Since 1949 the "Committee for Waterfront Structures" has operated on honorary base as a committee of the Society for Harbour Engineering (HTG), Hamburg, and since 1951 also as working group of the German Society for Geotechnics (DGGT), Essen. Its full designation reads "Committee for Simplification and Standardization of Calculation and Construction of Waterfront Structures", which also outlines its goals. Following on from the previous collective publications, the new edition of EAU 1996 contains the safety concept with partial safety factors in accordance with the Eurocodes or the European prestandards as well as with the corresponding German standards and prestandards, while taking the National Application Document (NAD) into account. The revised version thus follows the goal of harmonising standards in Europe. At the same time, much updating and streamlining means that the recommendations continue to satisfy the requirements for international recognition and application with regard to planning, design tendering, the awarding of contracts, construction and supervision, as well as the inspection and account for harbour and waterway structures from the point of view of uniformity.

Recommendations of the Committee for Waterfront Structures Harbours and Waterways EAU 1996

7th Edition

Ernst & Sohn
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5 Ship Dimensions and Loading of Waterfront Structures

5.1 Ship Dimensions (R 39)

The following exemplarily listed average ship dimensions may be used for the calculation and design of waterfront structures and in the design and layout of fenders and dolphins:

5.1.1 Seagoing Vessels

5.1.1.1 **Passenger Vessels** (table R 39-1.1)

Tonnage	Carrying capacity	Displace-ment *G*	Overall length	Length between perps	Beam	Draft
GT	DWT	t	m	m	m	m
80 000	–	75 000	315	295	35.5	11.5
70 000	–	65 000	315	295	34.0	11.0
60 000	–	55 000	310	290	32.5	10.5
50 000	–	45 000	300	280	31.0	10.5
40 000	–	35 000	265	245	29.5	10.0
30 000	–	30 000	230	210	28.0	10.0

5.1.1.2 **Bulk Carriers** (table R 39-1.2) (oil, ore, coal, grain, etc.)

–	450 000	524 000	424	404	68.5	25.0
–	420 000	490 000	418	398	67.0	24.5
–	380 000	445 000	407	386	64.5	24.0
–	365 000	428 000	404	383	63.5	23.0
–	340 000	400 000	398	378	62.5	23.0
–	300 000	356 000	385	364	59.5	22.0
–	275 000	326 000	376	355	57.5	21.5
–	250 000	300 000	367	346	55.5	20.5
–	225 000	270 000	356	336	53.5	20.5
–	200 000	240 000	345	326	51.0	19.5
–	175 000	212 000	330	315	48.5	18.5
–	150 000	180 000	315	300	46.0	16.5
–	125 000	155 000	295	280	43.5	16.0
–	100 000	125 000	280	265	41.0	15.0
–	85 000	105 000	265	255	38.0	14.0
–	65 000	85 000	255	245	33.5	13.0
–	45 000	60 000	230	220	29.0	11.5
–	35 000	45 000	210	200	27.0	11.0
–	25 000	30 000	190	180	24.5	10.5
–	15 000	20 000	165	155	21.5	9.5

5.1.1.3 **Mixed Cargo Freighters (Full Deck Construction)** (table R 31-1.3)

Tonnage	Carrying capacity	Displace-ment *G*	Overall length	Length between perps	Beam	Draft
GT	DWT	t	m	m	m	m
10 000	15 000	20 000	165	155	21.5	9.5
7 500	11 000	15 000	150	140	20.0	9.0
5 000	7 500	10 000	135	125	17.5	8.0
4 000	6 000	8 000	120	110	16.0	7.5
3 000	4 500	6 000	105	100	14.5	7.0
2 000	3 000	4 000	95	90	13.0	6.0
1 500	2 200	3 000	90	85	12.0	5.5
1 000	1 500	2 000	75	70	10.0	4.5
500	700	1 000	60	55	8.5	3.5

There appears to be no trend towards construction of larger cargo freighters. If necessary, the dimensions used in section 5.1.1.2 may be used accordingly.

