

BRITISH STANDARD

Maritime structures –

Part 8: Code of practice for the design of Ro-Ro ramps, linkspans and walkways

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This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 72, an inside back cover and a back cover.

Foreword

Publishing information

This part of BS 6349 is published by BSI and came into effect on 30 April 2007. It was prepared by Subcommittee B/525/11, *Maritime structures*, under the authority of Technical Committee B/525, *Building and civil engineering structures*. A list of organizations represented on this committee can be obtained on request to its secretary.

BSI Committee B/525 takes collective responsibility for the preparation of this part of BS 6349. The Committee wishes to acknowledge the personal contribution of Paul Lacey C Eng, FICE, FI Struct E., FIHT, FRSA, Chairman of B/525 from 1986 to 2005.

Relationship with other publications

This is a new part of the BS 6349 series. The other parts in the series are:

- Part 1: *Code of practice for general criteria*;
- Part 2: *Design of quay walls, jetties and dolphins*;
- Part 3: *Design of dry docks, locks, slipways and shipbuilding berths, shiplifts and dock and lock gates*;
- Part 4: *Code of practice for design of fendering and mooring systems*;
- Part 5: *Code of practice for dredging and land reclamation*;
- Part 6: *Design of inshore moorings and floating structures*;
- Part 7: *Guide to the design and construction of breakwaters*.

This part of BS 6349 should be read in conjunction with BS 5400. When using BS 5400 the word “bridge” should generally be read as “structure”. The various loads and load factors to be used when considering the ultimate limit state and serviceability limit state should be as given in Clause 8 of this part of BS 6349.

An alternative approach to the design of Ro-Ro ramps, linkspans and walkways is given in the Lloyd’s Register *Rules and regulations for the classification of linkspans* (hereinafter referred to as *Lloyd’s Rules*). BS 5400 is an ultimate limit state code and *Lloyd’s Rules* is a working stress design code, and the treatment of load factors and vehicle impact factors is very different between the two codes. It is permissible to use both *Lloyd’s Rules* and BS 5400 in the design of the same structure, provided that the designer takes the full implications of each code into account.

Both *Lloyd’s Rules* and BS 5400 can be used as the basis of structural design of linkspans, but only *Lloyd’s Rules* gives guidance on the structural design of floating structures.

CIRIA report C518 [1] gives an extensive discussion on the coverage and limitations of *Lloyd’s Rules*.

Information about this document

Assessed capability. Users of this part of BS 6349 are advised to consider the desirability of quality system assessment and registration against the appropriate standard in the BS EN ISO 9000 series by an accredited third-party certification body.

Use of this document

As a code of practice, this part of BS 6349 takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this part of BS 6349 is expected to be able to justify any course of action that deviates from its recommendations.

It has been assumed in the preparation of this part of BS 6349 that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions in this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

Attention is drawn to the regulations listed in the Note to **4.4**.

0 Introduction

0.1 Design traditions

The design of Ro-Ro linkspans and walkways has historically been carried out by two types of designers: highway bridge designers and naval architects. These two types of designers have historically used different types of design rules. Bridge designers have referred to bridge design codes, such as BS 5400. Naval architects have referred to *Lloyd's Rules*.

This part of BS 6349 includes recommendations for a number of issues that are not covered by either BS 5400 or *Lloyd's Rules*. In particular:

- a) BS 5400 does not cover:
 - pontoons or floating structures;
 - overall hydrostatic stability;
 - wave, current and ship-induced loadings;
 - aluminium structures;
- b) *Lloyd's Rules* does not cover:
 - specific rules for upstanding plate girders with U-frame action;
 - specific rules for dealing clearly with members in which lateral torsional buckling is likely;
 - overall hydrostatic stability;
 - concrete structures.

In addition to these differences, BS 5400 assumes a design life or return period of 120 years, whereas this part of BS 6349 deals with structures that have an anticipated design life of 30 years.

0.2 Limit states

Ultimate Limit State (ULS) and Serviceability Limit State (SLS) are terms defined by BS 5400 and are not used in *Lloyd's Rules*. If it is necessary to use these terms in conjunction with *Lloyd's Rules*, the following interpretations can be made:

- the ULS is the load or effect combination causing the largest stresses for comparison with the allowable stresses permitted by the *Rules*;
- the SLS is the load or effect combination causing the largest deflections or movements for comparison with the deflections or movements permitted by the *Rules*.

The Ultimate Limit State (ULS) usually covers:

- overall failure by rupture or yielding;
- overall instability by overturning or sinking;
- collapse, loss or removal of support to elements, including linkspans, ship ramps, adjustable flaps, flaps, fingers and bearings;
- failure or malfunction of operating machinery;
- failure by fatigue.

