

BS 6349-1-2:2016



BSI Standards Publication

Maritime works –

Part 1-2: General – Code of practice
for assessment of actions

Publishing and copyright information

The BSI copyright notice displayed in this document indicates when the document was last issued.

© The British Standards Institution 2016

Published by BSI Standards Limited 2016

ISBN 978 0 580 76229 1

ICS 47.020.01; 93.140

The following BSI references relate to the work on this document:

Committee reference CB/502

Draft for comment 15/30250707 DC

Publication history

First published as BS 6349-1, April 1984

Second edition as BS 6349-1, July 2000

Third (present) edition, June 2016

Amendments issued since publication

Date	Text affected
------	---------------

Contents

Foreword v

Section 1: General 1

- 1 Scope 1
- 2 Normative references 1
- 3 Terms, definitions, symbols and abbreviations 2

Section 2: Combinations of actions and structural design 14

- 4 Limit state design principles 14
 - 4.1 General 14
 - 4.2 Partial factors and combination formulae 14
- 5 Assessment of actions 20
- 6 Design situations and combinations of actions 20
 - 6.1 Design situations 20
 - 6.2 Combinations of actions 24
 - 6.3 Combination factors 25
 - 6.4 Partial factors for actions 25
- 7 Serviceability and other specific limit states 27

Section 3: Wave and water-level conditions 28

- 8 General recommendations on deriving wave and water-level conditions 28
- 9 Climate change 29
 - 9.1 General 29
 - 9.2 Sea-level rise 30
 - 9.3 Increased storminess 30
 - 9.4 Other climate change issues 30
- 10 Wave characteristics 31
 - 10.1 General 31
 - 10.2 Spectral description 31
 - 10.3 Non-linear wave theories 32
 - 10.4 Wave-forms and motions 33
 - 10.5 Nearshore wave processes 34
 - 10.6 Wave breaking 34
 - 10.7 Wave-current interaction 34
- 11 Offshore wave climate 35
 - 11.1 General 35
 - 11.2 Synthetic wave data 36
 - 11.3 Measured wave data 37
 - 11.4 Visually observed wave data 38
 - 11.5 Extrapolation of offshore wave data 38
- 12 Wave transformation 38
 - 12.1 General 38
 - 12.2 Channel effects 40
 - 12.3 Geological and bathymetric features 40
- 13 Long waves 40
 - 13.1 General 40
 - 13.2 Tsunamis 41
- 14 Water levels 42
 - 14.1 General 42
 - 14.2 Storm surge 42

15	Design event probability and extreme values analysis	43
15.1	Design event probability	43
15.2	Independent extremes analysis	44
15.3	Dependent (joint probability) extremes analysis	45
16	Wave structure interaction	45
16.1	Effects of breakwaters and walls on sea states	45
16.2	Harbour response	46
17	Numerical and physical models	46
17.1	Numerical models	46
17.2	Physical models	47
Section 4: Actions, loads and hydraulic responses 49		
18	General recommendations for actions, loads and hydraulic responses	49
18.1	Basic loads	49
18.2	Dynamic response	49
18.3	Spectral loading	50
18.4	Fatigue	50
19	Soil pressures	50
20	Winds	51
21	Snow and ice	51
22	Thermal actions	52
23	Water-level variations	52
24	Current actions	53
24.1	General	53
24.2	Steady drag force	53
24.3	Flow-induced oscillations	54
24.4	Scour due to vessels	54
25	Wave actions	55
25.1	General	55
25.2	Design wave parameters	56
25.3	Fatigue analysis	56
25.4	Wave action on vertical or inclined cylindrical structures	56
25.5	Wave action on sub-sea elements	57
25.6	Wave action on walls and breakwaters	58
25.7	Wave action on horizontal structures	59
25.8	Wave action on crest structures	59
25.9	Wave action on floating bodies	61
26	Hydraulic responses	61
27	Earthquakes	62
27.1	General	62
27.2	Structural performance	62
27.3	Assessing seismic excitations	64
27.4	Seismic design approach and detailing	65
28	Berthing actions	66
28.1	General	66
28.2	Operational factors	66
28.3	Actions from fenders	66
29	Mooring and breasting actions	67
29.1	General	67
29.2	Operational factors	67
29.3	Evaluation of wind and current forces	69
29.4	Actions on mooring and breasting structures	70

