Springer Tracts in Civil Engineering

Springer Tracts in Civil Engineering (STCE) publishes the latest developments in Civil Engineering—quickly, informally and in top quality. The series scope includes monographs, professional books, graduate textbooks and edited volumes, as well as outstanding Ph.D. theses. Its goal is to cover all the main branches of civil engineering, both theoretical and applied, including:

Construction and Structural Mechanics
Building Materials
Concrete, Steel and Timber Structures
Geotechnical Engineering
Earthquake Engineering
Coastal Engineering
Hydraulics, Hydrology and Water Resources Engineering
Environmental Engineering and Sustainability
Structural Health and Monitoring
Surveying and Geographical Information Systems
Heating, Ventilation and Air Conditioning (HVAC)
Transportation and Traffic
Risk Analysis
Safety and Security
To submit a proposal or request further information, please contact: Pierpaolo Riva at Pierpaolo.Riva@springer.com, or Li Shen at Li.Shen@springer.com

More information about this series at http://www.springer.com/series/15088

Ioannis Vayas · John Ermopoulos
George Ioannidis

Design of Steel Structures to Eurocodes

Springer

Ioannis Vayas
School of Civil Engineering
National Technical University of Athens
Athens, Greece

George Ioannidis
National Technical University of Athens
Athens, Greece

John Ermopoulos
National Technical University of Athens
Athens, Greece

ISSN 2366-259X ISSN 2366-2603 (electronic)
Springer Tracts in Civil Engineering
ISBN 978-3-319-95473-8 ISBN 978-3-319-95474-5 (eBook)
https://doi.org/10.1007/978-3-319-95474-5

Library of Congress Control Number: 2018962122

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

Buildings characterize urban areas and are related to the personal, social and professional activities of people. The selection of the appropriate materials for its structural elements (reinforced concrete, steel, aluminum, wood, masonry), depends on the characteristics of the building and the design criteria, such as economic, aesthetic, functional, execution time, as well as the conditions of soil quality and seismicity of the construction area. Steel, as a main structural material, is used in all countries, in a different by country extent, depending on the local conditions and the existing tradition in the construction methods. Steel buildings may be distinguished in single and multi storey. Single storey steel buildings are mainly erected for industrial, commercial, warehousing and sports applications. Multi storey constructions are mainly used for residential or office purposes.

The design and fabrication of buildings are performed following rules provided in specifications and Codes. During the last decades, an extended program of common Codes for all European countries was developed, called Eurocodes, covering both design and fabrication issues, in order to facilitate mobility of construction companies, design offices and engineers in the area of the European Community and beyond it. In addition the cooperation between authorities and technical organizations and personnel, coming from different countries, should become easier.

This book presents the rules for the design of steel buildings according to the above Eurocodes, covering the structure as a whole, as well as the design of individual structural members and connections. The presentation is supplemented by many numerical examples. Specific sections of the book are dedicated to the conceptual design, the fabrication and erection phases and the quality requirements. Rules for the seismic design, when required, are also included. The text is organized in 9 chapters. Chapters 1-5 deal with the methods of analysis, the limit states of design and the resistances of cross-sections, members and connections, while chapters 6-8 are related to the conceptual design of single and multi storey buildings as well as to the fabrication methods and the quality control. Chapter 9 includes numerical applications of the design rules in the form of 52 design examples.

Chapter 1 presents the bases of design, in the frame of Eurocodes, the actions applied to building structures, the load combinations for the various limit states of design, as well as the main steel properties and the steel fabrication methods.

Chapter 2 deals with the models and methods of structural analysis, in combination with the structural imperfections and the cross-section classification according to their compactness.

Chapter 3 discusses the cross-sections resistances, when subjected to axial and shear forces, bending or torsion moments and to combinations of the above.

Chapter 4 presents the members design and more specifically the design of members sensitive to instability phenomena, such as flexural, torsional and lateral-torsional buckling. A particular section is devoted to composite beams.

Chapter 5 refers to the design of connections and joints executed by bolting or welding, including beam to column connections in frame structures.

Chapter 6 discusses alternative configurations to be considered during the conceptual design phase of different types of single storey buildings. The design of crane supporting beams is discussed in a special section.

Chapter 7 gives information about the structural elements and systems of multi storey buildings, especially those ensuring their overall stability along the height, as well as about the alternative configurations that could be applied.

Chapter 8 refers to the fabrication and erection procedures, as well as the related quality requirements and the quality control methods. The procedures for bolting, welding and surface protection are included.

Chapter 9 presents fifty two representative numerical examples, based on the design rules for the verification of cross-sections and members, subjected to the usual types of loading, the verification of bolted and welded connections, as well as for specific items such as hollow sections' joints, uniform built-up compression members or column bases. The calculation steps are directly related in the text with the corresponding paragraphs of Eurocodes.

