can be beneficial and initial training can be minimal. If possible, the contractor should choose those who are serving with the local lifeboat as their training will be beneficial to the project.

⇒ Good practice: Rescue boat/safety boat and rescue procedure

Rescue boat/safety boat

The rescue boat should be fit for the purpose, of sufficient length and beam to afford reasonable stability and the engine size should be appropriate for any wave, river flow or tidal conditions. Where conditions merit, there is much to be said for inflatable craft, since they provide a better chance of getting a person aboard without injury. For work in tidal water or fast flowing river water, a power-driven craft is essential – with a fixed self-starting device on the motor. Engines of powered craft, when not patrolling, should be run several times a day to ensure full efficiency.

In coastal environments safety boats can create a false sense of security. They cannot be launched or operate safely in severe swell conditions when they would provide the most benefit. Their very existence may put the safety boat operatives in an unsafe environment. A risk assessment should be undertaken and, where possible, mitigation measures should be put in to avoid operatives falling in the water in the first place rather than providing a safety boat.

All rescue boats should carry three oars or paddles to cater for losing one overboard. Rowlocks should be removable and on retaining lines so that they can hang from the side without being lost.

Boats should be fitted with grab lines and carry at least one MCA approved lifebuoy. Boathook, baler, anchor and line should be standard equipment. Two-way communication between boat and shore is always advisable. If night work is to take place, a powerful spotlight should be fitted.

Irrespective of size, it is a wise precaution to seek the advice of the MCA marine surveyor on the suitability of the proposed rescue craft and its equipment.

Boats should be manned continuously – and on patrol whilst work is in progress – by experienced boatmen who are qualified first aiders. If possible, there should be two persons to a boat so that one is free to attend to the person in the water. Boatmen should always wear suitable buoyancy aids.

Whether first aid treatment can be given on the rescue boat, will depend on its size and the state of the rescued person. One of the crew members should be trained in first aid. Boats should at least carry sterile wound dressings and some bandages, a sucker for clearing a person's airway, and blankets. All first-aid equipment on board should have waterproof protection.

Rescue procedure

It is essential that:

- the number of persons at work is periodically checked to ensure that no one is missing
- operatives work in pairs so that there is always one to raise the alarm
- each person is trained in what to do in the event of an emergency.

The rescue procedure should consist of:

- a set routine for raising the alarm
- a set drill to provide rescue facilities
- a set routine for getting persons to hospital whether for a check-up following immersion in water (possibly polluted), or for treatment as the result of injury.

The first requirement should always be to get the rescued person, if only slightly hurt, to the nearest point where assistance is available as quickly as possible. Therefore, all other things being equal, the speediest and safest way of getting a person out of the water should be laid down. With small craft, for example, it may be possible to bring the person inboard over the stern; with larger, powered craft this will not be feasible because of the danger of fouling revolving propeller blades. Where this could occur consideration should be given to fixing some form of protective device around the propeller if this is feasible.

Various circumstances may combine to make a straightforward lifting operation out of the water impossible – the person might be too heavy, fully clothed, in a state of panic, or injured to the extent that it would be unwise to manhandle them. In cases like this, the following practice has much to commend it: the person is manoeuvred to port or starboard, near the bow, and a line, with hook and eye, is passed under the arms to secure them to the boat – in this position the person can be towed to the nearest landing point, the movement of the boat drawing the head clear of the water so that breathing can remain unimpaired and the person is kept clear of revolving propellers.

Rescue procedures should be practised at regular intervals involving all persons who would be required to participate in a rescue.

Rescue evacuation/preparedness needs to consider full evacuation to appropriate medical facilities including helicopter and decompression facilities. For instance, the contractor should contact the coastguard and discuss emergency evacuation procedures/preparedness.

5.3. OTHER PLANT

Landing craft exist world-wide as a variety of forms of vessel usually designed to meet military needs in the first place – which have a capacity to beach themselves and offload via some sort of ramp. In UK waters these range from small units, meant to carry personnel, to ocean-going ships with bow doors and ramps for offloading heavy plant. Their common attributes are very shallow draught (2 m or less maximum) and a ramp or ramps. They tend to be much more seaworthy than they feel, and the biggest danger to them is underwater obstructions in the beaching area. For this reason, it is good practice to establish a permanent landing area for them which is known to be free of obstructions at any state of tide, and which offers a good flat surface on which they may rest while discharging without risk of 'breaking their backs'. (Such landing area criteria apply equally to situations where any vessel or pontoon may be beached.)

The majority of land-based equipment with a marine capacity started life as a military vehicle. As nearly every government has different ideas as to their own military requirements, there are some very odd vehicles about. They may be divided into two types, wheeled and tracked, after which the possibilities for variation are endless. Intending users should ensure that they fully understand the exact capabilities and limitations of any vehicle, as similarities with other vehicles of which they may have previous experience may be deceptive.

6. Protecting the operatives, users and public

6.1. PROTECTING THE OPERATIVE

6.1.1. Basic welfare provisions

Those consulted as part of the project considered that there was often insufficient consideration given to basic welfare provisions. Coastal construction sites are often situated in remote locations where there are little existing welfare provisions. While records are maintained on lost time due to safety incidents, there is little or no record of lost time due to sickness and general poor health or absenteeism caused by unsociable hours/poor working conditions.

It is essential therefore to consider:

- how basic welfare and cleanliness provisions will be delivered to the operatives in a safe manner
- how the works will protect against disease and contamination risks (e.g. contaminated dredged material, Weils disease, etc.)
- how tidal working/unsociable hours might affect the operatives' health and the subsequent management of health and safety of the site (see example in Box 3.3). Long shifts (say 12 hours tidal cycle) and tidal working rotating around the clock, often mean that operators are obliged to work in poor weather and where it may be difficult for them to visit the mess hut
- how the safety of any lone-worker operations in remote areas will be delivered
- how fatigue and stress to the workers will be avoided and mitigation measures managed.

The above are significant issues in the coastal and maritime sector and failure to provide and consider basic welfare provisions will cost businesses money and delay.

6.1.2. Particular provisions

The following section is based on guidance developed by the MCA (CIP, 2004) but extended following consultation with the Project Partners.

⇒ Good practice: Particular provisions for working over water

Platforms, gangways, etc.

Shore-supplied platforms and gangways must comply with the requirements of the Construction (Health, Safety and Welfare) Regulations 1996. At all edges from which a person might fall into water, platforms, guardrails, barriers, etc. are required. Ship-supplied platforms and gangways must comply with Merchant Shipping legislation.

Warning notices regarding the location of the water's edge should be erected at all unguarded edges and boundaries near water and set so that operatives approaching the water's edge can easily see them.

Where platforms or gangways are erected above tidal water, decking boards should be secured (clipped or wired down) so that rising water or high winds cannot dislodge them.

The provision of additional handholds is always advisable as a precaution in the event of storms.

Safety nets

It is often better to use physical barriers rather than nets. However, where used these should be properly secured and slung sufficiently far above high water level for anyone caught in them to remain clear and so that free access of rescue craft is always possible. Manufacturers should be consulted on what type of net best suits the kind of work to be carried out and the prevailing conditions.

Harnesses

Harnesses should only be used where no other protective measure can be provided as they can pose an additional tripping hazard and potential fatal suspension trauma.

Barges, pontoons, etc. used as working platforms, must be fit for purpose, properly constructed and sufficiently stable to avoid tipping. Attention must be paid to good anchorage and ballasting; point loads near the edge should be avoided; due account should be taken of the variation of load at the different radii of crane jibs for the use of lifting appliances on barges and pontoons.

Lifting equipment

Handling of materials and equipment over water often requires the use of floating plant. Consideration must be given to the operational limits of such plant, in terms of wave and current forces as well as operable wind speeds. Particular attention is required when transferring materials to/from a floating platform to a fixed platform because of relative movements between the two.

⇒ Good practice: Particular provisions for working over water (continued)

Site tidiness

Site tidiness is key in minimising tripping hazards. Tools, ropes and other materials not in use should be stored away; rubbish should be cleared up promptly. Materials awaiting use should be stacked compactly and restrained, particularly on pontoons and boats. Mooring lines should be clearly marked and protected.

Slippery surfaces are dangerous and should be treated immediately. Seaweed, sea-slime and bird droppings should be cleaned off. Oily or greasy surfaces should be gritted. Icy or frosty surfaces should be treated with industrial salt or sand.

Drip trays should be sand-filled and set beneath all machinery to prevent the development of oily, slippery surfaces and, especially on pontoons, to minimise fire hazards.

The water area near the work should be kept clear of flotsam. Boatmen should be instructed to report its presence and to clear where possible.

First aid equipment

First aid facilities should be available, in the charge of a first aider or appointed person, on pontoons, barges and near all landing places.

Means of access: water transport

The Construction (Health, Safety and Welfare) Regulations, 1996 require the safe transport of any person conveyed by water to or from their place of work.

Passenger-carrying craft must be appropriate for the number of persons being transported. Such craft should be marked with the number of persons they are intended to carry and, where appropriate, the limits of operation. Where craft are of sufficient size to carry more than 12 passengers at any one time, they must be surveyed at least once each year by the MCA and a certificate obtained. Boats are only allowed to operate with a stipulated number of passengers according to size and the MCA makes several classifications of craft according to purpose, with a schedule of life-saving and fire-fighting appliances laid down for each. There are currently no specific requirements relating to the competence of the boat operator, although they must be competent to operate the craft being used.

A suitable means of communication should be established with the shore during any work activity and in the event of an emergency.

Manning of work boats and similar craft

The ‘Code of Practice for the Safety of Small Work Boats and Pilot Boats’ applicable to the manning of sea-going vessels of less than 24 metres in length, which carry not more than 12 passengers, is available from the MCA. The ‘Code of Practice for the Safety of Small Work Boats and Pilot Boats’ does not apply to vessels operating on inland waters where such waters form part of a river or are completely self-contained such as in a lake or reservoir. In such circumstances further advice should be sought from the river and/or water authority or the local authority regarding any local requirements that might apply.

⇒ Good practice: Particular provisions for working over water (continued)

Emergency planning/preparedness

Particular attention should be paid to effective emergency planning and provision of access to key emergency services such as:

- nearest Hospital
- RNLI
- Harbourmaster
- Coastguard
- Police
- Fire service
- Bomb disposal
- Decompression facility (where diving work is planned).

The safe means of access/egress of emergency services to/from the site, which may involve beach and surf-zone crossings and/or marine access must be clearly identified before the start of operations.

Protective clothing and equipment

Safety helmets
Safety helmets should be worn at all times for operatives in designated work areas, since anyone struck on the head and then falling into water is at special risk.

Footwear
Types with non-slip soles should be worn. Rubber and thigh boots should not be worn as, once filled with water, they act as dead-weight and could drag the wearer under water.

Personal buoyancy equipment
Life-jackets or buoyancy aids must be worn where there is a foreseeable risk of drowning when working on or near water and at all times while working on boats. Risk assessments can be used to identify areas which are safe and where no buoyancy equipment is required (e.g. accommodation blocks on a jack-up platform). Equally areas where there is a high risk should reinforce procedures.

A life-jacket is a personal safety device which, when fully inflated (if inflatable), will provide sufficient buoyancy to turn and support even an unconscious person’s, face upwards within five seconds (ten seconds if automatically inflated). The person’s head will be supported with the mouth and nose well clear of the water.

Some people are reluctant to wear life-jackets as they find them bulky and restrictive. However, either an automatically inflatable life-jacket or a type which is inflated by a manual pull-cord should overcome these problems. These are usually compact and allow for a full range of movement.

Buoyancy aids are worn to provide extra buoyancy to assist a conscious person to keep afloat. However, they will not turn over an unconscious person from a face down position. See also HSE (1999).