The Serviceability Limit State (SLS) usually covers:

- excessive deflection, slip within components, cracking of concrete, yielding, damage to finishes or protective coatings, all as defined by the various parts of BS 5400;
- grounding of vehicles causing damage or gross discomfort to users;
- excessive gaps, gradients, obstructions and other impediments to the safety of users of the facility;
- loss of reliability or performance of operating machinery due to excessive wear, impact or other effect;
- traps/pinch points.

0.3 Design conditions

0.3.1 Operating condition

This is when traffic is permitted on the facility and when traffic might travel between successive surfaces over joints where relative articulation or movement can occur. The maximum range of water levels, sea state and wind effects appropriate to the operating condition of the facility will not necessarily encompass the maximum movement of loads for which the facility is to be designed. At both ultimate and serviceability limit state all traffic and pedestrian areas need to be loaded such as to cause the maximum detrimental effect.

Additional SLS checks for clearances, movements, etc., need to be made with the associated live loading as appropriate. This is particularly the case with pontoon-supported linkspans because the linkspan's freeboard could vary as traffic traverses the pontoon or floating body.

0.3.2 Extreme tidal condition

This is when the facility is subjected to loads and/or movements arising from the most severe tidal and sea state conditions expected during its design life. Depending on operational requirements, traffic and pedestrian loading might be excluded in these circumstances, except for emergency vehicle loading. The risk assessment in 4.2 is expected to identify whether the circumstances are such that only the ultimate limit state need be considered.

0.3.3 Methods of adjustment

In Method I, the linkspan is supported by a system distinct from the lifting system. This support system ensures that the mass of the ramp and live loads are fully supported during boarding operations; and maintenance vehicles are fully supported during lifting system repair and replacement periods. Therefore the lifting system only supports permanent and environmental loads.

In Method II, the lifting system supports the linkspan during boarding operations whether being adjusted or not.

The systems of support include a floating pontoon or semi-submersible buoyant tank as well as mechanical lifting systems.

0.3.4 Prevention of collapse

The ramp supporting system needs to be designed to prevent sudden or catastrophic failure of the ramp, taking into account both the ultimate limit state and the serviceability state.

The risk assessment undertaken for the linkspan is expected to identify the conditions and loadings to which the linkspan and any machinery is likely to be subjected throughout its life.

Appropriate measures need to be taken to ensure that these risks are mitigated. A linkspan with a suspension system requires particular consideration (see 8.8).

0.3.5 Maintenance condition

This occurs during the time when the facility is not in use by vehicles or pedestrians, and is relevant to the design of spragging or parking facilities for the facility whilst being maintained, or stored out of use. Allowance needs to be made for specified maintenance vehicles and materials. The maximum range of water levels and sea state is appropriate to the extreme tidal and sea state condition.

0.3.6 Design criteria

The criteria for the operational conditions need to be agreed with the end user.

1 Scope

This part of BS 6349 gives recommendations for the design of roll-on/roll-off (Ro-Ro) ramps, linkspans and walkways, used for the transfer of passengers and vehicles between shore and ship.

It applies to the structural elements only and does not cover the design of any operational equipment, traffic control, mechanical or electrical equipment, heating, lighting, life saving or rescue equipment other than as the structures forming a facility need to incorporate and/or support any of these features. Most geometrical aspects of fixed shore ramps are covered in this part of BS 6349, but recommendations for all other aspects are given in BS 6349-2.

This part of BS 6349 does not apply to Ro-Ro facilities used by rail vehicles in that it does not give recommendations for railway loading and associated ramp gradients. However, many of its recommendations are applicable to rail Ro-Ro facilities and can be used in the absence of other guidance.

NOTE This part of BS 6349 is generally intended to cover facilities constructed in the British Isles. Although the majority of the contents are directly applicable elsewhere, local conditions might necessitate modifications, e.g. environmental effects and traffic loading.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Standards publications

BS 5400 (all parts), *Steel, concrete and composite bridges*

BS 6349-1:2000, *Maritime structures – Part 1: Code of practice for general criteria*

BS 6349-2:1988, *Maritime structures – Part 2: Design of quay walls, jetties and dolphins*

BS 6349-4:1994, *Maritime structures – Part 4: Design of fendering and mooring systems*

BS 6349-6:1989, *Maritime structures – Part 6: Design of inshore moorings and floating structures*

BS 6399-2:1997, *Loading for buildings – Part 2: Code of practice for wind loads*

BS 6399-3, *Loading for buildings – Part 3: Code of practice for imposed roof loads*

BS 6779-1:1998, *Highway parapets for bridges and other structures – Part 1: Specification for vehicle containment parapets of metal construction*

BS 7818:1995, *Specification for pedestrian restraint systems in metal*

BS 8004, *Code of practice for foundations*

BS EN 1997, *Eurocode 7 – Geotechnical design*

BS EN ISO 14122 (all parts), *Safety of machinery – Permanent means of access to machinery*

ISO 7061, *Shipbuilding – Aluminium shore gangways for seagoing vessels*

Other publications

LLOYD'S REGISTER. *Rules and regulations for the classification of linkspans*. London: Lloyd's Register, 2003.