5.1.1.4 **Fishing Vessels** (table R 39-1.4)

2 500	–	2 800	90	80	14.0	5.9
2 000	–	2 500	85	75	13.0	5.6
1 500	–	2 100	80	70	12.0	5.3
1 000	–	1 750	75	65	11.0	5.0
800	–	1 550	70	60	10.5	4.8
600	–	1 200	65	55	10.0	4.5
400	–	800	55	45	8.5	4.0
200	–	400	40	35	7.0	3.5

5.1.1.5 **Container Ships** (table R 39-1.5)

Carrying capacity	Dis-place-ment *G*	Overall length	Length between perps	Beam	Draft	Number of con-tainers	Genera-tion
DWT	t	m	m	m	m	circa	
75 000	90 000	350	335	45.0	14.0	6 000	6th
66 300	80 000	275	262	40.0	14.0	4 800	5th
64 500	77 500	294	282	32.2	13.5	4 400	5th
55 000	77 000	275	260	39.4	12.5	3 900	4th
50 000	73 500	290	275	32.4	13.0	2 800	3rd
42 000	61 000	285	270	32.3	12.0	2 380	3rd
36 000	51 000	270	255	31.8	11.7	2 000	3rd
30 000	41 500	228	214	31.0	11.3	1 670	2nd
25 000	34 000	212	198	30.0	10.7	1 380	2nd
20 000	27 000	198	184	28.7	10.0	1 100	2nd
15 000	20 000	180	166	26.5	9.0	810	1st
10 000	13 500	159	144	23.5	8.0	530	1st
7 000	9 600	143	128	19.0	6.5	316	1st

5.1.1.6 Car transport Ships (table R 39-1.6)

Carrying capacity	Displacement G	Overall length	Length between perps	Beam	Draft	No. of cars
DWT	t	m	m	m	m	approx.
28 000	45 000	198	183	32.3	11.8	6 200
26 300	42 000	213	198	32.3	10.5	6 000
17 900	33 000	195	180	32.2	9.7	5 600

5.1.1.7 Ferries and Ro-Ro Ships (table R 39-1.7)

Carrying capacity	Displacement G	Overall length	Length between perps	Beam	Draft
DWT	t	m	m	m	m
106 400	115 000	253.00	238.00	40.00	15.10
64 400	76 100	225.00	215.00	34.00	13.00
42 500	53 000	182.50	173.00	32.30	12.00
27 750	39 800	177.30	158.10	27.30	11.55
18 000	32 650	181.20	165.00	30.40	9.30
16 000	23 400	178.10	164.00	26.80	7.60
14 000	21 500	163.80	148.60	23.50	8.80
12 000	20 000	190.90	173.00	26.00	7.18
10 000	23 410	192.50	181.00	27.30	6.75
8 000	16 000	156.00	137.00	22.60	7.30
6 000	20 750	179.40	170.00	27.80	6.27
4 000	17 500	163.40	150.00	27.00	6.20
2 000	10 800	164.70	159.60	17.70	5.90

The data in the table vary according to type of load (cars, trucks, trailers, waggons, passengers) and load shares.

5.1.2 River-sea Ships (table R 39-2)

Tonnage	Carrying capacity	Displacement G	Overall length	Beam	Draft
GT	DWT	t	m	m	m
999	3 200	3 700	94.0	12.8	4.2
499	1 795	2 600	81.0	11.3	3.6
299	1 100	1 500	69.0	9.5	3.0

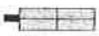
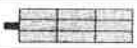
The length, width and draft of all types of freighters depend on the ship's construction and the country of origin. The dimensions can be expected to vary by up to 5 % (see also [197], [199] and [200]).
The gross tonnage (GT) is taken as the dimension-less gross space number [201]. The carrying capacity is stated in deadweight tons (DWT), namely the weight of provisions, supplies, fresh water, crew, reserves of boiler water, fuel, freight and passengers, measured in English tons (long tons) at 2240 lbs = 1016 kg.