⇒ *Good practice: Particular provisions for working over water (continued)*

A wide range of life-jackets and buoyancy aids is available and they should be marked with the relevant BS EN (see Appendix 3) and selection will depend on such matters as the type of water conditions, the work being undertaken and the protective clothing being worn. Further guidance is given in HSE Agricultural Information Sheet No. 1 (Revised): Personal buoyancy equipment on inland and inshore waters, HSE (1999).

Where appropriate, life-jackets should be weld protected.

Rescue equipment

Lifebuoys and rescue lines

The MCA approved lifebuoys, or rescue lines, should be set at intervals along the workings.

The lifebouys' lines must be checked to ensure that they are long enough to allow for the state of the tide, height of working place above water, or for the person being carried downstream by a current. They may be constructed of either cork with canvas covering, or of polyurethane foam with a rigid PVC cover. Both types are effective in salt or fresh water. If night work is carried out, standard MCA-type self-ignition lights should be fitted.

Various types of rescue lines are available. A typical rescue line incorporates 25 m of line in a canvas bag with a small flotation chamber. The end of this line is held, while the bag is thrown towards the casualty.

Lifebuoys or rescue lines should be thrown as near as possible to a person in the water; if any tide is running, they should be thrown on the upstream side. All persons involved in the work who may need to use the lifebouys or rescue lines should be instructed in their use and should be given regular opportunities to practice the action to be taken in the event of an emergency.

Daily checks should be made to ensure that lifebuoys and rescue lines are still in their proper place and that no repair work is required as a result of vandalism or other interference.

Grab lines

Grab lines, attached to the working place, or at other places downstream, and long enough to allow for the normal rise and fall in tide, can be supplied to give a person something to grab in an emergency. They should be of a buoyant type with a marker float at the free end. Trailing ends of undue length should be avoided so that there is no risk of boats being fouled.

Daily checks should be made to ensure that they are still in position and that their condition is sound.

Rescue/safety boats

See *Good Practice* in Section 5.2.6.

Rescue procedure

See *Good Practice* in Section 5.2.6.

⇒ Good practice: Particular provisions for working over water (continued)

General welfare provisions in an exposed environment

Give proper consideration to:

- how basic welfare and cleanliness provisions will be delivered to the operatives in a safe manner
- how the works will protect against disease and contamination risks (e.g. contaminated dredged material, Weils disease, etc.)
- how tidal working/unsocial hours might affect the operatives' health and the subsequent management of health and safety of the site
- how the safety of any lone-worker operations in remote areas will be delivered
- how fatigue and stress to the workers will be avoided and mitigation measures managed.

Flares and other equipment

Flares and other equipment should be provided as risks are identified through the risk assessment process. It is essential that full training for use of all the equipment is given and that the training process itself does not endanger life.

Inter-vessel transfer

Inter-vessel transfer should be avoided as much as possible, restricting access to controlled environments in port areas where full and proper provisions can be made. It is particularly hazardous and a fatality has been subject to investigation by the Marine Accident Investigation Board (MAIB, 1999) and there was recent guidance issued by HSE (2004).

That guidance states basket transfers to or from offshore installations are considered a high-risk operation. The notice confirms that the Billy Pugh type of personnel transfer basket (Figure 6.1) does not comply with Regulation 5 of the Lifting Operations and Lifting Equipment Regulations 1998 (LOLER) but it can be used in exceptional circumstances, i.e. emergencies or when transfer is essential and it is not practicable to gain access by less hazardous means. Alternative forms of basket are available which duty holders should consider if they offer a safer means of personnel transfer for their needs.

There is significant debate about the best method of inter-vessel transfer. Some comments given by contractors consulted are given below.

Some contractors prefer the Billy Pugh or Wor Geordie as it can be used on small modular jack-ups and accessed from a RHIB or small work boat. They consider that the Frog is more difficult to access from small vessels. They also consider that the Billy Pugh is more easily and more quickly accessed on the deck of a tug or multicat meaning that the vessel has to hold position for a shorter period of time. Those contractors also considered that the time taken to sit down and strap into the Frog could be detrimental under certain circumstances.

The contractors consider that the key to any transfer is ensuring it is properly managed. Any means of personnel transfer between marine craft must be covered by a complete risk assessment and methodology; personnel must wear stipulated PPE, transfer suits and life-jackets and the transfer must be overseen by a responsible person on the jack-up barge using a crane that has a quick rope speed to move the personnel carrier quickly onto and away from the vessel as required.

Figure 6.1. Example of a Billy Pugh personnel transfer basket

Figure 6.2. Example of a jack-up platform where different working areas with different requirements for protective measures have been designated

6.1.3. Other issues for consideration

Use of harnesses

The use of harnesses when working adjacent to water is perceived by many as the most appropriate mitigation strategy. However, suspension trauma has been investigated in detail by the Port of Liverpools's Safety Manager and reported in HSE (2002a). The key issues of this review and further discussion are given in Box 6.1.

Box 6.1. Issues associated with the use of harness near the water's edge and suspension trauma

A personal fall protection system comprises at least a body holding device, i.e. a harness of some type, a lanyard and a reliable anchor. A well thought-out system will seek to minimise the effects of any potential fall. If a fall does occur, that system will arrest the fall with a limited impact force. At this stage, the harness (and the rest of the components in the system) will have stopped the fall, hopefully without it causing any injury.

The fall and the arrest of it are only part of the story, and not necessarily the most dangerous. After the fall and its arrest comes the suspension phase, when the casualty either rescues him or herself, if capable, or awaits rescue by another person or persons. After a fall, the body is likely to be in a state of shock. If the casualty is badly injured or unconscious, there is unlikely to be any movement of the legs and there can be serious consequences. The orientation of the body and the comfort of the suspended person, determined to a large extent by the design of the harness and the position of its attachment point to the system, also play their part in the outcome.

The recent review undertaken for the HSE examined the potential problems of the suspension phase of a fall, how the position of the attachment points on various harnesses plays an important role in the comfort and survival of a casualty, and how a selection of harness standards addresses the issues surrounding suspension. The review reports on existing literature, gives background information to assist the reader, raises issues for discussion and gives recommendations for further work.

This investigation identified that, should a person fall and become suspended, it was essential to quickly (i.e. within 3/4 minutes) remove a suspended person from that position otherwise significant trauma or even death can occur.

Many frequently look at the use of harnesses as a 'last resort' where edge protection is not possible but many do not consider the subsequent recovery to a safe place.

Others argue that harnesses can cause tripping hazards. Tidal variations also need to be considered when assessing the length of the harness line as it would be very dangerous to allow someone to fall into the water with a harness on.

The Port of Liverpool's view that has been expressed to the HSE is that under operational conditions it is safer to allow a person to fall into the water than to have them suspended above it. This has been done on the principle of a simple risk assessment based on the circumstances at Liverpool and the means of rescue available for suspended and immersed casualties.

Emergency lighting

The extent of emergency lighting requirements and the residual risks can be an issue on coastal and maritime projects. Box 6.2 illustrates some of the issues involved.

Box 6.2. Issues associated with emergency lighting near water's edge

One port, operating at night, used normal port overhead lighting to provide a safe lighted environment. The HSE was concerned that the port did not have an emergency back-up system such that if the lighting failed there would, albeit temporarily, be no lighting adjacent to the water's edge. The HSE placed an improvement notice on the port operator to force them to provide emergency lighting. The port operator argued that the staff was well trained and familiar with the environment and such a requirement was inappropriate.

After discussions and two night time visits from the factory inspector, the improvement notice was lifted when the port operator agreed to invest in high luminosity paint which does provide a benefit for the untrained eye, but as only appropriately trained people are allowed onto the dolphins it is of limited use. The port operator also undertook a trial using photoluminescent strips but this was ineffective, as there was so much background light in 'blackout' conditions that it was impossible to see the strips glowing.

6.2. PROTECTING THE DIVER

Diving is a potentially hazardous activity in any coastal environment. However, when a good level of planning and preparation is carried out and strict controls applied to comply with information and procedures set out in the preparatory stage, risks can be mitigated and work can be successfully and safely completed.

The following sections draw on the requirements of the Diving at Work Regulations (1997) and good practice principles.

6.2.1. *Responsibilities*

The employer who requests the work must ensure that:

- the appointed contractor is competent to carry out the proposed work and is authorised and on the HSE competency list
- the proposed work site is safe and any known hazards, underwater restrictions or associated operational information is made known to the diving contractor
- other appropriate facilities or persons will be made available to the appointed diving supervisor should an emergency situation necessitate.

The competent diving contractor carrying out the works must ensure that:

- a detailed diving project plan is prepared and all risks fully assessed
- details of the plan are made known to anyone directly or indirectly involved in the diving operation or its support activities

- an adequate number of personnel, diving and essential support are available, that sufficient plant and equipment is available and adequate arrangements for first aid or emergency medical support are in place
- the immediate dive site is safe to conduct diving operations and adequate arrangements for the access and recovery of the diver even in an emergency are in place
- accurate records are maintained and all other appropriate regulations are adhered to.

The appointed diving supervisor, in addition to being confirmed in writing and properly qualified (see notes 1 and 2) to carry out the task, must ensure that:

- everyone involved in or required to support the diving operation is fully briefed and aware of the diving plan and any emergency arrangements that are applicable
- all information, local conditions, weather, tide, current or similar used in assessing the risks on the site remain valid during the period of the dive
- adequate records are kept and persons involved in the support of or working close to the dive site are fully appraised of progress as the operation progresses.

Notes:

1. The ADC operate a scheme for the certification of diving supervisors for inland/inshore diving operations. This scheme has been in operation since 2000 and is now a specified requirement by a number of organisations using divers in the UK.

   The scheme is recognised by HSE for inland/inshore diving, but current legislation does not demand that supervisors have this qualification and possession of an ADC certificate does not exclude the contractor from appointing the supervisor in writing.

   All persons who have successfully passed the course are listed on the ADC web site: www.adc-uk.info

2. The IMCA operate a scheme for the certification of offshore diving supervisors. While this is an internationally recognised qualification, the environment and work conditions offshore are very different to those found on inland/inshore work sites, it is not necessarily appropriate for offshore diving supervisors to automatically be considered as competent for all inland/inshore diving operations.

6.2.2. Team size

The correct selection of the number of divers necessary to complete a specified task goes some way to ensuring the safe conclusion of any diving operation. While Regulation 6 of DWR and the ACOP indicate the minimum team size to be four – supervisor, diver, standby diver and tender – the Diving Project Plan, in addition to detailing the task and associated risks, will address the requirement for diving team personnel and should specify and justify the team size necessary for a particular task.

Basic underwater tasks in controlled circumstances can be safely completed using a four-man diving team, however, as both the complexities in terms of tools, equipment use and depth of the dive increase so too does the likely need for additional members of the dive team.

6.2.3. Equipment

All commercial diving work should be carried using equipment that is maintained as part of a planned maintenance system and suitable for the work in hand. While DWR 1997 does not exclude the use of Self Contained Underwater Breathing Apparatus (SCUBA), the need to provide communications between the diver and the surface as well the requirements for an independent air supply reserve tend to reduce the benefit of SCUBA and actively encourage the diving contractor to adopt a Surface Supplied Diving Equipment (SSDE) spread.

In addition to the benefits of having a larger reserve of air provided from the surface, the working diver using modern lightweight air helmets can be afforded a high degree of head protection while working in the water.

6.2.4. Diving Project Plan (DPP)

Consistent with other H&S legislation, the DPP is intended to '… so far as reasonably practical' identify the hazards and risks existing on or at a site and detail how these will be controlled. In addition, the DPP will look specifically at the range of support equipment that will be necessary to cover all foreseeable eventualities on the dive site.