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this part of BS 6349, the definitions given in BS 6349-1 and the following apply.

3.1.1 abutment

structure onto which the shore bearings of a linkspan, shore ramp or link bridge are seated

NOTE 1 An abutment can provide resistance against anchorage forces. It can be placed at the edge of the quay, jetty approach bridge or on the edge of a reveted reclamation slope.

NOTE 2 An abutment is sometimes referred to as a “bankseat”.

3.1.2 approach ramp

fixed ramp or bridge structure at the shore end of a linkspan to allow access between the linkspan roadway level and the normal quay or paving level

3.1.3 approach span

bridge structure at the shore end of a linkspan, which is normally fixed in place

3.1.4 belting

projecting continuous-protective strip along the side of a Ro-Ro ship or ferry

NOTE Belting is usually at the level of the main vehicle deck, although at the bow or stern it might be at more than one level.

3.1.5 berthing line

front face of fenders alongside a quay or other type of berth

3.1.6 blunt-ended ramp

ramp that is not equipped with flaps

3.1.7 boarding pod

platform that is mechanically or buoyantly lifted, which allows pedestrian access to a ship via a brow or gangway and is connected to the hinged link

3.1.8 brow

bridge that is hinged onto a boarding pod or telescopic end and either rests on the coaming or other means of support at the ship's passenger access door or opening, or is supported by cantilever action from the boarding pod or the telescopic end

3.1.9 coaming

upstand from the deck plate at the passenger entrance in the hull of a ship or raised edge along an open deck on a ship

3.1.10 designer

person or organization that carries out the design of the structures which form a facility or part of a facility

3.1.11 design water level variation

variation of the water level that is used to establish gradients and dimensions for a facility

- 3.1.12 drawbridge**
liftable bridge section hinged at the shore end and supported by a mechanical strut or tie or rope system at the seaward end
- 3.1.13 extreme water level**
highest or lowest water level that is predicted to exist at a facility
- 3.1.14 facility**
part of a port that deals with Ro-Ro ships
- 3.1.15 finger flap**
narrow bridging element generally hinged to the end of a linkspan or ship ramp, which allows for varied amounts of articulation across the road or walkway width
- 3.1.16 fixed shore ramp**
fixed inclined structure between the normal quay level and a level upon which the shore end of a ship ramp can rest
- 3.1.17 fixed walkway**
walkway structure that has no moving parts
- 3.1.18 flap**
extension, normally hinged to a ship or to the shore end of a linkspan, that provides a transition with an adjacent road or walkway where relative articulation or movement could occur
- 3.1.19 gangway**
bridge that is hooked onto the coaming and supported on the telescopic end, boarding pod or drawbridge
- 3.1.20 guide pile**
vertical pile that is used as a guide structure to restrain a pontoon/link bridge or semi-submersible or integral tank type linkspan from floating away, but allows it to move up and down with the rise and fall of the tide
- 3.1.21 hinged link**
bridge between a ship or a boarding pod that is capable of rotating to take up level differences between the terminal building and the ship
NOTE A hinged link always rotates in the vertical plane, but can also rotate in the horizontal plane.
- 3.1.22 hoist tower**
structure mounted on the shore or on a dolphin for supporting the lifting equipment of a mechanically lifted type of linkspan
- 3.1.23 interface**
boundary between a ship ramp, ship vehicle access opening or ship passenger access opening and a linkspan or passenger walkway
- 3.1.24 interface limit line**
seaward end of a ship ramp landing area
- 3.1.25 lifting frame**
fixed or carriage-mounted frame that supports the lifting equipment
- 3.1.26 link bridge**
bridge connecting a pontoon to the shore

3.1.27 linkspan

articulating structure, which can be a floating or a lifted bridge structure, that links a Ro-Ro ship either directly to the shore, to a fixed structure or to a pontoon, or that links a pontoon with the shore

NOTE The term "linkspan" can also refer to facilities comprising a pontoon and link bridge combined.

3.1.28 motorized carriage

rail-mounted or rubber tyre-mounted bogey and carriage system that is motorized

3.1.29 operating water level

high or low water level at which operations are allowed to be carried out, i.e. traffic or passengers can be transferred across a facility

3.1.30 operator

person or organization responsible for operating a facility

3.1.31 passenger walkway

ship-to-shore facility for the transfer of pedestrians, capable of vertical and/or horizontal adjustment at the ship end and incorporating any fixed walkway

3.1.32 pontoon

floating structure of large plan area relative to its draught used as a buoyant support for a link bridge to the shore and sometimes as a manoeuvring area for vehicle movement

NOTE The ship ramp rests on the ship end of the pontoon.