5.1.3 Inland Vessels (table R 39-3)

Designation	Carrying capacity	Displacement G	Length	Beam	Draft
	t	t	m	m	m
Motor freighters:					
Large Rhine ship	4 500	5 200	110.0	11.4	4.5
2600-ton class	2 600	2 950	110.0	11.4	2.7
Rhine ship	2 000	2 385	95.0	11.4	2.7
"Europe" ship	1 350	1 650	80.0	9.5	2.5
Dortmund-Ems-Canal ship	1 000	1 235	67.0	8.2	2.5
Large-Canal-Class ship	950	1 150	82.0	9.5	2.0
Large-"Plauer"-Class ship	700	840	67.0	8.2	2.0
BM-500 ship	650	780	55.0	8.0	1.8
Kempenaar	600	765	50.0	6.6	2.5
Barge	415	505	32.5	8.2	2.0
Peniche	300	405	38.5	5.0	2.2
Large-Saale-Class ship	300	400	52.0	6.6	2.0
Large-Finow-Class ship	250	300	41.5	5.1	1.8
Push lighters:					
Europe IIa	2 940	3 275	76.5	11.4	4.0
	1 520	1 885			2.5
Europe II	2 520	2 835	76.5	11.4	3.5
	1 660	1 990			2.5
Europe I	1 880	2 110	70.0	9.5	3.5
	1 240	1 480			2.5
Carrier ship lighters:					
Seabee	860	1 020	29.7	10.7	3.2
Lash	376	488	18.8	9.5	2.7
Push tows:					
with one lighter Europe IIa	2 940	3 520[1]	110.0	11.4	4.0
	1 520	2 130[1]			2.5
with 2 lighters Europe IIa	5 880	6 795[1]	185.0	11.4	4.0
	3 040	4 015[1]	110.0	22.8	4.0
					2.5
with 4 lighters Europe IIa	11 760	13 640[2]	185.0	22.8	4.0
	6 080	8 080[2]			2.5

[1] Push vessel 1 480 kW; approx. 245 t displacement
[2] Push vessel 2963–3333 kW; approx. 540 t displacement

According to ECE resolution no. 30 dated 12.11.1992 – TRANS/SC 3R.153, the following classification applies to European waterways:

Type of inland waterway		Class of inland waterway	Motor vessels and barges in tow Type of vessel: general features					Push tow Type of pushed lighter: general features					Vertical clearance under a bridge [m][2]	Graphical symbol on the map
			Designation	Max. length L [m]	Max. beam B [m]	Draft d [m][7]	Tonnage T [t]	Formation	Length L [m]	Beam B [m]	Draft d [m][7]	Tonnage T [t]		
1		2	3	4	5	6	7	8	9	10	11	12	13	14
of regional significance	west of the Elbe river	I	Peniche	38.5	5.05	1.8–2.2	250–400						4.0	
		II	Kempenaar	50–55	6.6	2.5	400–650						4.0–5.0	
		III	Gustav Konigs	67–80	8.2	2.5	650–1000						4.0–5.0	
	east of the Elbe river	I	Large Finow	41	4.7	1.4	180						3.0	
		II	BM-500	57	7.5–9.0	1.6	500–630						3.0	
		III	[6]	67–70	8.2–9.0	1.6–2.0	470–700		118–132[1]	8.2–9.0[1]	1.6–2.0	1000–1200	4.0	
of international significance		IV	Johann Welker	80–85	9.5	2.5	1000–1500		85	9.5[5]	2.50–2.80	1250–1450	5.25 or 7.00[4]	
		Va	large Rhine ship	95–110	11.40	2.50–2.80	1500–3000		96–110[1]	11.40	2.50–4.50	1600–3000	5.25 or 7.00 or 9.10[4]	
		Vb							172–185[1]	11.40	2.50–4.50	3200–6000		
		VIa							95–110[1]	22.80	2.50–4.50	3200–6000	7.00 or 9.10[4]	
		VIb	[3]	140	15.00	3.90			185–195[1]	22.80	2.50–4.50	6400–12000	7.00 or 9.10[4]	
		VIc							270–280[1] 195–200[1]	22.80 33.00–34.20[1]	2.50–4.50	9600–18000 9600–18000	9.10[4]	
		VII							285	33.00–34.20[1]	2.50–4.50	14500–27000	9.10[4]	

Foot notes for the classification table:

[1] The first number considers the current situation, whereas the second shows both future developments and, in some cases, the existing situation.
[2] Considers a safety clearance of approx. 30 cm between the highest fixed point of the ship or its cargo and a bridge.
[3] Considers the dimensions of vessels under own power expected in Ro-/Ro- and container traffic. The stated dimensions are approximate values.
[4] Rated for transporting containers:
- 5.25 m for ships with two layers of containers,
- 7.00 m for ships with three layers of containers,
- 9.10 m for ships with four layers of containers.
- 50 % of the containers can be empty, otherwise ballast is required.