The DPP should make clear reference to the working methods that will be used and detail the control measures that will be implemented for dealing with water flows, underwater currents, low visibility, weather conditions, vessel movements, use of tools as well as specifying any special precautions that may be required to ensure liaison between the dive team and other vessels operating in the area.

In particular, there is a need to address the method of recovering the diver after completing the work or in an emergency situation when they may be unconscious. Entry tends to be quite simple but having completed an element of work the ability to climb a vertical ladder may be seriously impaired and some other form of controlled recovery may be required.

The DPP will be used to brief the divers and any other persons involved in the diving operation and a copy of the plan should be available to any interested party. Checklists are commonly used as part of a DPP to ensure that all aspects of the duties of the employer, contractor, diving supervisor and divers have been covered.

6.2.5. Emergency arrangements

As with all project planning regimes, ensuring arrangements exist to deal with emergency occurrences is important.

In addition to the need to provide a safe work environment, and provide adequate launch and recover facilities, the diving contractor must ensure that adequate arrangements exist for the emergency recompression of divers.

Where no in-water decompression is planned and the water depth does not exceed 10 m, arrangements to have a suitable recompression facility accessible within a maximum travelling time of six hours exist.

For dive operations between 10 and 50 m with either no in-water decompression or planned in-water decompression not exceeding 20 minutes, the requirement is reduced into having a suitable recompression facility within a maximum travelling time of two hours.

Where diving is planned to require more than 20 minutes in-water decompression, or either of the two requirements outlined above cannot be complied with, a suitable recompression facility will be required on the site.

It is worth stressing that for most coastal diving operations, the DPP and risk assessment is likely to demand the need for a recompression facility on site since the sea and weather conditions can change at very short notice thus compromising the ability to achieve either of the two or six hour requirements.

⇒ Good practice: Diving operations (see also Table 7.13)

Diving is a hazardous operation with potential for high risks and, where possible, alternative options should be examined through the use of risk assessments to determine whether the diving operation can be avoided. Use of other methods such as limpet dams may reduce the overall risk.

6.3. COMPETENCY TRAINING IN COASTAL ENGINEERING

6.3.1. Setting up a competency management system

Setting up competence management systems and ensuring adequate competence of the operative is a requirement of recent legislation. It is also considered by those consulted to be a key issue in coastal engineering projects.

Achieving and maintaining a suitable level of competence for both operatives and supervisory staff requires appropriate training by experienced trainers on a regular and monitored basis. The training needs may range from on the job training to formal classroom courses and formal qualifications such as NVQs. It is important that training covers not only the site operatives but also the supervisory staff, site agents and engineers, etc., who may require more management-based, rather than practical training, to achieve appropriate competence levels. Boxes 6.3 and 6.4 illustrate the five phases and 15 principles to be followed in setting up and running appropriate competence training.

6.3.2. Existing competency management systems

One major problem in the coastal/maritime construction sector is identifying suitable training organisations with the specific experience and expertise in this environment. While there are general civil engineering courses available, these are usually geared towards construction onshore. In some cases contractors have commissioned their own training courses from such training organisations, but with a particular emphasis on the coastal/maritime construction issues. Smaller specialist companies often link together to share specialist competency training.

CSCS system

The CSCS (Construction Skills Certification Scheme) aims to register every competent construction operative within the UK not currently on a skills registration scheme. Operatives will get an individual registration card which is valid for three or five years. The CSCS card also provides evidence that the holder has undergone health and safety awareness training or testing. Further information can be found on their web site www.cscs.uk.com. The Civil Engineering Contractors Association (CECA) in association with the Construction Industry Training Board (CITB) produces a manual of approved cards. There is currently an exemption for ‘Marine Construction’ but it is anticipated that formal competency schemes will be developed in the future.

IMCA system

The IMCA (International Marine Contractors Association) runs a self regulation competence assurance and assessment scheme (IMCA, 2003) to enable contractors to facilitate and improve safety in the offshore industry. This excellent framework enables contractors to assess and demonstrate to others the competence of ‘safety-critical’ personnel. It also includes competency measures for client’s representatives. While it focuses on the offshore industry this is very relevant to coastal and maritime works. Further details including guidance, guidance for assessors, logbooks, etc. can be obtained from www.imca-int.com.

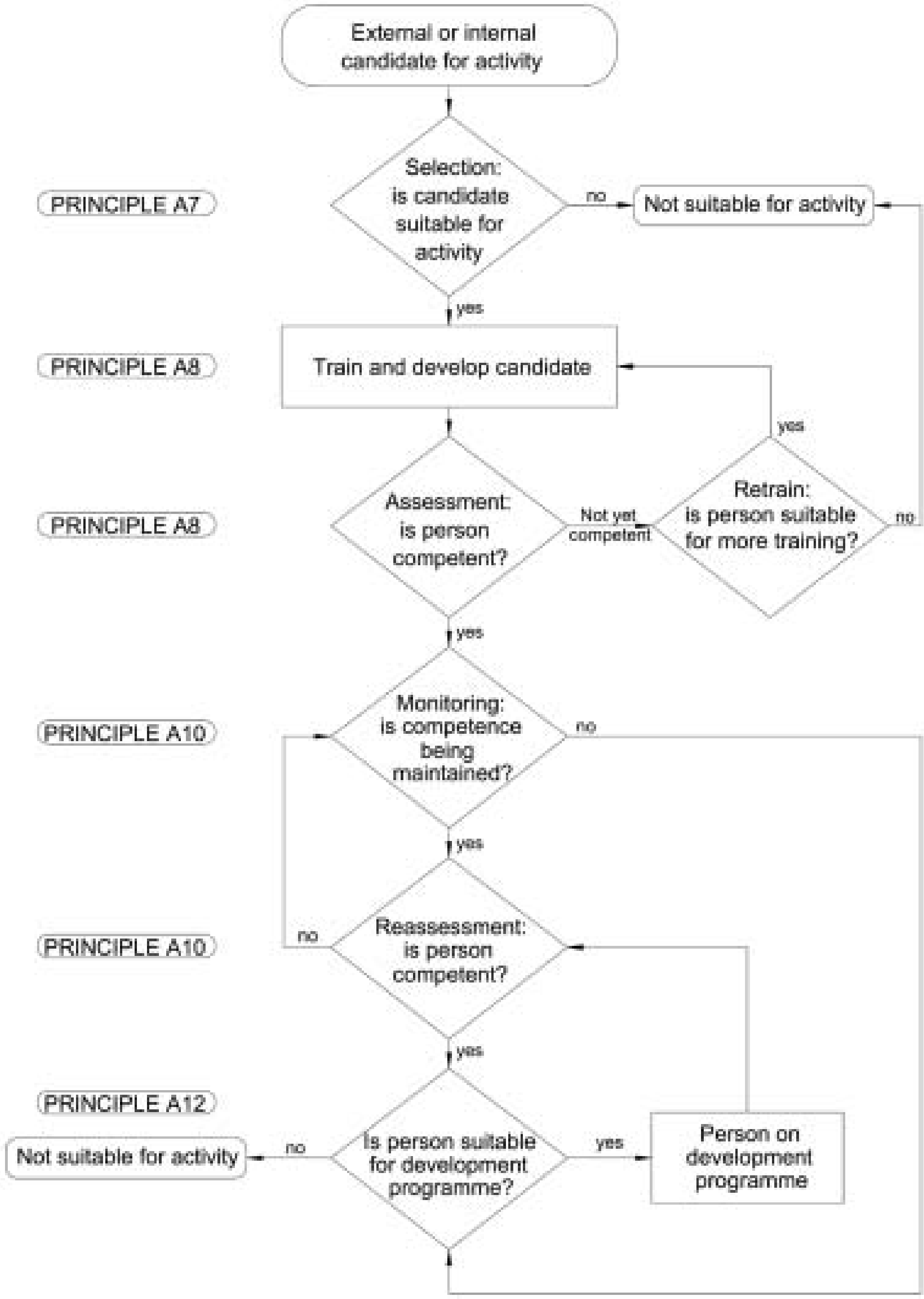
6.4. USERS OF THE COASTAL ENVIRONMENT AND PUBLIC SAFETY

The focus of this research is to examine risks associated with the construction, maintenance and demolition process rather than the risks to the users resulting from the permanent works during the use of the structure. However, the research has identified some useful background information which may enable designers to better consider health and safety during the use of the coastal structure and these issues which is presented here.

Box 6.3. Examples of setting up and running a competency system as it might apply to coastal engineering

The following flow diagram is from HSE (2002) and illustrates the basic principles of a Competency Management System (CMS). While designed specifically for the railway industry, its basic principles also apply to coastal engineering projects.

Box 6.4. Basic principles of a Competency Management System (CMS)



⇒ Good practice: Setting up and running a competency management system

- Use IMCA competency system to assess competence of staff working on the project.
- Consider setting up a competency system focused around the needs of the coastal sector not just the construction industry. Use staff with recognised experienced in this sector to advise on/formulate the system.
- Ensure competency training is appropriately focused by holding courses targeted on the industry sector. This could be achieved by:
  (i) Bringing in external trainers but illustrating the training with examples from the coastal sector.
- Use recognised experienced staff to hold internal training courses.
  (i) Club together with other specialists in the coastal sector to run targeted training.
  (ii) Augmenting standard training with short targeted training.
- Consider formalising the training to NVQ or other recognised accreditation systems.

6.4.1. Public safety during construction

This section considers health and safety issues associated with the construction, maintenance and demolition process.

The coastal zone is, by its very nature, an environment where it is difficult to totally separate the construction process from the public (Figure 6.3) and other users such as fishermen. By their very nature, the high costs associated with coastal defence projects can normally only be justified economically where there are significant assets at risk, with corresponding numbers of people using the area.

Figure 6.3. Note the problems of working in close proximity to the public (courtesy Van Oord)

Key issues to consider that raise hazards levels when working in close proximity to the public include:

- it is difficult to fence off large areas of coast during construction work
- the public are often attracted to the beach and construction works and may not realise that it is an operational construction site
- dog walkers often will use beaches in the early morning before safety/security guards are monitoring the site
- different users may be expected on coastal/maritime-based developments such as quad bikes, kite flyers, etc.
- marine leisure boat users may be attracted to the construction works and not be aware of the notice to mariners
- in particular, jet skiers and surfers may take a special interest in getting close to floating marine plant
- fishermen often operate outside daylight hours when the site may not be fully manned and they may not be fully aware of the notice to mariners
- establishing when it is it safe to hand back the site to the client and the public.

⇒ ***Good practice:*** Potential methods of reducing the risk to the public are given in Box 6.5.

Box 6.5. Potential methods of informing the public about coastal construction sites and protecting the public from entering the site boundary

Experience has shown that the public are less likely to pose a safety risk if they are better informed. The risks to public safety can be mitigated by informing the public through:

- hotlines
- newsletters
- newspaper advertisements/articles
- notice boards
- incorporating safe viewing stations
- school visits
- consultation meetings
- project web sites.

Protecting the site boundaries can be difficult on most coastal engineering projects due to the dynamic environment. However, consideration should be given to:

- security fencing where practicable. This can be targeted to protect active working areas whilst also ensuring non active areas are safe for public use
- security guards/beach marshalls
- buoys to help define the construction zone referred to in the FEPA license and notice to mariners.

See Figure 6.4.