The book is addressed to the structural engineering students, to young engineers working in the field of design or construction of steel buildings, as well as to engineers not familiar with the regulations of Eurocodes.

Acknowledgments

We would like to thank the following PhD students at NTUA for preparing Figures, Tables and providing Technical support: Stella Avgerinou, Maria-Eleni Dasiou and Zacharias Fasoulakis. We also thank Dr. Kostis Kalochairetis for his comments on part of the text.

About the Authors

Ioannis Vayas is professor and director of the Institute of Steel Structures at the National Technical University of Athens. He graduated in civil engineering at the same university and received his Dr.-Ing. from the Technical University of Braunschweig, Germany and his welding Engineer specialization from SLV Hannover, Germany. He has been involved in research, national and European codification and consultancy on steel structures for over 40 years.

John Ermopoulos is professor emeritus and former director of the Institute of Steel Structures at the National Technical University of Athens. He graduated from the School of Civil Engineering and received his PhD Thesis from the same university. He is author of numerous publications in international Journals and Conferences. He is also author of various technical books. He has been involved in European research projects and in Technical Committees regarding steel. He was for many years consultant in various public and private technical projects.

George J. Ioannidis is professor emeritus of the National Technical University of Athens (NTUA)-School of Civil Engineering, where he was teaching the courses of steel structures for many years. He graduated from this School, followed post-graduate studies in Aix-Marseille University (France) and received the PhD graduation from NTUA. He is the structural designer of numerous buildings and other civil engineering structures made from steel or reinforced concrete.

Contents

Symbols

Effort was made for the symbols to be in accordance with those used by the Eurocodes. A single symbol is used for those quantities where different symbols are used by different Eurocodes.

General symbols for geometric properties

b	width
d	depth
h, H	height
t	thickness
l, L	length, span

General symbols for mechanical properties

A	area
I	second moment of area (moment of inertia)
S	first moment of area (static moment)
W	cross-section modulus

General symbols for internal forces and moments

M	bending moment
M_T	torsional moment
N	axial force
V	shear force

General symbols for stresses

σ	direct (normal) stress
τ	shear stress

Indexes

a	structural steel
add	additional
b	beam
bat	batten
B	buffer

bear	bearing
c	concrete, compression, column, crane
ch	chord
cr	critical value
d	design value, diagonal
dur	durability
E	action effect
eff	effective
el	elastic
eq	equivalent
f	flange
f_o	upper flange
f_u	lower flange
fat	fatigue
G	permanent
H	horizontal
inf	lower value
k	characteristic value
L	longitudinal, longterm
max	maximum value
min	minimum value
nom	nominal value
o	top, opening
ov	over-strength
p	plate panel zone
pay	payload
pl	plate, plastic
r	rail
R	resistance
s	reinforcement, skewing
S	shrinkage, short
sa	steel + reinforcement
ser	serviceability
sup	upper value
sur	surface
t	tension
T	torsional, transverse
tot	total
u	ultimate, limit value, bottom
V	vertical
w	web, warping, weld
y	yield
I	first order
II	second order

Axes

x	longitudinal axis of member
y	major principal axis of cross-section
z	minor principal axis of cross-section

Operators

Δ	difference
δ	variation

Latin small letters

a	length, thickness of a fillet weld, distance between wheels, spacing, clearance, skewing angle
a_g	peak ground acceleration
b	width, free gap
b_{eff}	effective width
b_{fo}	width of top flange of steel girder
b_{fu}	width of bottom flange of steel girder
b_o	half distance between webs
b_r	width of a rail, width of a rib
b_s	spacing between ribs
c	outstand flange width, concrete cover of reinforcement/shear connectors, smeared spring constant, hole clearance
c_e	exposure factor
c_f	wind coefficient, force coefficient for the structure or elements
c_{min}	minimum value of concrete cover
c_{nom}	nominal value of concrete cover
c_{pe}	pressure coefficients for external pressure
c_{pi}	pressure coefficients for internal pressure
$c_s\, c_d$	structural factor
c_ϕ, c_θ	stiffness of rotational spring
d	differential, diameter, shank diameter of shear connector, length of diagonal, grain diameter, thickness of concrete slab, depth of cross-section
$d_{head,sc}$	head diameter of shear connector
d	hole diameter
d_r	design interstorey drift
e	eccentricity, length of a link
e_D	edge distance of shear connectors from steel flange
e_E	edge distance of shear connectors from concrete slab
e_L	spacing of shear connectors in longitudinal direction, length of a long link
e_s	length of a short link
e_T	spacing of shear connectors in transverse direction
e	imperfection, initial, bow
e_1, e_2	end/edge distance of bolts
f	reduction factor, stress, skewing angle coefficient, source to object distance