[5] Some existing waterways can be allocated to class IV on account of the greatest permissible length of ships and barges, although the greatest beam is 11.40 m and the largest draft 4.00 m.
[6] Vessels used in the region of the Oder and on the waterways between Oder and Elbe.
[7] The draft for a specific federal waterway is to be ascertained according to the local conditions.
[8] On certain sections of waterways in class VII, push tows can be used consisting of a larger number of lighters. Here the horizontal dimensions can exceed the values stated in the table.

Table R 39-3.1. Classification of the European inland waterways

5.1.4 Displacement

The displacement G [t] is the product of the length between perpendiculars, the width, the draft, the block coefficient c_B and the mass density ρ_w [t/m^3] of the water. The block coefficient varies from 0.50 to 0.80 for seagoing vessels, from 0.80 to 0.90 for inland vessels, and from 0.90 to 0.93 for push lighters.

5.2 Assumed Berthing Pressure of Vessels at Quays (R 38)

In preparation of the design, accidental impacts need not be taken into consideration but only the usual berthing loads. The magnitude of these berthing loads depends on the ship's dimensions, the berthing velocity, the fenders and the deformation of the ship's hull and the structure.

In order to give the quay sufficient stability against normal berthing loads, but on the other hand to avoid unnecessarily large dimensions, it is recommended that the front wall be so designed that at any position of a section, a concentrated impact load in the magnitude of the relevant line pull force can act, without the total stresses exceeding the permissible limits. Berthing impact for quay walls in seaports according to R 12, section 5.12.2 with the values in table R 12-1, and for quay walls in inland harbours 100 kN according to R 102, section 5.13.2.

This concentrated force may be distributed over a square area 0.50 m on a side. In sheet pile walls without solid superstructures, only the wales and bolts need be designed for this force.

The berthing loads on dolphins are dealt with in R 128, section 13.3.

5.3 Berthing Velocities of Vessels Transverse to Berth (R 40)

When vessels make their approach transverse to a berth, it is recommended that the following berthing velocities be taken into consideration when designing the corresponding fendering:

Condition	Approach	Berthing velocity transverse to berth (m/s)			
		up to 1000 DWT	up to 5000 DWT	up to 10000 DWT	Larger ships
		corresponding to approx. 1500 t displacement	6500 t	13000 t	
Strong wind and heavy sea	difficult	0.75	0.55	0.40	0.30
Strong wind and heavy sea	favourable	0.60	0.45	0.30	0.20
Moderate wind and heavy sea	moderate	0.45	0.35	0.20	0.15
Protected	difficult	0.25	0.20	0.15	0.10
Protected	favourable	0.20	0.15	0.10	0.10

Table R 40-1. Berthing velocity transverse to berth

5.4 Load Cases (R 18)

The following load cases (combination of actions) are considered as a general principle for the statical calculations and allocation of the partial safety factors:

5.4.1 Load Case 1

Loads due to active earth pressure (in unconsolidated, cohesive soils, separately for both initial and final states) and to water pressure differences where unfavourable outer and inner water levels frequently occur (see R 19, section 4.2), Earth pressures resulting from the normal live loads, from crane tracks and pile loads, directly acting surcharges from dead weight and normal live load.

5.4.2 Load Case 2

Same as load case 1, but with restricted scour from flow or from ship's screw action, and together with the following, insofar as they can occur simultaneously: water pressure difference according to R 19, section 4.2, wave loads from frequent waves ("design wave" as per R 136, section 5.6.5), water pressure difference caused by regularly anticipated flooding of the waterfront structure, the suction effect of passing ships, loads and active earth pressure from unusual local surcharges, hawser pull on bollards, recess bollards or mooring hooks, and the impact of vessels; the effect of temporarily unfavourable loads during construction and the protection afforded by any existing piling should be neglected.

