

Design of Ship Hull Structures

A Practical Guide for Engineers

Bearbeitet von
Yasuhisa Okumoto, Yu Takeda, Masaki Mano, Tetsuo Okada

xviii, 578 pgs. with 506 figs. 2009. Buch. xvii, 578 S. Hardcover

ISBN 978 3 540 88444 6

Format (B x L): 15,5 x 23,5 cm

Gewicht: 2230 g

[Weitere Fachgebiete > Technik > Verkehrstechnologie > Schiffsbautechnik.
Seeverkehr](#)

Zu [Leseprobe](#)

schnell und portofrei erhältlich bei

The logo for beck-shop.de features the text 'beck-shop.de' in a bold, red, sans-serif font. Above the 'i' in 'shop' are three red dots of increasing size. Below the main text, the words 'DIE FACHBUCHHANDLUNG' are written in a smaller, red, all-caps, sans-serif font.

beck-shop.de
DIE FACHBUCHHANDLUNG

Die Online-Fachbuchhandlung [beck-shop.de](#) ist spezialisiert auf Fachbücher, insbesondere Recht, Steuern und Wirtschaft. Im Sortiment finden Sie alle Medien (Bücher, Zeitschriften, CDs, eBooks, etc.) aller Verlage. Ergänzt wird das Programm durch Services wie Neuerscheinungsdienst oder Zusammenstellungen von Büchern zu Sonderpreisen. Der Shop führt mehr als 8 Millionen Produkte.

Contents

Part I Fundamentals

1	Philosophy of Hull Structure Design	3
1.1	Importance of Hull Structure Design	3
1.2	Design Procedure of Structures	5
1.3	Hull Structure Design Policy	7
1.4	Basic Idea of Hull Structure Design	8
1.5	Studies on Loads Applied	9
1.6	Reliable Design	10
2	Structural Design Loads	17
2.1	Introduction	17
2.2	Longitudinal Strength Load	20
2.3	Transverse Strength Load	23
2.4	Ship Response Calculation in Waves	27
2.4.1	Introduction	27
2.4.2	Strip Method	27
2.4.3	Short-Term Prediction	28
2.4.4	Long-Term Prediction	30
3	Strength Evaluation	33
3.1	General	33
3.1.1	Introduction	33
3.1.2	Procedure of Structural Strength Evaluation	33
3.2	Stress and Strain	37
3.2.1	Stress Pattern	37
3.2.2	Biaxial Stress Condition [12]	38
3.2.3	Combination of Normal Stress and Shearing Stress [12]	39
3.2.4	Principal Stress and Principal Shearing Stress [12]	40
3.2.5	Equivalent Stress	42
3.2.6	Evaluation of Stress Calculated by FEM	43
3.3	Evaluation of Stress	45
3.3.1	Criteria of Failure	45
3.3.2	Allowable Stress	47

3.4	Fatigue Strength	49
3.4.1	Introduction	49
3.4.2	S–N Curve	49
3.4.3	Fatigue Damage	52
3.5	Buckling of Ship Structure	54
3.5.1	Introduction	54
3.5.2	Column Buckling	55
3.5.3	Plate Buckling	57
3.6	Plastic Strength	60
3.6.1	Philosophy of Plastic Strength	60
3.6.2	Plastic Bending	62
3.6.3	Plastic Section Modulus	64
3.6.4	Collapse of a Beam	65
3.6.5	Collapse of a Plate	68
3.7	Vibration in Ship	69
3.7.1	Introduction	69
3.7.2	Basic Theory of Single Degree of Freedom Vibration System	70
3.7.3	Vibration Problems in Ships	74
3.7.4	Vibration Prevention Design	75
3.8	Selection of Strength Analysis Method	76
3.8.1	Introduction	76
3.8.2	Type of Analysis Method	77
3.8.3	Analysis Procedure	78
3.8.4	Evaluation of Analysis Result	79
4	Hull Structure Design System	81
4.1	Design Flow	81
4.2	Basic Design of Hull Structures	84
4.2.1	Role of Basic Design	84
4.2.2	Check of General Arrangement	87
4.2.3	Check of Other Drawings	87
4.2.4	Optimization Technique in Basic Design Process	88
4.3	Structural Drawings	90
4.3.1	Approval Drawings	90
4.3.2	Detail Drawings	90
4.3.3	Production Data	92
4.4	Standardization	92
4.5	Negotiation with Owner	95
5	Progress in Ship Design	97
5.1	Increase in Ship Dimensions of Tankers	97
5.2	Specialization of Ships	100
5.3	Change of Hull Form	104
5.4	Ship Vibration Caused by Socio-Economical Change	105
5.5	Regulations for Environmental Conservation	108
5.6	Technical Innovation	109