3.1.33 project adviser

person who helps the purchaser to identify the options for procurement and who assists in preparing the project brief

3.1.34 restraint systems**3.1.34.1 pedestrian restraint system**

device to restrain pedestrians from falling off the edge of a structure or part thereof, or to guide pedestrians to keep them from unsafe terminal or vehicle movement activities

NOTE Examples of pedestrian restraint systems include pedestrian parapets, guardrails and handrails.

3.1.34.2 vehicle restraint system

device to keep vehicles in designated traffic lanes, to protect vulnerable features or to prevent vehicles from driving off the edge of a structure.

NOTE 1 Examples of vehicle restraint systems include vehicle parapets and safety barriers.

NOTE 2 Vehicle restraint systems are also known as road restraint systems.

3.1.35 Ro-Ro ramp

fixed ramp or bridging structure that enables vehicles to pass between a Ro-Ro ship's vehicle decks and the shore

NOTE Either the ship ramp lands on the end of the fixed ramp, or the fixed ramp is between the linkspan and the shore. Ro-Ro ramps include approach ramps, approach spans and fixed shore ramps.

- 3.1.36 semi-submersible linkspan**
linkspan that derives its seaward support from a fully submerged underwater tank, usually with narrow legs between tank and bridge deck, but which is additionally supported by the ship or other means during operation
- 3.1.37 service walkway**
designated route for use by service operational personnel only
- 3.1.38 ship ramp**
adjustable structure fitted to a ship that when lowered to and resting on the approach structure, quayside, or linkspan, forms the connecting roadway between the ship and approach structure, quayside, or linkspan
- 3.1.39 slave carriage**
rail-mounted or rubber tyre-mounted carriage that is not motorized but moves when pulled by a motorized carriage
- 3.1.40 slave pod**
platform supported on a slave carriage
- 3.1.41 sprag**
short pin or bar used to support a lifted platform or structure at a particular height on a spragging frame or beam so that the lifting equipment can be taken out of operation
- 3.1.42 systems engineer**
person appointed by a contractor or supplier to carry out the co-ordination of the electrical and mechanical aspects of linkspan or walkway works, including design, manufacture, commissioning and handover
- 3.1.43 telescopic end**
section at the end of a hinged link or drawbridge that is co-linear with the hinged link or drawbridge and capable of being extended telescopically
- 3.1.44 traversing drawbridge**
drawbridge that is able to traverse laterally in a boarding pod and hinge vertically
- 3.1.45 threshold height**
height of a vehicle or passenger deck above the water level at the vessel's door opening
- 3.1.46 well deck**
platform on the ship end of a linkspan or pontoon, set at a lower level than the roadway, onto which a blunt ended ramp can rest
- 3.1.47 whole life cost**
cost of construction, maintenance and removal of a structure

3.2 Symbols

For the purposes of this part of BS 6349, the following symbols apply.

A_2	solid area in normal projected elevation, viewed longitudinally, of a structure, in square metres (m ²)
$a_1, a_2, \text{ etc.}$	surface areas of individual windward face, leeward face, roof and floor, in square metres (m ²)
C_D	drag coefficient relating to frontal area
C_F	frictional drag coefficient depending on the surface roughness
c	speed of wave propagation in a material, in metres per second (m/s)
E	Young's modulus of a material, in newtons per square metre (N/m ²)
$H_{\max}$	maximum design wave height, in metres (m)
j	maximum ordinate on influence line, in newtons (N)
L_b	base length of influence line, in metres (m)
N	whole number of lanes greater than 3
n	number of effective longitudinal members in a parapet
P_{LL}	total longitudinal wind load from live load, in newtons per square metre (N/m ²)
P_{LS}	total longitudinal wind load from structure, in newtons per square metre (N/m ²)
P_T	transverse wind force, in newtons per square metre (N/m ²)
q	dynamic pressure head as defined in BS 5400-2:2006, 5.3.3 , in newtons per square metre (N/m ²)
T	magnitude of proof test load, in newtons (N)
V	velocity of impact, in metres per second (m/s)
V_b	basic hourly mean wind speed, in metres per second (m/s)
V_d	maximum wind gust speed, in metres per second (m/s)
V_s	site hourly mean wind speed, in metres per second (m/s)
W	applied design load, in tonnes (t)
γ_L	partial load factor
γ_3	factor that takes account of the inaccurate assessment of the effects of loading, unforeseen stress distribution in the structure, and variations in dimensional accuracy achieved in construction.
γ_m	reduction factor specified in the relevant parts of BS 5400
ρ	density of a material, in kilograms per cubic metre (kg/m ³)

4 General recommendations

4.1 Planning

The purpose of a Ro-Ro ramp, linkspan or walkway is to enable the safe transfer of traffic between the shore and the designated ships, taking account of relevant environmental considerations, for the design working life of a facility. When planning a Ro-Ro facility, account should be taken of current traffic requirements, the number and type of ships, and also the possibility of future developments which could economically be met by modification or relocation of part of all of the facility. Fixed ramps should be designed in accordance with BS 6349-2:1988, Section 8.