5.4.3 Load Case 3

Same as load case 2, but taking into consideration additional surcharges not previously allowed for on larger areas, or the possibility that elements which help to stabilize the structure in general may fail because of unfavourable circumstances. Examples of these contingencies are the complete failure of the drainage system, an unusual slumping of an underwater slope in front of the sheet piling, unusual scouring due to current or ship's screws, water pressure difference after extreme water level situations and wave loads from rare waves ("design wave" as per R 136, section 5.6.5), unexpected flooding of the banks or a severe groundwater rise due to an ice jam with subsequent sudden drop of the outer water after the jammed ice goes out, the bursting of a large water pipe behind the waterfront structure, unforeseen transhipment of unusually heavy goods. The combination of several such unfavourable actions is also to be taken into consideration, as far as this occurrence is possible and probable.

5.4.4 Partial Safety Factors

It must be taken into account whether the acting loads are stated as "*nominal* loads" (i.e. design loads) or "*characteristic* loads". In the latter case, they are to be multiplied by the partial safety factors according to DIN V 1054-100. For load case 3, as a rule the partial safety factor 1.0 is used.

5.5 Vertical Live Loads (R 5)

All quantitative loads (actions) stated in this section are *characteristic* values.

5.5.1 General

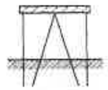
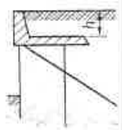
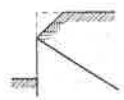
Vertical live loads (variable loads in accordance with DIN V ENV 1991-1) are essentially the surcharges resulting from stored material and the loads from vehicular traffic. The load actions of rail-mounted or vehicular mobile cranes must be considered separately, insofar as they exert any effect on the waterfront structures. At waterfront structures in inland ports, the latter is generally only the case for waterfront structures which are expressly intended for heavy load handling with mobile cranes. In seaports, in addition to the rail-mounted quay cranes, mobile cranes are being used increasingly for general cargo handling, that is to say, not only for heavy loads.
A distinction is to be made between three different basic types (table R 5-1) for the live loads:

In *basic type 1*, the bearing members of the structures are driven over directly by the vehicles and/or stressed by the stacked materials, e.g. at pier bridges (table R 5-1a).

In *basic type 2*, the load from vehicles and the stacked material acts on a more or less deep bedding course, which distributes and transmits the loads to the structural members. This type of design is used for example at super-structured slopes with load distributing bedding layer on the pier slab (table R 5-1 b).

In *basic type 3*, the load from vehicles and the stacked goods acts only on the solid mass of earth fill behind the waterfront structure, which consequently is subject only indirectly to additional stress from the live loads as the result of increased active earth pressure. Simple sheet piling bulkheads or partially sloped banks are characteristic for this (table R 5-1c).

Supplementing the three basic types, there are also transitional types, for example pile-founded structures on piles with a short pile cap.
If complete and reliable calculations are available, the live loads should normally be taken at the anticipated magnitude. Any subsequently necessary increases in the live loads can be better accommodated within the tolerable limits, the greater the deadweight share and the better the distribution of loads in the structure. Support systems according to basic type 2 and in particular basic type 3 offer particular advantages in this respect.
Reference is made to R 18, section 5.4 when it comes to allocation of the corresponding loads to load cases 1, 2 and 3.

Basic type	Traffic live loads[1]				Storage area outside the waterfront cargo-handling area
	Railroad	Roads			
		Vehicle	Road-bound cranes	Light-weight traffic	
a) BT 1 	Issue B.3 dated 08.03.93 (DS 804) Regulations for railroad bridges and other engineering structures (VEI)	Load assumptions as per DIN 1072 (road and foot bridges – load assumptions)	Fork lift loads as per DIN 1055, Claw loads of 550 kN for mobile cranes	5 kN/m²	Loads according to the use actually anticipated in accordance with section 5.5.6
	Impact factor: The parts exceeding 1.0 can be decreased by half				
b) BT 2 	As 1, but further reduction of the impact factor to 1.0 at bedding layer thickness $h = 1.00$ m. For bedding layer thickness $h \geq 1.50$ uniformly distributed surface load of 20 kN/m²	33.3 kN/m²			
c) BT 3 	Loads as in BT 2 with a bedding layer thickness of more than 1.50 m				