Figure 6.4. Fencing around an active construction work area. Security guards were also used (courtesy Van Oord)

6.4.2. Public safety during the use of the coastal structure

In 1996 the NRA (now part of the Environment Agency) undertook a review on public safety access to the coastal environment. The overall purpose of that research (Environment Agency, 1996 and 1997) was to assist the authority to define a consistent policy for responding to public safety issues and to provide a system for determining appropriate responses. While this research has not resulted in any formal policy, it is worth noting that as a result of this work the Agency now has a process of Public Safety Risk Assessment which is mandatory for all new EA projects.

The first stage was a diagnosis of the scope of the problem of public safety related to coastal structures, and the review identified potential responses to this problem. The second stage developed a systematic approach to the selection and implementation of hazard mitigation measures and risk management responses to improve public safety.

Research into public safety incidents obtained evidence on 31 incidents from NRA records during the period from the creation of the Authority in 1989 up to June 1994. These are summarised in Figure 6.5.

The review of past incidents combined an assessment of the views of some of the Authority's staff and others on perceived hazards, possible outcomes and potential responses. Information on past incidents and current perceptions were combined and analysed, to provide a basis for understanding hazards, their causes and responses.

Responses to public safety issues were categorised into:

- those that modify the hazard

- those that modify public behaviour
- those that modify the outcome of an accident.

At that time the NRA design and operations staff identified the preferred responses to public safety needs:

- control the hazard through safety sensitive design
- prevent access to the hazard
- reduce contact with the hazard
- control the development of the hazard through adequate maintenance.

This is consistent with the approach adopted in Health and Safety legislation. The analysis of current responses by the Authority produced the following observations:

- Responses to public safety hazards were not implemented consistently.
- The use of new construction materials or innovative designs, while being more cost effective than those previously used, may create new safety hazards.

At that time the major components of safety-related spending were ranked in the following order, in terms of their perceived impact on safety:

1. use of safety sensitive designs and materials
2. maintenance
3. patrolling, inspection, monitoring
4. signs
5. safe routes around hazards.

Stage 2 of the review identified a Safety Management Procedure (SMP) that should be taken up by the Environment Agency. This allowed a structured risk assessment to be carried out using local factors and site specific details. The process allows decisions to be made regarding whether further safety measures are required, and if so what form they should take.

Step 1: involves the setting up of a **Site register** ready for use in the assessment process and assembly of site information relevant to safety management.

Step 2: applies a set of **screening** tests to determine the appropriate degree of detail of the safety assessment and the urgency or priority of the assessment.

Step 3: identifies the public safety hazards at the site, taking existing safety measures into account in order to determine how safe the site is by completing the **Risk register**.

Step 4: identifies and evaluates responses to public safety risks by completing the **Response register**. Assessments of the adequacy of existing safety measures and the merits of alternative or additional responses are made. The most appropriate public safety response for the site is then selected.

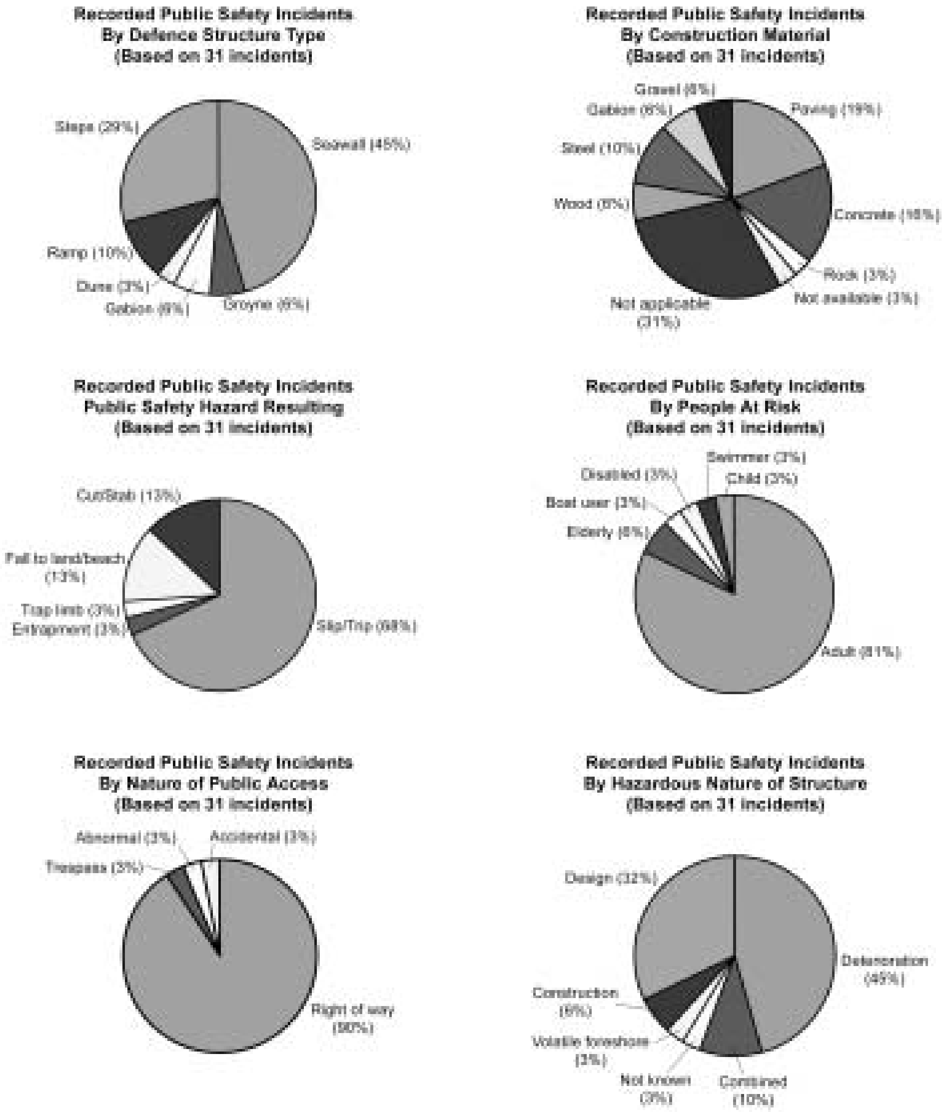


Figure 6.5. Summary of accident data from an Environment Agency research project in 1996 (based on 31 incidents)

7. Good practice principles to be applied during each project phase

7.1. HOW TO USE THIS CHAPTER

This section covers good practice issues during the feasibility, design and construction operations. It highlights the risks that the designer, contractor, client and other stakeholders need to consider and address based on generic construction areas proposed in CIRIA (2003). Use the guidance contained in this chapter combined with the checklist contained in the following tables (at the end of the chapter):

General coastal and maritime engineering	**Table 7.1**

+ Plus

Marine operations	Table 7.2
Dredging and excavation	Table 7.3
Drilling and blasting underwater	Table 7.4
Installation of pipelines and cables	Table 7.5
Nourishment and reclamation	Table 7.6
Rockworks/placement of concrete	Table 7.7
Timber works	Table 7.8
Piling	Table 7.9
Masonry	Table 7.10
Painting	Table 7.11
Concrete/grouting works	Table 7.12
Diving operations	Table 7.13

Use the Health and Safety Plan and File to store and communicate the assessments you make.

7.2. GOOD PRACTICE PRINCIPLES TO APPLY AT EACH PROJECT PHASE

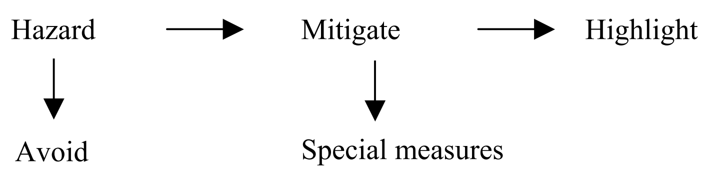
For any coastal/maritime construction project the following general principles of prevention should be applied throughout the project cycle:

- If possible avoid a risk altogether – do the work in a different way, taking care not to introduce new hazards.
- Evaluate risks that cannot be avoided by carrying out a risk assessment.
- Combat risks at source, rather than taking palliative measures – cure problems not alleviate.
- Adapt work to the requirements of the individual.
- Take advantage of technological and technical progress.
- Implement risk prevention measures.
- Give priority to measures which protect the whole workplace and everyone who works there.
- Ensure that operatives understand what they must do.
- Ensure a positive health and safety culture within the organisation.

The following sections provides examples of good practice principles to apply at each stage of the coastal or maritime engineering project.

7.3. DESIGN PHASES

As with all construction works, the designer must be aware of safety during design. However, for maritime and coastal works this is particularly important at all the stages in both the development and design of maritime works. Risk evaluation will be a central part in the basic shaping of a scheme and must continue throughout the design process.



At the early stages, consideration will be given to high-level risks and their avoidance or mitigation by fundamental changes to the nature of the project. Elements of the work, which will be examined and adjusted to improve the safety of the project, will include location, nature of works, construction materials, programming, etc. However, the focus will become sharper as the project progresses through outline and detail design stages when individual work elements will be considered and adjusted to reduce the overall risk profile. Such elements may include access, temporary works, construction sequence, etc.

7.3.1. Concept and feasibility stage

The designer should:

- assess risk at the feasibility stage of a project and ensure that the client, under the duties of the CDM Regulations, appoints a planning supervisor at concept or feasibility stage. By assessing risk at this early stage then risks can be mitigated early on. (See Boxes 7.1 to 7.5)
- review options to minimise exposure to maritime hazards. Does the construction need to be built in a maritime environment? For example, sea walls may be less risky to construct than offshore breakwaters as a tidal flood defence
- consider construction materials, particularly in relation to the location where they are to be placed. Prefabrication or no-dig methods may be less risky
- be aware of the environmental factors, which exist at the site, that may affect safety in construction. For example, avoid the need for heavy lifts, which will be subject to wind and swell waves
- always consider access and working area arrangements, and optimise the design to avoid the need for working in risky areas. (See Boxes 7.1 to 7.5)
- include construction safety as a key criterium when appraising and selecting options.

Box 7.1. Example of consideration to health and safety issues when selecting options

A seaside town was at risk of coastal erosion and flooding. A set of detailed studies were undertaken to assess the best solution for protecting the town, which was technically achievable, environmentally acceptable and provided maximum cost benefit. These studies identified that an offshore reef breakwater would provide the best solution. This was particularly attractive to those involved as it was a relatively innovative solution and was accepted by the town's population. The designer was then asked to proceed with the detailed design of the scheme.

In accordance with CDM, the later (detailed) design process included a risk assessment which served to identify and mitigate risks through minor changes to the design. The reef was constructed without major incident despite two lives being lost on a similar earlier project. The reefs have performed well although significant accretion has occurred behind the reef and it is now possible to walk out to the reef at low tide.

While the project was constructed without major incident, some considered that the construction of the reefs was a hazardous operation and, due to the high accretion, they now pose a public safety issue. The construction operations were particularly hazardous as they involved marine plant working close to rock structures in the surf zone. The accretion behind the reef and subsequent public access means that health and safety issues will be a problem for the whole design life. The environment used to consist of a naturally sloping sandy beach but now includes an accessible rock reef which is hazardous to climb and with deep water existing on the seaward side of the structure.

Box 7.1. Example of consideration to health and safety issues when selecting options (continued)

The solution adopted probably provided the best option at that location. However, it is important to recognise that health and safety issues should receive full attention at the project *inception* stage when the fundamental decisions of the optimum solution are reached. This is especially important in coastal engineering where early consideration to the health and safety implication of each option can enable risks to be avoided. For instance, a beach recharge alone has a very different risk profile to an offshore reef but sometimes these decisions are made before the formal design process commences. Incorporating a formal risk assessment process from project inception enables these questions to be addressed.

Box 7.2. Example of consideration to method-related issues at an early stage

A scheme located on a river estuary involved an extension to an existing quay at a marina. The quay was to be able to carry heavy plant and cranes throughout its design life, therefore the superstructure needed to be of significant member sizes.