Assessed capability. *Users of this British Standard are advised to consider the desirability of quality system assessment and registration against the appropriate standard in the BS EN ISO 9000 series by an accredited third-party certification body.*

NOTE *The Introduction gives information on the historic background to the methods recommended in this part of BS 6349 and the design philosophy behind the recommendations.*

4.2 Risk assessment

It is essential to undertake a fundamental risk assessment prior to establishing the exact type of facility to be provided. This should take into account the hazards, risks and consequences of all credible uses and failure modes of the facility. The form of the facility should be selected such that the structural integrity and control systems are not compromised.

Further risk assessments should be carried out, as part of the design process, for each element of the facility.

The effects of extreme environmental conditions should be included in the assessment.

4.3 Operation and maintenance manual

Each facility needs to have an operation and maintenance manual, which is usually written by the supplier of the facility. The author of the manual is expected to be experienced in the writing of such manuals for machinery but is often not in possession of the overall design specification for the facility. It is the designer's responsibility to supply the author of the manual with all information that the author needs concerning the overall capability and limitations of the facility.

4.4 Design parameters

NOTE *Attention is drawn to the following regulations:*

- *Supply of Machinery (Safety) Regulations 1992 [2];*
- *Management of Health and Safety at Work Regulations 1992 [3];*
- *Lifting Operations and Lifting Equipment Regulations 1998 [4];*
- *Provision and Use of Work Equipment Regulations 1998 [5];*
- *Construction (Design and Management) Regulations 1994 [6].*

4.4.1 General

Design parameters that are likely to affect the overall concept of the facility should be established to form a project brief.

4.4.2 Layout of facility

The overall layout of the facility should be established early on in the procurement process and before detailed design of the facility is commenced. It should include the required numbers and relative location of linkspans and walkways, taking account of the anticipated traffic flows, type of ships, and location of loading and discharge points onto the ships.

In the design of the facility, account should be taken of the need to provide an adequate means of escape in the event of emergency, including fire escape arrangements.

4.4.3 Ships

The type and characteristics of ships that are expected to use the facility should be determined. Information that should be obtained for each ship includes:

- draught;
- beam;
- length;
- displacement;
- threshold height dimensions;
- dimensions and positions of openings and deck accesses;
- height of ship belting;
- propulsion system forces;
- ship ramp details (e.g. dimensions, flaps, permitted gradients and mass);
- variation of ship trim and roll during the unloading and loading cycle;
- passenger and ship access door positions;
- swept geometry of bow visors or clamshell doors;
- the geometry of bulbous bows;
- whether multi-deck access is required.

Depending upon the type of ship, it should be determined whether loading and discharge is at bow, stern, side or any combination of these.

Where the Ro-Ro ship does not have a ship ramp, full details of the ship openings should be obtained, including the vertical profile within the ship, so that the requirements for any finger flaps forming part of the facility can be determined. Other details of ships should be obtained that might affect the facility, such as protrusions below water line and location of propellers.

4.4.4 Usage and design life

The frequency of ship berthing and required speed of turn-around should be established, together with any demands for continuity of use and seasonal use. The intended maintenance regime, including availability of competent personnel, should be investigated and agreed with the maintenance organization. The intended design life should be determined. A design life for structural elements within the facility is typically taken as 30 years for the purposes of verifying fatigue endurance.

4.4.5 Method of ship control

The method of control of ship movements, including berthing and mooring procedures, should be established for all ships that might use or could affect the facility. This can affect a decision as to whether the facility is required to perform any function in the berthing and mooring of ships. Wherever practicable the arrangements for berthing and mooring of ships should use independent elements such as berthing fenders or mooring dolphins that do not involve the transfer of loads through linkspans or walkways. Fixed ramps should be designed in accordance with BS 6349-2:1988, Section 8 and design criteria should be determined in accordance with BS 6349-4.

The facility should be designed to take into account the possibility of accidental or residual impact and to minimize any adverse effects from such an impact.

4.4.6 Degree of automation in operation of facility

The degree of automation of the linkspan or passenger walkway should be determined taking account of the envisaged usage (see 4.4.4). This can affect the method of height or other adjustment to be used and the form of traffic control, e.g. whether vehicles are likely to be present on the facility during adjustment.