[1] Crane loads are to be taken as stipulated in R 84, section 5.14

Table R 5-1. Vertical live loads

5.5.2 Basic Type 1

Railroad live loads correspond to the load diagram UIC[1)] 71 of the Regulation for Railroad Bridges and other Engineering Structures (VEI), issue B3 of 8.4.1993 (DS 804). The load assumptions according to DIN 1072 are to be applied for road traffic. Bridge class 60/30 is to be adopted in general. In indicated impact factors (DS 804) and vibration coefficients (DIN 1072), with which the live loads of the main track are to be multiplied, the parts exceeding 1.0 can as a rule be decreased by half, because of the slow speed. For piers in seaports, loads from fork lifts are to be taken according to DIN 1055 and claw pressures for mobile cranes of 550 kN, insofar as higher assumptions are not required in special cases (see table R 84-1, section 5.14.3).

Outside the waterfront cargo handling area, the actually expected surcharge from stored goods is to be taken, but at least 20 kN/m^2 (see section 5.5.6), because of later possible changes in use of the area. A live load of 5 kN/m^2 is adequate if the nature of the facility means that only light traffic is possible or anticipated.

5.5.3 Basic Type 2

Essentially the same as basic type 1. The impact factors and coefficients however may be linearly further reduced according to bedding layer thickness, and completely ignored when the bed is at least 1.00 m thick, for road traffic taken from the top of the road, and when the rails are embedded in the pavement, from the top of the rails. Load by sections is however still to be taken into account.

If the bedding layer thickness is at least 1.50 m, the total live load can be replaced by a uniformly distributed area load corresponding to the actually anticipated live load, but not less than 20 kN/m^2. In cases of light traffic, a live load of 5 kN/m^2 suffices.

5.5.4 Basic Type 3

Load as for basic type 2, with a bedding layer thickness of more than 1.50 m.

5.5.5 Load Assumptions Directly Behind the Head of the Waterfront Structure

When working with heavy vehicular cranes or similar heavy-duty vehicles and heavy construction gear, such as crawler excavators and similar, which drive along directly behind the front edge of the waterfront structure, the following are to be applied for the design of the uppermost parts of the structure, inclusive of an eventual upper anchoring:

a) Live load = 60 kN/m^2 from rear edge of coping, inboard for 2.0 m width, or
b) Live load = 40 kN/m^2 from rear edge of coping, inboard for 3.50 m width.

In a) and b), effects from a claw end load $P = 550$ kN are covered insofar as the distance between the axis of the waterfront structure and the axis of the claw is at least 2.0 m.

[1)] UIC = Union Internationale des Chemins de Fer.

5.5.6 Loads Outside the Waterfront Cargo Handling Area

Outside the waterfront cargo handling area, the following live loads are taken as the basis in accordance with [140], working on the basis of 300 kN gross load for 40' containers and 200 kN for 20' containers.

- Light traffic (cars) — 5 kN/m^2
- General traffic (trucks) — 10 kN/m^2
- General cargo — 20 kN/m^2
- Containers:
  - empty, stacked 4 high — 15 kN/m^2
  - full, stacked 2high — 35 kN/m^2
  - full, stacked 4 high — 55 kN/m^2
- Ro-Ro loads — 30–50 kN/m^2
- Multi-purpose facilities — 50 kN/m^2
- Offshore feeder bases — 55–150 kN/m^2
- Paper
- Timber products
- Steel
- Coal
- Ore

(Paper, Timber products, Steel, Coal, Ore: depending on the bulk/stacking height, calculating values of the weight density according to DIN1055, part 4)

Further details regarding the material properties of bulk and stacked goods are to be found in the tables of ROM 02.-90 [197].

When calculating the active earth pressure of retaining structures, as a rule the differing loads in the cargo handling and container area can be grouped together to produce an average surface load of 30 to 50 kN/m^2.

5.6 Determining the "Design Wave" for Maritime and Port Structures (R 136)

5.6.1 General

In order to rate the wave loads acting on maritime and port structures, the sea conditions in the planning area should be analysed and studied with regard to probabilities. This includes an investigation of the wave data, such as wave heights, periods, lengths and directions in connection with wind conditions, tides and currents, including their seasonal frequency. It is then possible to determine the applicable wave value as so-