The plan was to extend the quay using 30 m long tubular piles with a suspended concrete deck 100 m long and 15 m wide over the estuary. The water depth varied due to tidal conditions from 4 m to 8 m at high water.

It was recognised by the designer at *concept* stage that construction over water can be hazardous and that any method which could be suggested that would alleviate the need for personnel working directly above open water would be a health and safety benefit.

The designer recommended that once the tubular pile had been driven then precast concrete pile caps should be placed over the piles on which to bear precast concrete beams. The spans (and therefore the weights) of the beams were designed such that the beams could be craned into position from the existing quay with a suitable crane, reducing the need for floating plant.

All drawings produced identified lifting points, bearing lengths required and identified weights of each precast unit so as to avoid confusion or inappropriate lifting techniques on site.

Proprietary precast deck slabs were then used to span between the beams and act as permanent soffit shuttering. On this surface the reinforcement could be fabricated and an in situ deck slab formed in safety with no chance of the workmen falling into the water.

This approach reduced to an absolute minimum the time when any personnel were exposed to height or working over water.

This approach, together with the contractors ‘tidy site’ policy, meant that there were no incidents on site.

Box 7.3. Example of consideration of access at an early stage due to licence requirements

A beach nourishment scheme was undertaken at a location where no local quay was available to provide ready all-tide access for work boats or safety boats. The nearest such access was several hours steaming away. Local site communications between shore and floating plant developed initially by using a beach-launched work boat. Tragically, the work boat was overturned during launching in unexceptional conditions and both of the crew drowned.

In subsequent stages of the work a temporary jetty was provided to avoid the need for further risky beach launching. The required approvals and consents for construction of a temporary landing structure cannot be quickly secured. The need for such provision must therefore be considered at scheme design stage and the appropriate consents included with the main scheme.

Box 7.4. Example of consideration of construction access and public safety at an early stage

A client identified the need for a scheme to protect a small village from flooding from the sea. The village had only single-lane road access from the land. The scheme required the installation of two large rock groynes consisting of 10 000 tonnes of rock armour together with 30 000 tonnes of shingle recharge. Particular construction stage hazards identified early in the design stage were:

- the site had limited access because the nearest ramp that could take plant to the beach was one mile away and the existing timber groynes were of such a length that access could then only be to site for a few hours, allowing for tracking back to the access ramp
- the groyne would prevent public access along the beach at high tide, increasing the likelihood that the public would climb onto and over partially constructed structures.

At option development stage, the designer together with the client agreed measures to alleviate these problems.

- The lack of access would be a major risk to personnel of being cut off due to tides and it was agreed that a plant access point would be designed into the scheme at the site location from the minor road running behind the beach (thus being paid for by the client as it was part of the permanent works). This would not only serve during construction but, with the installation of stop logs, would provide access for maintenance vehicles during the ‘in service’ period for the structures, an activity which had in the past needed to use the existing access ramp a mile away.
- To overcome the public access problem, steps either side of the structures were designed and provided before main construction started, removing the need for members of the public to climb onto the structure while trying to move east/ west along the beach.

Box 7.4. Example of consideration of construction access and public safety at an early stage (continued)

Further 'in service' risks of the rock structures were identified at an early stage in the project conception and, as the site is a tourist amenity, meetings were held with locals to discuss this issue. The format and wording of warning signs were agreed with the client; these were installed at all access points to the beach.

Road access to the village and through to site was also a major issue. Because of the proximity of the quarry to site (three miles away) the rock armour and shingle were brought to site by road. By careful planning and liaison with local residents and the contractor and highway authorities at an early stage, all rock armour and shingle deliveries went ahead without any incidents involving the public or site personnel.

During the five months construction no incidents were reported.

⇒ Good practice: Consideration of health and safety at an early stage

It is essential that health and safety is considered as early as possible especially as in coastal engineering often it is the decisions made before the formal 'design' process begins that affect health and safety. One marine consultant now includes a short section on health and safety implications of solution selection in all reports (including simple risk assessment tables where applicable) from project inception, through feasibility stages and detailed design. This enables consideration of health and safety issues to be made at an early stage as well as providing a systematic way of recording decisions made.

7.3.2. Detailed design stage

The designer should:

- consider the construction process and examine the likely safety of part constructed work. Improving *buildability* will often make construction safer
- determine critical construction sequences, which minimise the exposure to hazards
- consider access and working areas in detail, both in the temporary construction and final completed state
- examine each element to minimise hazards in construction. Does this fitting really need to be welded overhead, offshore, at a level just above MHWS, or is there a better way?
- early contractor involvement in design. It is now more frequent for the contractor appointment to be made during the appraisal and design stages, with the anticipated benefit of more cost certainty, sustainability and buildability. However, the key benefit of such early involvement is in the mobilisation of both design and construction skills at a key development stage in the project, with the result of an inherently safer project. Consideration should be given to this approach which can yield significant safety benefits

- provide wind, wave, current and tide tables and extreme water level data in the tender documents.

As discussed in Chapter 5, coastal and maritime construction sites are particularly sensitive to weather conditions. The CDM regulations impose a clear obligation on the designer to bring together information on all relevant hazards. Therefore it is essential to provide wind, wave, current and water level data in the tender documents wherever possible. At this stage this information is brought together to create the Health and Safety Plan.

Box 7.5. Example of the need to consider public access

A sea defence scheme included the placing of sand beach nourishment over rock armour. It was not appreciated at the time that voids remained in the buried armour, which only filled with sand slowly under tidal action.

The result was the unexpected formation of 'sink holes' in the beach over a period of weeks after the beach was re-opened to public access. A disabled member of the public became trapped in one such sink hole and had to be rescued by emergency services.

Works in a maritime environment may well take time to stabilise after construction, and due consideration to this should be given in assessing the safety of permitting public access on completion.

⇒ Good practice: Issues to consider including in Health and Safety Plan

- Consider issues raised in Boxes 7.1 to 7.5.
- See Tables 7.1 to 7.13.
- Wave, wind, water level and current data.
- Public access safety issues.
- Overtopping risks.
- Flooding risk.
- Management issues, signage and notices.
- Hazard reductions methods (e.g. antislip surfaces/stairs, handrailing, lifeline belts, specifications, barriers, emergency access/egress, flood gates/barrier specifications, flags, marker buoys, notices, wardens/lifeguard assumptions).
- How to safely maintain the structures.

7.4. CONSTRUCTION PHASE

Before construction commences health and safety file should be prepared to include the items specific to coastal construction. See Boxes 7.6 to 7.8.

Box 7.6. '20-second' risk assessment for changing environments

A 20-second risk assessment is a good way to reassess the risks in a constantly changing environment such as coastal engineering. At the start of a new shift, after tea break or when conditions start to change:

Look around:

- *Is anybody missing?*
- *What is happening?*
- *What has changed? – tide height, tidal flow weather vessel positions*
- *Actions required?*

⇒ Good practice: Issues to consider in Health and Safety File

- See prompt list for Health and Safety Plan in Section 7.3.
- See Tables 7.1–7.13.
- Also check availability of:
  i) general preparedness/contingency planning procedures
  ii) procedures for obtaining weather forecasts
  iii) locations, details of safe haven
  iv) safety boat procedures and planning
  v) the nearest decompression chamber if diving operations are involved
  vi) harbour master contact details
  vii) coastguard contact details
  viii) RNLI contact details and facility locations.
- The environment is constantly changing. Consider reviewing risk assessments or doing a 20-second risk assessment.

Box 7.7. Planning ahead: Sources of coastal weather warning forecasting

The Met Office provides an online phone and fax weather service. Designed specifically for the construction industry, the service provides regional or site-specific weather information, essential for day-to-day coastal engineering operations. Bespoke forecasting for specific coastal sites can be arranged with the Met Office, with a daily email or fax containing a five-day forecast of weather and sea state, targeted to the actual coastal construction site. Go to www.met-office.gov.uk/construction for more details.

The relevant Environment Agency can also give information on flood warnings, covering both coastal and estuarial flooding (www.environment-agency.gov.uk and www.sepa.org.uk). Radio weather forecasts can be obtained from the Shipping Forecast which is provided four times a day on BBC Radio 4 (various frequencies).

Box 7.8. Preparedness: Emergency assistance

If you are involved in or observe a maritime emergency situation on the coast, in an open estuary or in the sea, telephone the Coastguard Agency on 999. The HM Coastguard Maritime Rescue Co-ordination Centres and Sub Centres maintain a continuous distress watch on VHF Digital Selective Calling (DSC) Channel 70 which is the primary means of distress alerting in the VHF Marine Band under GMDSS. Coastguard Centres also currently maintain a loudspeaker listening watch on VHF Channel 16.

You should also establish and make contact with:

- RNLI
- harbour master
- bomb disposal.

As many of the risks in coastal engineering are plant and method-related, particular attention should be given to revisiting the design to establish whether risk can be avoided through use of different plant or method of construction (Box 7.9).

Box 7.9. Example of designing out the risk on a coastal engineering project

Project description: Saltburn Pier Restoration
Contractor: John Martin Construction Ltd/Edmund Nuttall

Figure 1 Completed pier

Box 7.9. Example of designing out the risk on a coastal engineering project (continued)

Introduction

The original pier was constructed in the 1860s and consisted of a hardwood deck supported on cast iron columns. It is the last remaining pier on the north east coast. Each support was originally constructed with three cast iron columns driven into the underlying shale. These were replaced with structural steel beams and timber planks in the 1940s. Since construction, storm events had gradually eroded away the shale bed undermining the foundations and leaving the pier vulnerable.

Tender stage

The contractor submitted both compliant and alternative tenders during the tender stage, and upon award of the contract the client became receptive to the development of the alternative tender. The aims of the alternative tender were to reduce:

- health and safety risks
- environmental impacts
- risk to delicate structure
- programme duration
- cost to the client.

The key areas in which the above reductions were achieved are as follows:

1. Deck to be prefabricated and assembled in compound.
   Advantages:
   a) minimised work at height and above water
   b) work became non tidal resulting in substantial time and cost savings
   c) work carried out in controlled conditions resulting in improved build quality.

2. Trestles removed from beach and transported to compound area for refurbishment.
   Advantages:
   a) refurbishment work became non tidal
   b) allowed blasting and painting of trestles in a controlled environment
   c) with trestle removed new foundations could be considered.

3. New tubular pile foundations.
   Advantages:
   a) reduced the number of piles required from 240 to 60, with the obvious time and cost savings
   b) eliminated the risk of damage to the trestles from in situ piling.

Box 7.9. Example of designing out the risk on a coastal engineering project (continued)

Construction

The construction programme was based around spring and neap tidal cycles, working seaward on spring tides and landward on neap tides. Dismantling started in the middle of the pier with the existing decks lifted off and disposed.

The temporary works, which were attached then concreted in, were designed to be sufficient for the expected storms.

Figure 2. Storm conditions at the end of dismantling of existing pier

The deck of the pier was prefabricated in the workshop. The individual pieces were marked up, the deck disassembled and transported to site and reassembled in an allocated compound.

Box 7.9. Example of designing out the risk on a coastal engineering project (continued)

Figure 3. Deck prefabrication

The construction was a success aided by designing out risks at a pre-construction stage, with the following conclusions:

- improved build quality
- work carried out in a safer manner
- reduced environmental impacts
- client received a better product for their money.

7.5. COMMISSIONING AND POST-CONTRACT PHASE

Consideration should be given to the following at this phase.