f_{cd}	design compression strength of concrete
f_{ck}	characteristic compression strength of concrete
f_u	tensile strength
f_{ub}	tensile strength of bolts
f_{vw}	shear strength of welds
f_y	yield stress of steel
f_{yd}	design yield strength of steel
f_{yk}	characteristic yield stress of structural steel
$f_{y,w}$	yield stress of web
g	permanent load, acceleration of gravity, gap, length of a haunch
g_a	self-weight of steel girder
g_c	self-weight of concrete
h	height, magnitude of weld imperfection
h_c	height of concrete slab
h_p	height of a trapezoidal sheet
h_r	height of rail
h_w	height of web
h_o	notional size, height of a web opening
i	index, radius of gyration
i_M	polar radius of gyration in respect to shear center
i_p	polar radius of gyration
k	spring constant, constant for relationship between yield strength and grain size, floor stiffness
k_1, k_2	reduction coefficients for concrete strength
k_σ	plate buckling coefficient
k_τ	shear buckling coefficient
l	length
l_{eff}	effective length
l_k	buckling length
l_T	buckling length in respect to torsion
l_y	effective loaded length
m	mass, distributed moment
m_{Ny}	non-dimensional strong axis bending resistance allowing for axial force
$m_{N.y.w}$	non-dimensional resistance of web for strong axis bending allowing for axial force
m_{Nz}	non-dimensional weak axis bending resistance allowing for axial force
m_u	non-dimensional bending moment for angles strong axis
m_v	non-dimensional bending moment for angles weak axis, number of single wheel drives
m_y	non-dimensional bending moment, strong axis
m_{yf}	non-dimensional resistance of flanges for strong axis bending
m_{yw}	non-dimensional resistance of web(s) for strong axis bending
m_z	non-dimesional bending moment, weak axis
m_{zf}	non-dimensional resistance of flanges for weak axis bending
m_{zw}	non-dimensional resistance of web(s) for weak axis bending

n	non-dimensional axial force, number, number of, modular ratio of concrete, distribution coefficient
n_f	non-dimensional axial resistance of both flanges
n_L	modular ratio depending on the type of loading
n_w	non-dimensional axial resistance of web(s)
n_o	number of openings on beam's web
n_1, n_2	non-dimensional resistance of web(s) for weak axis bending, distribution factors
p	uniformly distributed load, pitch between bolt holes
p_R	probability of exceedance
p_1, p_2	spacing of bolts, parallel/perpendicular to force
q	uniformly distributed load, behavior factor
q_b	basic wind pressure
q_{fk}	uniformly distributed imposed load on buildings
q_p	peak velocity pressure
$q_{u,kin}$	collapse load of kinematic theorem
$q_{u,stat}$	collapse load of static theorem
r	radius
s	snow load, length in lattice girders, spacing of staggered bolt holes, spacing
s_k	snow load, characteristic value
s_o	spacing between web openings
t	thickness
t_f	thickness of flange
t_{fo}	thickness of top flange of steel girder
t_{fu}	thickness of bottom flange of steel girder
t_w	thickness of web
u	perimeter, displacements, cross-section major axis of bending for angles
v	loading speed, deformation in y-direction, cross-section minor axis of bending for angles, travelling speed of a crane
v_b	basic wind velocity
v_L	longitudinal shear flow
$v_{L,Ed}$	longitudinal shear flow, design value
$v_{L,Rd}$	longitudinal shear flow, design resistance
v_{Mt}	shear flow due to torsional moments
w	width, deformation in z-direction, deflection
w_M	deflection due to moments
w_V	deflection due to shear forces
x_{pl}	depth of plastic neutral axis

Greek small letters

α	aspect ratio of panel, imperfection factor, amplification factor
α_{crit} ,α_{cr}	critical load multiplier
α_f	ratio of the area of both flanges to the total area of the cross-section