6	Materials	111
6.1	Hull Steel	111
6.2	Grades of Steel	112
6.3	Higher-Strength Steel	116
6.4	Steel Sections	116
6.5	Other Materials	117
6.6	Scattering of Material Properties	117
6.7	Scattering of Physical Properties	121
6.8	Residual Stress [42]	122
7	Finite Element Method	125
7.1	Characteristics of FEM	125
7.2	Fundamentals of FEM	126
7.2.1	Stiffness Matrix [44]	126
7.2.2	Plane Stress [43]	128
7.3	Procedure of FEM	130
7.4	Application of FEM	133
7.4.1	Mesh Division	133
7.4.2	Loading and Supporting Condition	134
7.4.3	Degrees of Freedom	136
	References	139

Part II Theory

1	Design of Beams	143
1.1	Effective Breadth of Attached Plates	143
1.1.1	Bending in Elastic Conditions	144
1.1.2	Effective Width After Plate Buckling	144
1.2	Span Point of Beams	146
1.3	Design of Cross Section	149
1.3.1	Calculation of Section Modulus	150
1.4	Bending Moment	152
1.5	Easy Solution of Statically Indeterminate Beams	154
1.6	Boundary Condition	156
1.7	Cross-Sectional Area of Beams	161
1.8	Optimum Design of Beam Section	162
1.8.1	Elastic Design	163
1.8.2	Plastic Design	165
1.8.3	Optimal Proportion for Beams	166
1.9	Simply Supported Beams and Continuous Beams	167
1.10	Effect of Struts	170
1.11	Additional Bending Moment due to Forced Displacement	172
1.12	Lateral Movement of Beams	174

2	Design of Girders	177
2.1	Shearing Force	177
2.2	Rational Design of Girders	181
2.3	Bottom Transverses Supported by Centerline Girder [5]	184
2.4	Deflection of Girders	187
3	Damage of Girders	191
3.1	Buckling Caused by Compression	191
3.2	Buckling Caused by Bending	194
3.3	Buckling Caused by Shearing	195
3.4	Buckling Caused by Concentrated Loads	199
3.5	Cracks Around Slot	202
3.5.1	Cracks of First Generation [8]	202
3.5.2	Cracks Propagating into Longitudinals	208
3.5.3	Cracks Around Slots due to Shear Stress on Transverses	210
4	Design of Pillars	211
4.1	Slenderness Ratio of Pillars	211
4.2	Sectional Shape of Pillars	214
4.3	Pillar Supporting Tensile Force	217
4.4	Connection of Pillar at Top and Bottom	219
4.5	Cross Ties	221
4.6	Radius of Gyration of Square Section	224
5	Design of Plates	227
5.1	Boundary Conditions of Plates	227
5.2	Strength of Plates Under Lateral Loads	230
5.3	Strength of Plates by In-Plane Loads	237
5.4	Plates Supporting Bending and Compression Simultaneously	242
5.5	Stress Concentration Around Openings	244
5.6	Material and Roll Direction	248
5.7	Damage of Plates	251
6	Design of Stiffened Panel	253
6.1	Grillage Structure	254
6.2	Optimum Space of Girders	257
6.3	Optimum Space of Beams	258
6.3.1	Design Condition Against Lateral Load like Water Pressure	258
6.3.2	Design Conditions from Vibration Viewpoint	259
6.3.3	Minimum Plate Thickness	260
6.3.4	Optimum Beam Space	260
7	Torsion	267
7.1	Overview of the Theory	267
7.2	Torsion Theory of Closed Section Bars	268
7.3	Torsional Rigidity of Various Sections	274