30	Docking and slipping	72
31	Cargo storage	72
31.1	General	72
31.2	Dry bulk stacks	72
31.3	Other commodities	72
31.4	Containers	73
31.5	Other loads	73
32	Cargo handling and transport systems	74
32.1	General	74
32.2	Fixed and rail-mounted equipment	74
32.3	Ship to shore container cranes	74
32.4	Conveyors, pipelines and loading arms/hoses	75
32.5	Rail traffic	75
32.6	Road traffic	77
32.7	Rubber-tyred port vehicles	77
33	Channelized loading in pavements and decks	81
34	Movements, dynamic response and vibrations	82
34.1	Assessment of movements and vibrations	83
34.2	Impulsive loads	83
34.3	Static and long-term cyclic loads	84
34.4	Expansion and contraction	84
Annexes		
Annex A (informative) Linear ("first order" or "sinusoidal") wave theory		85
Annex B (informative) Nearshore wave processes		88
Annex C (informative) Wave prediction using charts		100
Annex D (informative) Independent extreme values analysis		108
Annex E (informative) Wave and current actions		110
Annex F (informative) Approximate method of assessment of response and displacement of simple structures under cyclical loading		116
Annex G (informative) Wind and current forces formulations		119
Annex H (informative) Additional background guidance on assessment of design situations, loads and partial factors for mooring loads		130
Annex I (informative) Physical properties of commonly stored cargoes		134
Bibliography		136
List of figures		
Figure 1 – Relationship between design working life, return period and probability of an event exceeding the normal average		44
Figure 2 – Typical container crane dimensions		76
Figure 3 – Dimensions of roll trailer vehicle		80
Figure A.1 – Linear wave theory – definition diagram		85
Figure B.1 – Wave shoaling and estimation of wave height in the surf zone		88
Figure B.2 – Schematic diagram of wave refraction		93
Figure B.3 – Wave height reduction factor for bottom friction		95
Figure B.4 – Breaker types		97
Figure C.1 – Significant wave prediction chart – Fetch lengths up to 1 500 km		102
Figure C.2 – Significant wave prediction chart – Fetch lengths from 200 km to 20 000 km		103
Figure C.3 – JONSWAP wave spectrum		104
Figure C.4 – Pierson–Moskowitz wave spectrum		105
Figure C.5 – Significant wave height and peak period for wave spectra		107
Figure E.1 – Drag force coefficient values for circular cylinders		111
Figure E.2 – Critical flow velocity for circular piles for in-line oscillations		112
Figure E.3 – Schematic diagram of wave-in-deck loads		116
Figure G.1 – Envelope of wind force coefficients for dry cargo vessels and small tankers		121

Figure G.2 – Wind force coefficients for very large tankers with superstructures aft	122
Figure G.3 – Wind force coefficients for typical container ship	123
Figure G.4 – Current drag force coefficients, all ships, deep water case	124
Figure G.5 – Water depth correction factors for lateral current forces	125
Figure G.6 – Water depth correction factor for longitudinal current forces on container ships	125
Figure G.7 – Typical longitudinal projected areas of tankers	126
Figure G.8 – Container ships: lengths and longitudinal projected areas	126

List of tables

Table 1 – Partial factors for actions	16
Table 2 – Formulae for combinations of actions	19
Table 3 – ψ factors for load combinations in maritime structures	26
Table 4 – Typical frequencies of environmental forces	50
Table 5 – Importance classes for maritime structures	63
Table 6 – Characteristics of the reference peak ground acceleration, a_{gR} , at the site of a maritime structure	63
Table 7 – Nominal bollard loadings for vessels up to 20 000 t displacement	69
Table 8 – Basis of loads on mooring structures with partial factors for actions	71
Table 9 – Accidental loads for multiple hooks	71
Table 10 – Typical stacking heights	73
Table 11 – Equivalent uniformly distributed loading for rubber-tyred port vehicles	77
Table 12 – Fork lift truck wheel loading: container handling duties	78
Table 13 – Reach stacker axle loads	78
Table 14 – Mobile crane outrigger reactions	79
Table 15 – Roll trailer loading: axle loads and effective wheel pressures	80
Table 16 – Loading due to tracked cranes	81
Table A.1 – Linear wave theory – useful equations	86
Table E.1 – Modification factors for critical flow velocity	112
Table F.1 – Added mass of entrained water	118
Table F.2 – Indicative mass allowance for marine growth	119
Table H.1 – Commentary on use of partial load factors from Table 8 according to method of assessment of actions and operational factors	131
Table H.2 – Accidental loads for multiple hooks	132
Table H.3 – Illustrative comparison of total factored loads on mooring points for different operating conditions and methods of assessment	133
Table I.1 – Typical dry bulk densities and angles of repose	134
Table I.2 – Typical stacked densities for common commodities	135

Summary of pages

This document comprises a front cover, an inside front cover, pages i to vi, pages 1 to 138, an inside back cover and a back cover.