4.4.7 Adjustment of facility

Where the design water level variation is too great for a fixed shore ramp used in conjunction with the ramp of a ship (normally a maximum of 1.5 m), a device for height adjustment of the facility at the ship end should be provided. The amount of height adjustment should be established for each deck level where access is to be provided. In certain cases transverse adjustment might be necessary in order to cater for different locations of ship openings. This applies especially in the case of passenger walkways.

Longitudinal adjustment might also be necessary to cater for different ships, especially where access is required to more than one deck level. The need for longitudinal adjustment, and the required amount thereof should be established and taken into account.

4.4.8 Types of vehicles

The types of vehicles that are likely to use the facility should be established. These might include all or any of the following:

- cars with restricted height (e.g. 1.8 m);
- cars with extra height;
- cars with caravans;
- vans;
- coaches;
- HGVs;
- port vehicles, e.g. tractors, roll-trailers, cranes, fork-lift trucks;
- military vehicles, e.g. tanks;
- vehicles with abnormal mass;
- vehicles with abnormal height, width or length;
- vehicles required for the maintenance of the facility.

The numbers of each vehicle type for each ship berthing should be estimated, taking account of the type of ships (see **4.4.3**) and the envisaged usage (see **4.4.4**).

4.4.9 Passenger traffic

The number of passengers who are likely to be using a passenger walkway at a given time should be determined, together with the method by which passengers will be transferred from the terminal building onto the ship, as this will affect the extent and widths of walkways. Where there is to be specific provision for disabled access, allowance might have to be made for more gradual gradients and extra landings. Details of typical gradients are given in **6.3.3**.

NOTE Attention is drawn to the Disability Discrimination Act 1995 [7].

4.4.10 Parking of vehicles or storage

Any requirement to park vehicles or store cargo or materials on the facility during any of the design conditions given by **0.3** should be identified.

4.4.11 Services

The requirements for services on the facility, e.g. water, fuel, sewage, electrical supply, telecommunications, stores, refuse/waste disposal, baggage facilities, etc., should be established and quantified as these can affect the overall dimensions of the facility and loadings carried.

4.4.12 Operational equipment

The required forms of operational equipment should be determined, including:

- a) method of sensing for automatic operations;
- b) degree of redundancy in controls;
- c) extent and forms of traffic control to regulate the use of traffic on the facility.

4.4.13 Water levels

Water levels at the location of the facility should be determined for at least:

- highest recorded tide (HRT);
- mean high water springs (MHWS);
- mean low water springs (MLWS);
- highest astronomical tide (HAT);
- lowest astronomical tide (LAT);
- lowest recorded tide (LRT);
- highest impounded level for an enclosed basin (HIL);
- lowest impounded level for an enclosed basin (LIL).

The design water level variation should be based on the MHWS and MLWS, or HIL and LIL for an enclosed basin, unless otherwise required for the operation of the facility.

The operating water level should be agreed with the operator of the facility.

The facility should also be designed for an extreme condition based on the HAT and LAT plus an allowance to cover for atmospheric pressure and storm surge due to wind (see BS 6349-1). Alternatively, if reliable values of HRT and LRT are available, these can be used instead.

Any predicted long-term or short-term rise or fall in general water level should also be taken into account for both the design and the extreme conditions.

4.4.14 Wave data

Wave data should be established for the location of the facility; if necessary hydraulic modelling should be carried out. Guidance is given in BS 6349-1.

4.4.15 Effect of passing ships

The effect of wash and other displacement effects on the facility and the berthed ship should be taken into account in the design of the facility.

4.5 Environmental conditions

4.5.1 Environmental impact

The potential impact of the construction, operation, maintenance and decommissioning of the facility upon the marine and terrestrial environment should be taken into account (see BS 6349-1:2000, **5.2**).

4.5.2 Meteorology and climatology

Meteorological and climatological data should be taken into account (see BS 6349-1:2000, Clause 7). For wind speeds and air temperatures at coastal and inland locations, guidance can be obtained from BS 5400-2, but data should be collected where possible for the location of the facility.

NOTE Attention is drawn to the effects of temperature on the selection of appropriate steel grades (see BS 5400-3 and Lloyd's Rules).

4.5.3 Bathymetry

Bathymetric information should be obtained, including any updating to allow for changes in water depth due to siltation, dredging, etc. (see BS 6349-1).

NOTE Floating or semi-submersible linkspans might need additional depths to those required by the ships.

4.5.4 Geotechnical considerations

Geotechnical studies and site investigations should be undertaken to ascertain whether ground conditions are suitable for support of the facility or whether they might be affected by any earthworks envisaged. This should include any adjacent dredging or reclamation (see BS 6349-5).