7.4	Torsion Theory of I-Section	277
7.5	Torsion Theory of Open Section Bars	279
8	Deflection of Hull Structures	285
8.1	Deflection of Hull Girder	286
8.2	Deflection of Beams with Optimum Section	291
8.3	Deflection of Girders and Web Frames	292
8.4	Additional Stress Caused by Deflection	293
8.5	Shearing Deflection	295
9	Welding	297
9.1	Butt Welding	298
9.2	Fillet Welding	302
9.3	Fillet Welding with Higher Strength Electrode	308
9.4	Water Stopping Welding	309
9.5	Scallop and Serration	309
9.6	Conversion of Butt Welding to Fillet Welding	311
9.7	Long Intermittent Welding	314
9.8	Shrinkage of Deposit Metal	315
9.9	One Side Welding	317
10	Fracture Control	319
10.1	Jack-Knifed Failure of Liberty Ships	319
10.2	Fracture Mechanics	321
10.2.1	Principles	321
10.2.2	Linear Fracture Mechanics	322
10.2.3	Non-Linear Fracture Mechanics	324
10.2.4	Fracture Toughness	325
10.2.5	Grade of Steel	325
10.3	Fatigue Strength Design	328
10.3.1	Crack Propagation Calculation by Paris's Equation	328
10.3.2	Fatigue Strength Design Taking into Account Construction Tolerances [39]	330
11	Hull Structural Vibration	335
11.1	Introduction	335
11.2	Basic Features of Hull Structure Vibration	336
11.3	Overview of Ship Vibration	338
11.4	Boundary Conditions of Hull Structure Vibration	341
11.5	Current Boundary Conditions of Hull Structure Vibration	345
	References	349

Part III Applications

1	Hull Structure Arrangement	353
1.1	Hold Arrangement	353
1.2	Criteria of Design of Hull Structure Arrangement	355
1.2.1	Wing Tanks of Tankers	355
1.2.2	Bulkhead Arrangement of Bulk Carriers	358
1.3	Bulkhead Arrangement Beyond Cargo Hold	359
1.3.1	Bow Construction Without Extended Longitudinal Bulkheads	360
1.3.2	Engine Room Construction Without Extended Longitudinal Bulkheads	360
2	Longitudinal Strength of Hull Girder	363
2.1	Allowable Stress for Longitudinal Strength	363
2.2	Position of Maximum Longitudinal Bending Moment	367
2.3	Calculation of Section Modulus of Hull Girder	369
2.4	Longitudinal Strength and Hull Steel Weight	370
2.5	Application of High Tensile Steel	372
2.6	Longitudinal Strength Analysis in Waves	374
2.7	Arrangement of Longitudinal Strength Members	379
2.8	Stress Concentration on Longitudinal Strength Members	381
2.9	Additional Bending of Local Members Due to Hull Girder Bending	383
2.10	Longitudinal Bending Stress in Fore & Aft Parts of Ship	385
2.11	Hull Steel Weight Reduce to Ultimate Strength	386
3	Transverse Strength of Ship	387
3.1	Allowable Stress for Transverse Strength	388
3.2	Long Taper & Snake Head	391
3.3	Shape of Bottom Transverse in Center Tank	392
3.4	Shape of Bottom Transverse in Wing Tank	393
3.5	Transverse Strength of Tanker	394
3.5.1	Cross Ties	394
3.5.2	Load Applied on Transverse Strength Members	397
3.5.3	Inside Pressure in Wide Tanks	399
3.5.4	Connection Between Transverse Ring and Side Shell	400
3.5.5	Buckling on Web of Transverse Rings	401
3.5.6	Straight Type and Circular Type Construction	403
3.5.7	Transverse Rings at Fore & Aft Parts of Tank	405
3.6	Transverse Strength of Ore Carrier	405
3.7	Transverse Strength of Bulk Carrier	410
3.8	Transverse Strength of Container Ships	415