Foreword

Publishing information

This part of BS 6349 is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 30 June 2016. It was prepared by Technical Committee CB/502, *Maritime works*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

Together with BS 6349-1-1, BS 6349-1-3 and BS 6349-1-4, this part of BS 6349 supersedes BS 6349-1:2000, which is withdrawn.

Relationship with other publications

BS 6349 is published in the following parts:

- Part 1-1: *General – Code of practice for planning and design for operations*;
- Part 1-2: *General – Code of practice for assessment of actions*;
- Part 1-3: *General – Code of practice for geotechnical design*;
- Part 1-4: *General – Code of practice for materials*;
- Part 2: *Code of practice for the design of quay walls, jetties and dolphins*;
- Part 3: *Code of practice for the design of shipyards and sea locks*;
- 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*;
- Part 8: *Code of practice for the design of Ro-Ro ramps, linkspans and walkways*.

Information about this document

A full revision of BS 6349-1:2000 has been undertaken and the principal change is to split the document into four smaller parts:

- BS 6349-1-1: *Code of practice for planning and design for operations*;
- BS 6349-1-2: *Code of practice for assessment of actions*;
- BS 6349-1-3: *Code of practice for geotechnical design*;
- BS 6349-1-4: *Code of practice for materials*.

The principal changes in respect of the actions content are:

- incorporation of information regarding partial factors for limit state design approaches and actions previously covered in other parts of the BS 6349 series;
- substantial changes to content relating to sea-state and loads, movements and vibrations, to reflect scientific and technological advances since preparation of the previous version of BS 6349-1.

This revision also updates and replaces the recommendations given in BS 6349-2:2010, 5.1, 5.2, Annex A and Annex B, which will be removed from BS 6349-2 at its next revision.

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 British Standard is expected to be able to justify any course of action that deviates from its recommendations.

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.

Where words have alternative spellings, the preferred spelling of the Shorter Oxford English Dictionary is used (e.g. "organization" rather than "organisation").

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.

Section 1: General

1 Scope

This part of BS 6349 gives recommendations for the assessment of actions for the planning and design of maritime works.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 6349-1-1:2013, *Maritime works – Part 1-1: General – Code of practice for planning and design for operations*

BS 6349-4:2014, *Maritime works – Part 4: Code of practice for design of fendering and mooring systems*

BS EN 1990:2002+A1:2005, *Eurocode – Basis of structural design*

BS EN 1991 (all parts), *Eurocode 1 – Actions on structures*

BS EN 1992 (all parts), *Eurocode 2 – Design of concrete structures*

BS EN 1993 (all parts), *Eurocode 3 – Design of steel structures*

BS EN 1994 (all parts), *Eurocode 4 – Design of composite steel and concrete structures*

BS EN 1995 (all parts), *Eurocode 5 – Design of timber structures*

BS EN 1996 (all parts), *Eurocode 6 – Design of masonry structures*

BS EN 1997 (all parts), *Eurocode 7 – Geotechnical design*

BS EN 1998 (all parts), *Eurocode 8 – Design of structures for earthquake resistance*

BS EN 1999 (all parts), *Eurocode 9 – Design of aluminium structures*

ISO 21650:2007, *Actions from waves and currents on coastal structures*

NA to BS EN 1990:2002+A1:2005, *UK National Annex for Eurocode – Basis of structural design*

NA to BS EN 1991-1-3, *UK National Annex to Eurocode 1 – Actions on structures – Part 1-3: General actions – Snow loads*

Other publications

[N1] AMERICAN SOCIETY OF CIVIL ENGINEERS. *Seismic design of piers and wharves*. ASCE 61-14. Reston, VA: ASCE, 2014.

[N2] OIL COMPANIES INTERNATIONAL MARINE FORUM. *Mooring equipment guidelines*. Third edition (MEG 3). London: OCIMF, 2008.