4.5.5 Water quality

Information should be obtained where possible to assist with the overall design and operating performance [i.e. corrosion protection, materials selection (including for machinery), cathodic protection, etc.], including:

- a) a water sample to determine at least the following:
 - maximum and minimum water temperatures;
 - PH;
 - conductivity;
 - Langelier Index;
 - sulfate content;
 - chloride content;
- b) a mud sample if appropriate to determine the same parameters as for the water sample;
- c) historical information with regard to suspended solids, sediment transportation rates, water velocities, marine growth, marine fauna, etc.;
- d) any history of microbiological-induced corrosion.

NOTE For information regarding water quality and sediment transport, refer to BS 6349-1:2000, Clause 13 and Clause 14.

Although much of this data is important to allow the robust design of the fixed elements of the structure and to assess the environmental impact of the facility, it is equally important to allow the selection of suitable materials for machinery, such as ballast pumps, anti-fouling screens, pipework and the like. This data will ensure that the whole life cost approach can be readily adopted.

4.6 Load testing

Each linkspan or walkway should be proof tested in its working position by applying appropriate test loads after installation, and following any major repair, renewal or modification. This helps determine the capability of the structure and its support arrangement. Testing should be carried out throughout high and low tide conditions to allow for the dynamic effects of tidal movement.

NOTE Testing has limitations for verifying structural integrity and will not verify fatigue strength.

The magnitude of the proof test load, T , should be based on the applied design load, W , in tonnes (t), of the linkspan, ramp or walkway section derived from the design loads. In the case of linkspans and ramps, the maximum vehicle load or safe working load is as follows:

$$T = 1.25W \text{ where } W \leq 20$$

$$T = W + 5.0 \text{ where } 20 < W \leq 50$$

$$T = 1.1W \text{ where } W > 50$$

The purpose of the load test is to test the lifting machinery and bearing elements and their associated linkages rather than to test the integrity of the structures themselves. Therefore, in most cases, it is sufficient to apply loads that will induce the maximum loads to lifting machinery or bearings only. Loads should also be applied to measure the flotation performance of the facility.

If the facility is identified as being of unusual construction either in whole or in part, consideration should be given to carrying out a load test to determine the integrity of the structure or appropriate part of the structure as well as the machinery.

5 Types of structure

5.1 General

The types and forms of structures making up the facility should take account of the design parameters and environmental conditions given in 4.4 and 4.5.

Whatever type of structure is adopted, the design should take account of the relative movements that are likely to occur between the stationary shore end of the facility and the ship, which will be subjected to vertical, translational and rotational movements. The type of structure is mainly dependent upon the water level variation and upon the range of ship deck heights to be accommodated and the ramp or linkspan gradients to be achieved.

5.2 Ro-Ro linkspans

A variety of structures is possible for Ro-Ro ramps and linkspans. Where the design water level variation is small (typically 1.5 m), fixed shore ramps might be suitable. For larger design water level variations, a combination of fixed approach ramps and linkspans, or only linkspans, is likely to be more appropriate. Generally vehicles are loaded at the bow or stern of ships at lower deck levels, but multi-deck access or access from the quarter or side of the ship is also possible. For all ramps and linkspans, a primary design consideration is the transition areas (between gradients) to avoid grounding of the vehicles.

Generally two elements are provided.

- a) The first is an articulated structure that connects the shore with a point close to the ship, the seaward end of which moves up and down to take account of the range of water levels and/or of different ship deck heights. This structure may consist of:
 - 1) a mechanically lifted linkspan;
 - 2) an integral tank or semi-submersible linkspan; or
 - 3) a link bridge supported by a pontoon.
- b) The second, often shorter, element provides the connection onto the ship and mainly caters for movements of the ship, particularly rolling or pitching. It may be formed by the ship ramp itself that rests on the linkspan, either on the designated ship ramp landing area (see **6.2.3.1**) or within a well deck. Alternatively, where the ship has no ship ramp then fingers are provided as part of the facility and these rest on the ship's deck. This arrangement is commonly used for the upper decks of two deck facilities and should allow for the variations in the relative longitudinal position of the edge of ship upper decks relative to the lower deck.

Typical types of structure for Ro-Ro linkspans for different water level variations and ship ramp heights are given in Figure 1.