4	Torsional Strength	417
4.1	Structural Damage Due to Torsion (Example No. 1)	418
4.2	Structural Damage Due to Torsion (Example No. 2)	420
5	Shell Structure	423
5.1	Thickness of Shell Plates	423
5.2	Shell at Bottom Forward	425
5.3	Shell at Bow Flare	426
5.4	Bilge Shell	428
5.5	Shell near Stern Frame	428
5.6	Shell Damage	429
6	Bulkheads	431
6.1	Strength of Bulkhead Plates	431
6.2	Horizontal Girders on Transverse Bulkheads (in Center Tank)	433
6.3	Horizontal Girder Arrangement on Bulkheads	436
6.4	Vertical Stiffeners on Transverse Bulkheads	439
6.5	Swash Bulkheads	440
6.6	Horizontal Stiffeners on Transverse Bulkheads	443
6.7	Minimum Thickness of Longitudinal Bulkhead Plates	447
6.8	Sharing Ratio of Shearing Force	449
6.9	Corrugated Bulkheads	451
6.10	Horizontal Girders on Corrugated Bulkheads	454
6.11	Stiffness of Corrugated Bulkheads Against In-Plane Loads	456
7	Deck Structure	461
7.1	Stress Concentration at Hatch Corners	461
7.1.1	General	461
7.1.2	Contour Shape Optimization of Container Ship Hatch Corners	464
7.2	Deck Strength for Locally Distributed Loads	467
7.3	Deck Sustaining Upward Loads	471
7.4	Damage to Deck Structure	472
8	Double Hull Structure	475
8.1	Structural System of Double Hull Structure	475
8.2	Double Hull Structure and Single Hull Structure	477
8.3	Examples of Double Hull Structures	478
8.3.1	Cargo Ships	478
8.3.2	Tankers	479
8.3.3	Container Ships	480
8.3.4	Nuclear Ships	480
8.3.5	Large Bulk Carriers	481

9	Fore Construction	483
9.1	Structural Arrangement	483
9.2	Structure of Shell Construction	485
9.3	Vertical Acceleration Depending on Pitching	486
9.4	Deck Structure	487
9.5	Structural Continuity	488
9.6	Large Damage in Fore Construction	488
10	Engine Room Construction	491
10.1	Engine and Pump Rooms Arrangement	492
10.2	Rigidity Criteria in Engine Room Structure Design	494
10.2.1	Double Bottom in Engine Room	495
10.2.2	Panel, Web, Stiffener Etc.	496
10.3	Design of Structural Members in Engine Room	497
10.4	Girders and Floors in Engine Room Double Bottom	499
10.5	Problems Caused by Deflection of Engine Room Double Bottom	501
10.6	Deflection of Engine Room Double Bottom	503
10.6.1	Bending and Shearing Deflection of Hull Girder in the Vicinity of Engine Room	503
10.6.2	Deformation of Web Frame Which Supports Engine Room Double Bottom	505
10.6.3	Bending and Shearing Deflections of Engine Room Double Bottom Itself	505
10.7	Allowable Limit of Deflection of Engine Room Double Bottom	506
10.8	Control of Deflection of Engine Room Double Bottom	509
10.9	Sea Chest in Engine Room Double Bottom	511
11	Stern Construction and Stern Frame	513
11.1	Aft Peak Tank Construction	514
11.2	Vibration of Stern Structure	515
11.2.1	Vibration of Stern Overhang	515
11.2.2	Transverse Vibration of Stern Bossing of a Single Screw Vessel	518
11.2.3	Vertical Vibration of Twin Bossing in Twin Screw Vessel	518
11.3	Stern Frame	521
12	Vibration Prevention	527
12.1	Exciting Forces	528
12.1.1	Magnitude of Propeller Excitation	529
12.1.2	Magnitude of Diesel Engine Excitation	532
12.1.3	Magnification of Exciting Force by Resonator	534
12.1.4	Cancellation of Exciting Force	541
12.1.5	Reduction of Main Engine Exciting Force by Elastic Mounting	543

12.2	Prevention of Ship Vibration	545
12.2.1	Flexural Vibration of Hull Girder	546
12.2.2	Vibration of Superstructure	548
12.2.3	Active Mass Damper for Superstructure Vibration	550
12.2.4	Vibration of In-Tank Structures	552
12.2.5	Calculation Methods of Natural Frequency of In-Tank Structures	552
13	Superstructure	559
13.1	Example of Damage to Long Superstructures	559
13.2	Interaction of Superstructures and Main Hull	559
13.3	Magnitude of Longitudinal Bending Stress	561
13.4	Prevention of Structural Failures	564
13.4.1	Structural Discontinuity	564
13.4.2	Round Shape of Side Wall Opening Corner	565
13.4.3	Buckling	568
13.4.4	Expansion Joints	570
	References	571
	Index	573