- Care should be taken as to when it is safe to hand back the works or part of the works to the client. For instance, the dynamic environment may mean that hazards (e.g. waste materials such as lumps of concrete or reinforcing bars) within a sandy beach may be hidden at hand-over but exposed at a later stage.
- The Health and Safety file should include data relevant to the maritime structure. See Box 6.5 (including public access safety, overtopping and management issues).
- Often lessons can be learnt-through with respect to health and safety by undertaking post project evaluation. This data should be recorded in the Health and Safety file which can provide a safety feedback and incorporate lessons learnt, see Figure 7.1.

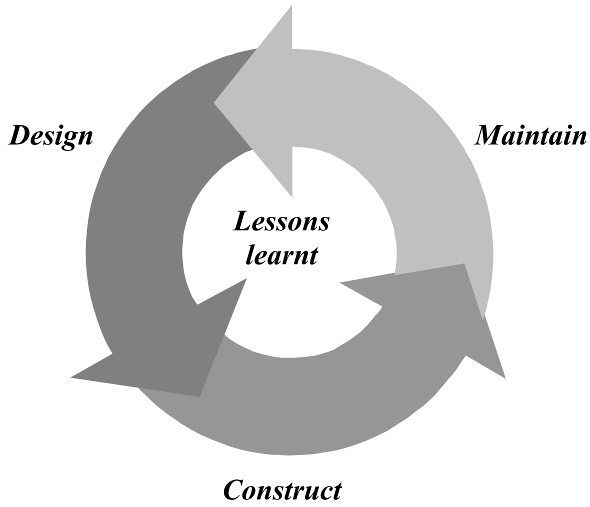


Figure 7.1. Health and safety feedback loop (information held in Health and Safety file)

7.6. MAINTENANCE AND DEMOLITION

Consideration of maintenance and demolition issues are key requirements of CDM. It is essential that consideration should be given to how the coastal or maritime structure will be safely maintained and procedures for demolition implemented if appropriate. Consideration to 'whole life safety' should be an issue when considering 'whole life cost' as part of the Project Appraisal Procedure at feasibility stage. This kind of approach is illustrated in Box 7.10.

⇒ ***Good practice:*** Consider whole life safety (see Box 7.10)

Box 7.10. Example of ALARP and 'whole life safety' concept

The existing railings on a coastal promenade required replacing. The design first considered that standard railings would provide the best whole life cost solution. However, due to heavy exposure these railings required repainting every 12 months and the repainting process would require operators to work at height walking on slippery concrete with algae growth. The designer undertook a risk assessment and concluded that the better approach was to consider whole life safety and specify new railings which incorporated higher specification protection and therefore less maintenance, coupled with setting the railings back marginally to provide easier access. The increased cost was justified as the risk was lowered to a level which was as low as reasonably practicable (ALARP).

Table 7.1. General: Coastal construction hazards and potential mitigation measures

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
Public wandering onto the site	Can: • a risk assessment be undertaken to assess whether the works should avoid the tourist season whilst also not working in worst weather periods? • information boards be erected (usually by the client) describing the scheme and asking for the public to keep clear on grounds of safety? • substantial moveable barriers be placed longitudinally along the site with warning signs to warn the public? This is a statutory requirement • plastic fencing be placed transversely at each end of the working area, moved as required while keeping the site to a minimum length with warning signs? • the contractor use security patrols where appropriate? • the contractor train all site staff and labour in the necessity of keeping the public clear of the works and in how to deal with the public? • the contractor clearly mark pipelines and any other submerged/awash hazards? • notices be erected warning swimmers, surfers and boat users, including jet ski users? • the project manager check that the necessary licence is in date and hard copy available? • the project manager obtain the necessary permissions or approvals from the Port Operator?		

Table 7.1. General: Coastal construction hazards and potential mitigation measures (continued)

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
	Can: • it be ensured that the Notice To Mariners is posted through the appropriate authority and checked that a copy is available in the contract file? • the Harbour Office/Master be informed of start date, vessels being used and location? • the client's representative be informed of planned activity? Ensure a confirmation letter is sent. • it be ensured that copies of relevant paperwork, licences and other documentation are available on board all vessels involved in the contract? • it be checked that surveys or drawings being used are current? • the contractor ensure banksmen/security guards are used with all machines moving outside any fenced-off area? • the contractor ensure personnel are wearing safety helmets /high-visibility clothing to distinguish them from the public and make the public aware of 'something different'? • the contractor check that competencies extend to the coastal engineering work proposed? • the contractor fence off pipeline stacks including fencing over the ends of pipes?		

Table 7.1. General: Coastal construction hazards and potential mitigation measures (continued)

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
	Can: • it be checked that all personnel involved are inducted prior to commencement of work? Induct all additional personnel as they attend the site. 'Permits to Work' must be checked and appropriately validated. Ensure permit to dive is received before the dive and returned at the end of the dive. • the contractor instruct staff and labour that work should be stopped if the public approach the works area? • leaflets be issued to the public warning them of the hazards present during the operations? • meetings be held with local representatives to raise awareness of the dangers? • safe system of work be set-up at ingress and egress points for vehicles and plant? • the contractor inspect completed work for dangers prior to public access?		
Weather risk	Can: • the work be undertaken from the land to avoid marine-based risk? (This may introduce other H&S risks associated with lorry delivery, etc.) • a harbour of refuge be used to protect vessels during storm conditions? • a weather management system be put in place to manage the weather risk? • good housekeeping procedures be put in place to prevent slip trips and falls, particularly during extreme weather conditions?		

Table 7.2. Marine operations: Coastal construction hazards and potential mitigation measures

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
Management/ General	• Have all personnel received a safety and emergency procedures brief? • Has a project health and safety plan been prepared and implemented? • Have emergency contingency plans been put in place and posted? • Have alarm systems been functionally tested? • Has a load line exemption certificate been issued, available and in date? • Are statutory registers and certificates held for lifting and safety equipment? • Have all personnel been issued with a safety manual? • Are risk assessments and method statements available and up to date? • Is the following information posted/displayed: Insurance Certificates; Safety Policy Statement; Environmental Loading Chart; SOLAS 1; Health and Safety Law Poster; Emergency Contact Numbers/Channels? • Are COSHH assessment and product data sheets available and up to date?		
Working platform/ pontoons	• Is the jack-up evenly loaded and operating within payload and stability limits? • Are pontoons securely connected, level and free from obvious damage? • Have all pontoons/vessel chambers been inspected for structural integrity (leaks, damage, structural alterations)		

Table 7.2 Marine operations: Coastal construction hazards and potential mitigation measures (continued)

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
	• Are pontoons/walkways free from obstructions, are equipment, plant and materials stored safely and securely? • Is edge protection in place to prevent falls (guard rails)? • Are all holes/gaps covered or securely fenced? • Is adequate lighting provided throughout the working area and access and egress points? • Is emergency lighting installed and, if so, is it functioning correctly?		
Electrical equipment/ supply	• Are all switchgear covers and retaining screws in place and secure? • Are all distribution cables protected from sharp objects or from being trapped in openings, etc.? • Are all cables, sockets and protection devices in good condition, i.e. not cracked or damaged and functioning correctly? • Are all portable electrical tools and equipment supplied at 110 V and identified with an issue tag? • Are all portable electrical tools including cables, plugs and extension leads in good condition, undamaged and in date for annual inspection/test?		

Table 7.2 Marine operations: Coastal construction hazards and potential mitigation measures (continued)

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
Cranes and lifting accessories	• Have the crane(s) been inspected post installation and every 12 months thereafter (six months when lifting persons)? Are records available? • Are daily and weekly inspections being carried out on the crane(s)? Are the inspections being recorded? • Where applicable, are all lifting accessories within the current colour code, i.e. chains, shackles, wire strops, hooks? • Are all lifting accessories clearly marked with the safe working load (SWL), in good condition and free from visual defects, e.g. frayed nylon, webbing and wire ropes; corrosion (particularly at wire termination); damaged/distorted shackles, eye bolts, wire ropes and chain slings?		
Fixed and auxiliary plant, machinery and tools	• Are all jack-up support leg interlocks/locking mechanisms operating correctly and in good condition? • Are all plant and equipment being maintained and appropriate records kept? • Are all dangerous parts, e.g. exposed gears, drive shafts, pulleys, etc. guarded? • Are guards secured and in good condition? • Are all safety devices functioning correctly, e.g. emergency stops, interlocks? • Are all hand-held tools in good condition and free from defects?		
Access equipment	• Is the jack-up access ladder in good condition, secure at the top with adequate hand holds?		

Table 7.2 Marine operations: Coastal construction hazards and potential mitigation measures (continued)

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
	• Are all other ladders and access platforms in good condition and properly positioned? • Is the Crown-Block access ladder fitted with safety hoops and or a fall-arrestor? (If so, is it in date for test?) • Is the safety harness in good condition and in date for test/inspection?		
Fire and safety equipment	• Is all safety equipment, where applicable, in date for inspection/test, correctly located and in good condition, e.g. life-rafts, flare packs, life-rings/lines, man overboard smokes/lights, life-jackets, first aid kits, eye wash bottles, foghorn and VHF radio? • Are all fire extinguishers identified with an issue tag, in date for inspection/test, in good condition and correctly positioned?		
Hazardous substances/compressed gases	• Are oxygen and acetylene cylinders, gauges, regulators, flashback arrestors, hoses and torches in good condition and free from damage or contamination, e.g. oil, grease, cuts, cracks or any other surface defects? • Are spare oxygen and acetylene cylinders segregated by at least three metres (where possible) and secured in an upright position? • Are all hazardous substances secure and stored correctly, e.g. oxygen, acetylene, petrol, oils, greases and solvents?		
Personal protective equipment and clothing (PPE)	• Has adequate PPE, e.g. hard hats, safety boots, overalls, gloves, dust/vapour masks, life-jackets, buoyancy aids, immersion suits, goggles, ear protection and wet weather gear been provided? • Is PPE stowed correctly, i.e. where appropriate hung up in a dry, dust-free area?		

Table 7.2 Marine operations: Coastal construction hazards and potential mitigation measures (continued)

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
Welfare and first aid	• Is there adequate first aid provision, i.e. first aid kit, stretcher, eye wash bottles, at least one appointed person per shift? • Have toilets been provided on the jack-up or appropriate arrangements made to use shore side facilities? • Are adequate hand washing facilities available (hot water, soap and towel)? • Is fresh drinking water available on site? • Is the rest room being kept in a clean, tidy, warm and dry condition?		
Crew boat/RHIB	• Is the crew boat in seaworthy condition, e.g. hull and buoyancy free from any obvious structural damage and leaks? • Are the lifting points in good condition, secure and in date for inspection/test? • Is all safety and other equipment, where applicable, in date for inspection/test, correctly located and in good condition, e.g. flare packs, life-rings/ lines, first aid kit, compass, GPS, torch, fire extinguisher, thermal blanket, anchor, spare fuel, foghorn, VHF radio and paddle? • Is the outboard engine in a good state of repair, functioning correctly and bolted and locked to the transom? • Has the use of a second/auxiliary engine been considered?		

Table 7.3. Dredging and excavation: Coastal construction hazards and potential mitigation measures

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
General	• Has the stability of the adjacent dockside, quay wall reclamation or revetment been assessed for the new dredging depths? • Have the effects of new dredging depths been taken into account when dredging adjacent to existing piles? • Will the dredging works be clear of underground pipelines and services crossing the site? • Can the dredging operation be carried out clear of other commercial ship operations or floating plant movements? • Can dredge depths and location be accurately controlled from the plant chosen to undertake the work?		
Ordnance	Can: • the existence of ordnance be checked against military records? • magnetometer surveys be undertaken? • the client warn contractors of the presence of ordnance based on past local experience? • control measures be put in place? • the existence of ordnance be checked against military records? See also Section 4.2.6.		