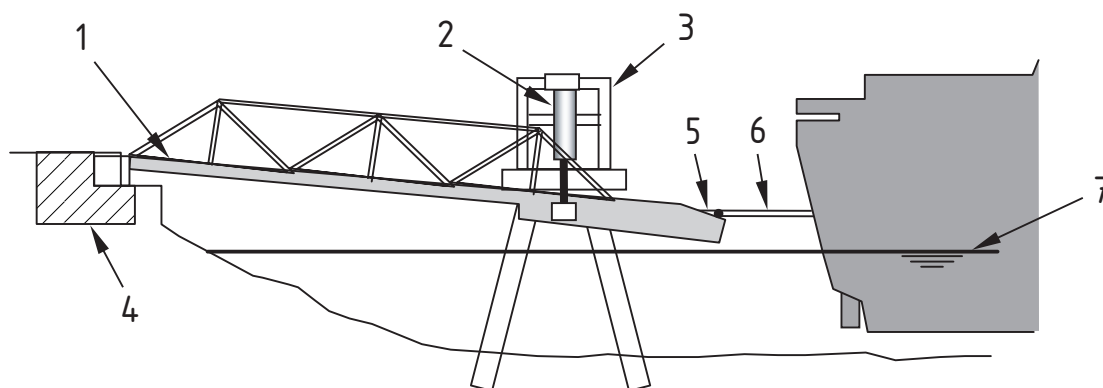
The type of structure might depend upon other factors, such as:

- the wave climate at the site, which could prevent the use of floating facilities;
- a terminal layout that is favourable to the use of a pontoon type linkspan. For instance, the surface area of a pontoon may conveniently be used for turning vehicles prior to entry to the vessel. Equally, if one pontoon can serve two Ro-Ro berths, a pontoon might be favoured;
- a terminal layout that favours the use of a lifted type of linkspan. Lifted linkspans are generally more compact and can be fitted into constrained site areas more easily;
- whether the facility is required to provide multi-deck access.

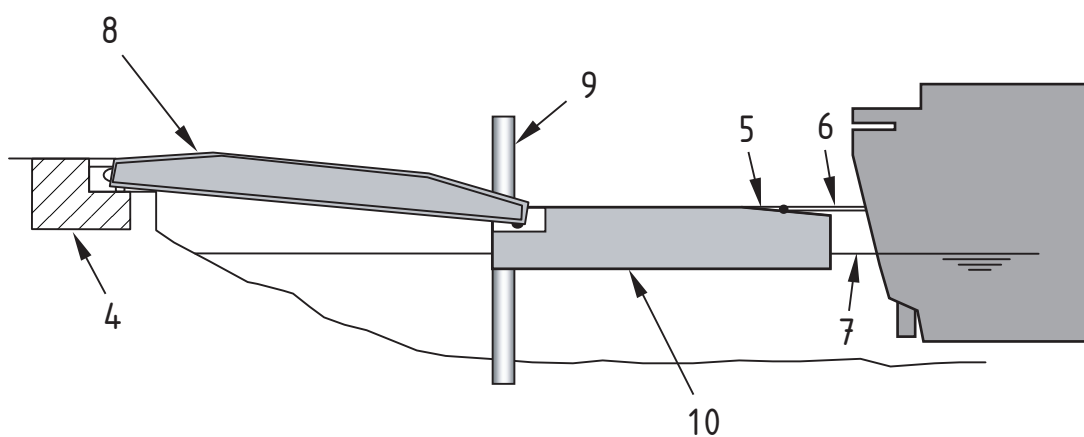
Pontoon structures might be appropriate where relocation of the facility to another site is planned, although the cost of providing new shore abutments and restraints at the new positions for such a facility are significant and should be assessed before concluding that there is a benefit.

Sometimes it is necessary to provide facilities that receive quarter ramps or side-loading ramps from ships.

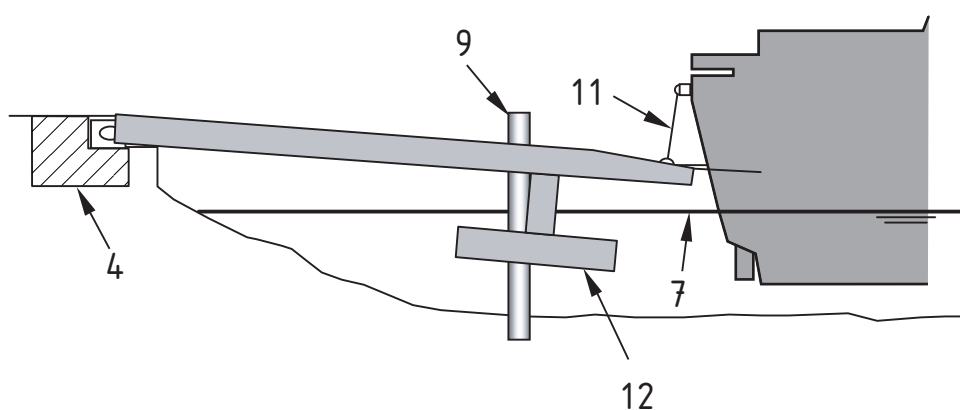
Figure 1 Linkspan types



a) Lifted type



b) Pontoon type



c) Semi-submersible type