Table 7.4. Drilling and blasting underwater: Coastal construction hazards and potential mitigation measures

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
	Can: • a system be set up to warn divers/other users when work is proposed? • vibration be monitored? • vibration be reduced by using shaped charges or method of placing charges? • adjacent structures withstand the vibration within acceptable limits? • the charges damage marine craft? • Is the safest means of detonation being used? • Can the temporary works take/transfer the loads from drill jamming? • Is the flushing liquid environmentally friendly? • Are the drillers protected from blow back?		

Table 7.5. Installation of pipelines and cables: Coastal construction hazards and potential mitigation measures

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
General	Can: • consideration be given to anchorage capacity, pulling forces and winch hazards on the pipe pulls? • safe working practices be established for radiography on the pipe testing? • consideration be given to a safe working procedure for i) surf zone working ii) cofferdams/excavations? • consideration be given to including design loads conditions, evacuation routes? • consideration be given to the availability of safe working space in the stringing yard? • consideration be given to changing the design to minimise diver content? • sufficient investigations be undertaken to survey and clear obstructions/ordnance/wrecks/pipelines/cable along the pipeline/cable route? • the risks of trapping of personnel during the pipeline pull be identified? • cofferdams for landfall (design loads, excavation route, waves) be considered?		
Live flows	Can: • the work be carried out at slack tide? • a warning system be put in place to warn of stormwater flows? • appropriate precautionary measures be employed to protect against Weils disease?		

Table 7.6. Reclamation and beach renourishment: Coastal construction hazards and potential mitigation measures

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
General	See also Table 7.1 General, particularly with respect to public access issues. Can: • fencing be put up around the active area? • public, personnel and plant be kept away from 'rainbowing' operations • placement be managed to avoid blockage of natural watercourses? • formation of quicksand be avoided? • personnel and public be warned of quicksand potential? • adequate drainage for dewatering and run-off be ensured? • a beach master who is in constant communication with the ship's master be employed to monitor safety of the works?		

Table 7.7. Rockworks/concrete armour: Coastal construction hazards and potential mitigation measures

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
General	Can: • rock/concrete movement be minimised? • rock be more angular than round? • experienced operatives be used? • the sequence of placing be well planned? • crush zones be marked off?		
Changes to beach levels under vessel beaching area	Can: • the rock be delivered by bottom dumping barges rather than by using beaching (this will reduce possible vessel damage but may introduce other risks)?		
Rock dumping – temporary instability	Can: • the rock storage areas be made secure and operators and the public be made aware of the risks?		
Waves impacting on construction plant	Can: • the design be altered to work from the land, e.g. raise the construction level above the high tide and out of the zone of wave runup?		

Table 7.8. Timber works: Coastal construction hazards and potential mitigation measures

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
Toxicity of tropical hardwood timbers; tropical hardwood timbers are prone to splintering and the splinters are toxic if they cause wounding	Can: • the timber works be prefabricated and standardised as much as possible to reduce the amount of work undertaken in the exposed environment? • hardwood substitutes be used? • dust creating operations be avoided? • it be checked that full and appropriate PPE is being used, when working with timber and when applying any preservatives?		

Table 7.9. Piling: Coastal construction hazards and potential mitigation measures

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
General	Can: • a risk assessment be undertaken to assess whether the works should be constructed from land? • hand-over hand construction be used? • plant, public, operatives be segregated to avoid collision hazards? • the design be optimised to minimise underwater fixings and thereby minimise divers' time? • the working area be clearly defined with buoys? • working space and storage space be planned? • piles be released from the gates at all stages of the tide and remain stable? • the piles be braced after installation? • safe access be provided to the piles for post installation work? • piling plant be planned to avoid crushing zones, or set up demarcation zones?		
Plant-related	Can: • a fixed jack-up or even walking rig be used rather than a floating rig? • plant be selected to reduce noise and ground vibration? • methods be provided of clutch engagement rather than working at height? • pile lengths be reduced to minimise jib lengths and wind problems? • piles be pitched in properly sized gates? • barges be stabilised using spuds and winches? • hammers be chosen to continue the drive at all states of the tide?		

Table 7.9. Piling: Coastal construction hazards and potential mitigation measures (continued)

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
	Can: • the piles be stored in stable condition for handling? • floating storage piles be assessed for crushing risk to a man overboard? • floating storage craft be moored fast alongside? • storage craft be moored safely away from each other?		

Table 7.10. Masonry: Coastal construction hazards and potential mitigation measures

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
Manual handling hazards	Can: • the masonry elements be either very lightweight to allow safe manual handling or much larger, clearly requiring mechanical lifting? • prefabricated cladding panels be used?		

Table 7.11. Painting: Coastal construction hazards and potential mitigation measures

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
General	Can: • painting be done on shore or before delivery to site? • a suitable safe and appropriate paint system be used for remedial work? • the paint system be designed to minimise the requirement for maintenance and the associated additional risks? • appropriate access points be installed into the permanent works for maintenance?		

Table 7.12. Concrete/grouting works: Coastal construction hazards and potential mitigation measures

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
Concrete pours and aftercare	Can: • the concrete works be precast and standardised as much as possible to reduce the amount of work undertaken in the exposed environment? (Consider impacts on craneage requirements and associated risks) • the design be made as simple as possible to avoid complex details/reinforcement fixing in an exposed environment? • formwork be designed to withstand wave loading? • reinforcement be deleted to avoid reinforcement fixing requirements?		

Table 7.13. Diving: Coastal construction hazards and potential mitigation measures

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
General hazards	Can/has: • the overall risk be reduced by avoiding diving? • appropriate signage be erected? • the project manager check divers' experience, qualifications, diving record and medical certificates? • the number of risks in the activity be checked and the appropriate number of divers determined? • it be ensured that ship to shore, ship to ship radios are working and on frequency? • essential recompression facilities be identified and it be confirmed that they are available within specified travel times? • the project manager checked that a Diving Project Plan has been prepared, made known to all interested parties and a copy made available on the dive site? • the project manager checked that the necessary licence is in date and hard copy available? • the project manager obtained the necessary permissions or approvals from Port Operator? • it been ensured that the Notice To Mariners is posted through the appropriate authority and checked that a copy is available in the contract file? • the Harbour Office been informed of start date, vessels being used and location?		

Table 7.13. Diving: Coastal construction hazards and potential mitigation measures (continued)

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
	Can/has/have: • the client's representative been informed of planned activity – ensure confirmation letter has been sent? • it been ensured that copies of relevant paperwork, licences and other documentation are available on board all vessels involved in the contract? • it been checked that surveys or drawings being used are current? • it been ensured that the divers and support crews are fully briefed on contract requirements, site-specific rules or limitations, emergency procedures, welfare facilities, objectives, safety, working hours, reliefs, etc. and any other guidelines specific to the site? • method statements be prepared, including dive depths and dive times, communications, location of compressor (avoidance of fumes)? Risk assessments and site-specific rules made available where appropriate – ensure copies are available on board all vessels and that personnel understand why they are required. • it been ensured that no outstanding planned maintenance works are required on any of the plant or equipment to be used on the site? Check with the maintenance technician that all necessary certification is in date, obtain copies. • it been ensured that the most appropriate vessels and barges are being used for the contract, discussing any concerns with the appropriate manager?		

Table 7.13. Diving: Coastal construction hazards and potential mitigation measures (continued)

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
	Can/has/have: • it been checked that all personnel involved are inducted prior to commencement of work? Induct all additional personnel as they attend the site. • 'Permits to Work' been checked and appropriately validated? Ensure permit to dive is received before the dive and returned at the end of the dive. • it been ensured that the Diving Operations Log is completed daily? • monitoring and reviewing progress on a daily basis been submitted on weekly summary? • it been ensured that a safety briefing is carried out before each dive and all safety requirements are being followed – taking the necessary action when breaches in safety are noted? • the benefit or failure of any site-specific rules be monitored and adjusted as appropriate? • it been ensured that daily site records appropriate to the requirements of the contract are maintained and submitted the relevant authorities weekly? • liaison been undertaken with the client or their designated representative periodically to update them on the activity? Summarise the general progress of the works when requested. • it been confirmed that any relevant on-site or telephone conversations with the client or representative have been recorded in writing?		

Table 7.13. Diving: Coastal construction hazards and potential mitigation measures (continued)

Construction operation and causative factor/ hazard	Potential mitigation measures	Action by whom?	Mitigation in place Yes/ No/ NA
	Can/has: • it been ensured that all variation orders, day works or additional works are instructed by an appropriate person and that all are confirmed in writing in due course? • necessary periodic inspections be undertaken to record the progress of the works? • collection of weekly time sheets from all personnel been co-ordinated? Check they are accurate, forwarded to the pay office and that copies are available for use in producing site costings. • the contract file be checked as and when necessary to ensure that it is maintained up to date with any relevant site-orientated correspondence or documentation? • The contract file be checked, if and when appropriate, and arrangements made for a post work survey to be carried out when the works are completed?		

8. Recommendations for future action

Extensive information is given in this document including discussions of ways to improve the current situation. Key recommendations are captured below.

- Contractors should categorise their accident statistics to capture this market sector. It is only by really understanding the nature of the hazards in this sector that a full understanding of the risks and optimum management actions can be established.
- Clients, designers and contractors should formalise competence in the coastal engineering sector using focused training courses and reference material such as this publication.
- Designers should address project health and safety issues at conception.
- Designers should engage contractors into discussions on health and safety.
- The Health and Safety Executive, the Marine Accident Investigation Branch and the Maritime and Coastguard Agency should help emphasise Health and Safety requirements/issues during their dealings with the maritime engineering industry.
- A forum should be set up to enable stakeholders to discuss and resolve health and safety issues.

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Appendices

Appendix 1. Abbreviations

(Commonly used in connection with Health and Safety in coastal and maritime engineering.)

ACOP	Approved Code of Practice
ADC	Association of Diving Contractors
ALARP	As Low As Reasonably Practical
AUWED	Amended directive to the Use of Work Equipment Directive
CDM	Construction (Design and Management) Regulations 1994
CECA	Civil Engineering Contractors Association
CERC	Cambridge Environmental Research Consultants
CHSWR	Construction (Health, Safety and Welfare) Regulations 1996
CIP	Construction Industry Publication
CIRIA	Construction Industry Research and Information Association
CITB	Construction Industry Training Board
CMS	Competency Management System
COLREG	Preventing Collisions at Sea
COPA	Control of Pollution Act
COSHH	Control of Substances Hazardous to Health
CPN	Construction Productivity Network
CPT	Cone Penetration Test
CSCS	Construction Skills Certificate Scheme
CUR	Centre for Civil Engineering Research and Codes
Defra	Department of Environment, Food and Rural Affairs
DETR	Department of the Environment, Transport and the Regions (Now DTI, Defra and DfT)
DfT	Department for Transport
DPP	Diving Project Plan
DSC	Digital Selective Calling
DTI	Department of Trade and Industry
DWR	Diving at Work Regulations 1997
EA	Environment Agency
EPIRB	Emergency Equipment Indicating Radio Beacon
FEPA	Food Environment Protection Act
GMDSS	Global Maritime Distress and Safety System
GPS	Global Positioning System
H&S	Health and Safety
HMRI	Her Majesty's Rail Inspectorate
HMSO	Her Majesty's Stationery Office
HSC	Health and Safety Commission
HSE	Health and Safety Executive
HSWA	Health and Safety at Work etc. Act 1974
ICE	Institution of Civil Engineers
ILO147	Minimum Standards for Seafarers

IMCA	International Marine Contractors Association
IMO	International Maritime Organisation
ISM	Institute of Safety and Health Management
ITC69	Tonnage Measurement
KPI	Key performance indicators
LOLER	Lifting Operations and Lifting Equipment Regulations 1998
MAIB	Marine Accident Investigation Branch
MARPOL	Prevention of Pollution from Ships
MCA	Maritime and Coastguard Agency
MHSWR	Management of Health and Safety at Work Regulations 1999
MHWN	Mean High Water Neaps
MHWS	Mean High Water Springs
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Springs
MSL	Mean Sea Level
MSN	Merchant Shipping Notice
MWL	Mean Water Level
NCE	New Civil Engineer (publication of ICE)
NDP	Nominated Departure Point
NRA	National Rivers Authority
NVQ	National Vocational Qualification
OPITO	National Training Organisation for Oil and Gas Extraction
OSD	Offshore Safety Division
PIANC	International Navigation Association
POL	Proudman Oceanographic Laboratory
PPE	Personal Protective Equipment
PUWER	Provision and Use of Work Equipment Regulations
RHIB	Rigid Hull Inflatable Boat
RIDDOR	Reporting of Injuries, Diseases and Dangerous Occurrences Regulations
RNLI	Royal National Lifeboat Institution
ROV	Remotely Operated Vehicle
SART	Search and Rescue Radar Transponder
SBV	Standby Vessels
SCUBA	Self Contained Underwater Breathing Apparatus
SD	Surface Decompression
SEPA	Scottish Environmental Protection Authority
SHA	Statutory Harbour Authority
SHERMS	Safety, Health and Environmental Risk Management System
SMP	Safety Management Procedure
SOLAS	Safety of Life at Sea
SSDE	Surface Supplied Diving Equipment
STCW	Standards of Training Certification and Watchkeeping
SWL	Safe Working Load
UKOOA	UK Offshore Oil Association
VHF	Very High Frequency

Appendix 2. Key current regulations

Regulation	Comment on particular issues in the coastal environment
• Approved requirements for the Transportable Pressure Receptacles 1998	For diving equipment
• Carriage of Dangerous Goods	Of particular relevance to port operations especially oil and gas terminals
• Coast Protection Act 1949	
• Construction (Design and Management) Regulations 1994	Competency should include that relating to coastal and maritime construction and not just land based
• Construction (Health, Safety and Welfare) Regulations 1996	As above plus welfare provisions should be provided
• Continental Shelf Act 1989	
• Diving at Work Regulations 1997	Inshore waters (see text)
• Docks Regulations (Northern Ireland) 1989	
• Docks Regulations 1988	See main text
• Health and Safety (First Aid) Regulations 1981	
• Health and Safety at Work etc. Act 1974	Applicable to Great Britain
• Health and Safety at Work etc. (Application Outside Great Britain) Order 2001 (SI 2001/2127)	Applicable to outside Great Britain
• Lifting Operations and Lifting Equipment Regulations 1998	See main text
• Management of Health and Safety at Work Regulations 1999	See main text
• Manual Handling Regulations 1992	Particular hazards relate to placing of rock armour
• Merchant Shipping (Guarding of Machinery and Safety of Electrical Equipment) Regulations1988	
• Merchant shipping (Hatches and Lifting Plant) Regulations 1988	
• Merchant Shipping (Port State Control) Regulations 1995 (SI 1995/3128)	

Regulation	Comment on particular issues in the coastal environment
• Merchant Shipping (Prevention of Oil Pollution) Regulations 1996 (SI 1996/2154) • Merchant Shipping Act 1995 • Merchant Shipping and Fishing Vessels (Health and Safety at Work) (Amendment) Regulations 2001 (SI 2001/54) • Merchant Shipping and Maritime Security Act 1997 • Minerals Workings (Offshore Installations) Act 1971 • Noise at Work Regulations	
• Offshore Safety Act 1992	Relevant to offshore installations
• Personal Protective Equipment at Work Regulations 1992	
• Petroleum Act 1987	Controls hazardous substances in port areas
• Provision and Use of Work Equipment Regulations 1998 • Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995	

Appendix 3.
Key documents and guidelines

Document	Comment on particular issues in the coastal environment
• Allsop, N.W.H., Bruce, T., Pearson, J., Alderson, J. and Pullen, T. (2003). Violent wave overtopping at the coast, when are we safe? *Proc. Coastal Management 2003*, ICE, Thomas Telford, London, pp. 54-69.	General description of overtopping hazards
• Besley P. (1999). *Overtopping of seawalls – design and assessment manual.* R&D Technical Report W 178, ISBN 1 85705 069 X, Environment Agency, Bristol.	The overtopping manual. Technical guidance on overtopping design issues
• British Standards (2004). BS 6349	For design but provides information on maritime structures and terms, etc.
• British Standards, (Various dates). Lifejackets and harnesses: • BS 1397 Specifications for industrial safety belts, harnesses and safety lanyards • BS 3913 Industrial safety nets • BS 4211 Steel ladders for permanent access • BS 8093 Code of practice for the use of safety nets, containment nets and sheets on constructional works • BS EN 361 Full body harness • BS EN 393 Life jackets and personal buoyancy aids: Life jackets: 50N • BS EN 394 Life jackets and personal buoyancy aids: Additional items • BS EN 395 Life jackets and personal buoyancy aids: Life jackets: 100N • BS EN 396 Life jackets and personal buoyancy aids: Life jackets: 150N • BS EN 399 Life jackets and personal buoyancy aids: Life jackets: 275N	Specific requirements on protective measures

Document	Comment on particular issues in the coastal environment
• Bruce, T., Allsop, N.W.H. and Pearson, J. (2002). Hazards at coast and harbour seawalls – velocities and trajectories of violent overtopping jets. *Proc. 28th Int. Conf. Coastal Engg.* (ASCE), Cardiff.	Design guidance/hazards
• CIP (2004). Construction health and safety manual. Construction Industry Publication.	Excellent detailed guidance on construction health and safety issues. Includes a section on working over water (including coastal construction) generated from this publication
• CIRIA (1991). *Manual on the use of rock in coastal and shoreline engineering.* CIRIA special publication 83/CUR Report 154.	Design guidance (being updated)
• CIRIA (1996). Sea Outfalls – Inspection and Diver Safety. CIRIA Report 158.	Good guide but a little dated now
• CIRIA (1999). Safety in Ports, ship to shore linkspans and walkways, CIRIA, C518.	Good guidance on safety legislation, design and procurement relating to linkspans and walkways
• CIRIA (2002). Site safety guide.	Good general guide but no specific guidance on coastal construction
• CIRIA (2003). Coastal and Marine Environmental Site Guide.	Good guide to specific environmental issues in coastal construction
• CIRIA (2004). CDM Regulations – work sector guidance for designers. C604, 2nd edn., CIRIA.	For use by the designer only. Includes a section on working over water generated from this publication
• CITB GE700 (2004). Construction site safety – Health, Safety and Environmental Information 2004, CITB, June.	Very useful but no specific guidance on coastal construction issues
• Franco, L., de Gerloni, M. and van der Meer, J.W. (1994). Wave overtopping on vertical and composite breakwaters. *Proc. 24th Int. Conf. Coastal Engg.*, Kobe, ASCE.	Design guidance on defining hazards/tolerable limits

Document	Comment on particular issues in the coastal environment
• HSE (1999). Agricultural Information Sheet No 1 Personal Buoyancy Equipment on inland and inshore waters, 1999.	Advice on buoyancy equipment
• HSE (1997). Port Industry Guidance on the Diving at Work Regulations, 1997.	
• HSE (2001a). Rough weather rescue, HSE, Offshore Technology Report, 2001/089.	The report documents research to review the types of equipment and techniques currently in use for rescue of persons from the water around offshore platforms in rough weather, and to determine the limitations of that equipment due to extreme environmental conditions
• HSE (1997a). Commercial Diving Projects Inland/Inshore. Approved Code of Practice, HSE, 1997.	Essential guidance for inland/inshore diving
• HSE (1997b). Commercial Diving Projects Offshore. Approved Code of Practice, HSE, 1997.	Essential guidance for offshore diving
• HSE (1998). Are you involved in a Diving Project? HSE. INDG266, 1998.	Useful first guide to the requirements
• HSE (2001a). Managing Health and Safety in Construction (HSG 224, ISBN 0-7176-2139-1), 2001.	No specific references to coastal engineering
• HSE (2002). Managing health and safety in dockwork. (HSG177), 2002.	Aimed at all those who manage or who are involved in dock operations or all those who supply labour for dockwork. Contains sources of further information
• HSE (2002). Revitalising Health and Safety in Construction, HSE, 2002.	
• IMCA (1999). Record of competence	Record forms
• IMCA (2000). Guidance on assessor training	Guidance for assessors
• IMCA (2001). Basic safety training for non-marine personnel on specialist vessels	

Document	Comment on particular issues in the coastal environment
• IMCA (2002). Marine inspection checklist for small work boats	
• IMCA (2003). Competence assurance and assessment – guidance document and competence tables: All divisions	Guidance document on achieving competency in marine construction
• IMCA (2003). Competence assurance and assessment – guidance document and competence tables: Marine division.	Guidance document on achieving competency in marine construction (Marine)
• IMCA (2003). Competence assurance and assessment – guidance document and competence tables: Diving division.	Guidance document on achieving competency in marine construction (Diving)
• IMCA (2003). Competence assurance and assessment – guidance document and competence tables: Offshore survey division.	Guidance document on achieving competency in marine construction (Offshore surveys)
• Owen, M.W. (1980). Design of seawalls allowing for overtopping. HR Wallingford, Report EX924.	Design guidance (General purpose reference on overtopping)
• Simm, J.D. and Cruickshank, I.C. (1998). Construction risk in coastal engineering.	Good general guide on risk issues related to coastal construction. It focuses on contractor financial and logistical risk issues as opposed to health and safety

Appendix 4.
Useful contact details and web sites

Department for Transport

- Logistics and Maritime Transport Directorate is based at the DfT office at Ashdown House, 123 Victoria Street, London, SW1E 6DE.
- Maritime and Coastguard Agency, Tutt Head, Mumbles, Swansea, W. Glamorgan, SA3 4HW.
- Marine Accident Investigation Branch has its headquarters at 1st Floor, Carlton House, Carlton Place, Southampton SO15 2DZ.

Health and Safety Executive

- HSE has two headquarters. One is at Rose Court, 2 Southwark Bridge, London, SE1 9HS, the other is in Magdalen House, Trinity Road, Bootle, Merseyside.
- HSE's Offshore Safety Division (OSD) has headquarters in Aberdeen, Norwich and Liverpool.

Other

- Institution of Civil Engineers, Maritime Board, 1 Great George Street, London.
- Association of Diving Contractors (ADC), 83 Boundary Lane, St Leonards, Ringwood, Hampshire, BH24 2SF.
- International Marine Contractors Association (IMCA), Carlyle House, 235 Vauxhall Bridge Road, London SW1V 1EJ.

Web Sites

www.hmso.gov.uk	Access to Acts
www.ecmwf.int	European wave conditions
www.cefas.co.uk	Real-time wave heights (Note these are offshore and will be different to the nearshore wave conditions)
www.rnli.org.uk	Royal National Lifeboat Institution
www.mcga.gov.uk	Maritime and Coastguard Agency
www.cscs.uk.com	Competence training
www.hse.gov.uk	Health and Safety Executive
www.hse.gov.uk/pubns/estuary.htm	Advice on H&S when working in estuaries
www.met-office.gov.uk	UK Meteorological Office
www.ice.org.uk	Institution of Civil Engineers
www.adc-uk.info	Association of Diving Contractors
www.imca-int.com	International Marine Contractors Association
www.environment-agency.gov.uk	Environment Agency
www.sepa.org.uk	Scottish Environmental Protection Agency

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