α_h, α_m	reduction factors for sway imperfection
α_{LT}	imperfection factor for lateral torsional buckling
α_{pl}	shape factor of a cross-section
α_t	coefficient of thermal expansion
$\alpha_{ult.k}$	load multiplier to reach the characteristic resistance
α_w	ratio of the web area to the total area of the cross-section
β	buckling length coefficient
β_w	correlation factor for welds
γ	safety factor, specific weight, sliding angle
γ_A	partial safety factor of accidental actions
γ_{AE}	partial safety factor of seismic actions
γ_c	partial safety factor for concrete
γ_f, γ_F	partial safety factors for actions
γ_{Ff}	partial safety factor for fatigue stresses variation
γ_G	partial safety factor of permanent actions
γ_m	partial safety factor for a material property
γ_{M}	partial safety factor for resistance
$\gamma_{\mathrm{M}f}$	partial safety factor for fatigue resistance
γ_{M0}	partial safety factor for yield
γ_{M1}	partial safety factor for stability
γ_{M2}	partial safety factor for fracture and connections
γ_{M3}	partial safety factor for slip
γ_Q	partial safety factor of variable actions
γ_{Rd}	partial safety factor for resistance
γ_s	partial safety factor for reinforcement
γ_v	partial safety factors for shear connectors
γ_I	importance factor
δ	deflection, Dischinger coefficient
δ_{pay}	deflection due to payload
ε	strain, coefficient depending on f_y
ε_y	yield strain
ε_u	ultimate strain
θ	rotation, angle of twist, inter-story sensitivity coefficient
θ_p	rotation of a plastic hinge
κ	curvature
λ	slenderness, damage equivalent coefficient, skewing forces coefficient, overlapping percentage
λ_1	reference slenderness
$\bar{\lambda}$	relative slenderness for flexural buckling
$\bar{\lambda}_{LT}$	relative slenderness for lateral torsional buckling
$\bar{\lambda}_{op}$	relative slenderness for out-of-plane buckling
$\bar{\lambda}_p$	relative slenderness for plate buckling
$\bar{\lambda}_w$	relative slenderness for shear buckling
$\bar{\lambda}_y$	relative slenderness for major axis buckling
$\bar{\lambda}_z$	relative slenderness for minor axis buckling

μ	slip factor, ductility index, efficiency factor for built-up members
μ_i	snow shape coefficient
ν	Poisson ratio, reduction factor
ξ	damping ratio
ρ	density, reduction factor for plate buckling, reduction factor for presence of shear, strut index, warping rigidity
ρ_s	reinforcement ratio
σ	direct stress
σ_a	stress in structural steel
σ_c	stress in concrete
σ_{cr}	critical buckling stress
$\sigma_{cr,p}$	critical stress for plate buckling
$\sigma_{cr.FT}$	critical flexural-torsional buckling stress
$\sigma_{cr.T}$	critical torsional buckling stress
σ_s	stress in reinforcement
σ_{true}	true stress
σ_w	stress in web
τ	shear stress
τ_{cr}	critical shear buckling stress
τ_{Ed}	design shear stress
τ_f	flange shear stress
τ_w	web shear stress
ϕ	angle, dynamic factor
ϕ	initial sway imperfection
χ	buckling reduction factor
χ_c	reduction factor for column buckling
χ_{LT}	reduction factor for lateral-torsional buckling
χ_{op}	reduction factor for lateral or lateral-torsional buckling
χ_w	reduction factor for shear buckling
χ_y	reduction factor for major axis buckling
χ_z	reduction factor for minor axis buckling
ψ	stress ratio, end moments, ratio combination factor of one action with other actions
ψ_0	basic value of combination factor
ψ_1	frequent value of combination factor
ψ_2	quasi permanent value of combination factor
ω	warping function
ω_0	natural circular frequency

Capital letters

A	cross-section area, gross section area, accidental action
A_d	cross-section area of a diagonal
A_E	seismic action
A_{eff}	effective cross-section area
A_f	flange area of cross-section

A_{net}	net section area at holes
A_p	gross area of plate
A_{ref}	reference area for wind force
A_s	stress area of bolts
A_u	minimum cross-section area after fracture
A_v	shear area
A_w	web area of cross-section, throat area of weld
A_0	initial cross-section area, area enclosed by the middle line of a hollow section
B	warping bimoment
B_{Ed}	design warping moment
$B_{el.Rd}$	elastic bimoment resistance
$B_{p.Rd}$	punching resistance of bolts
$B_{pl.Rd}$	plastic bimoment resistance
C	concrete, creep of concrete, wind load factor, spring constant
C_d	rotational spring, limiting design value of the effects of actions in SLS
C_e	exposure coefficient
C_m	equivalent uniform moment factors
C_t	thermal coefficient
D	maximum acceptable relative displacement, diameter, compressive force
Δh	height variation
Δl	elongation, contraction
ΔT_M	linear temperature difference
ΔT_p	temperature difference between structural parts
ΔT_u	uniform temperature difference
E	modulus of elasticity
E_a	modulus of elasticity of structural steel
E_c	modulus of elasticity of concrete
$E_{c,28}$	modulus of elasticity of concrete at 28 days
E_{cm}	modulus of elasticity of concrete – mean value
E_d	design value for effect of actions
$E_{d,dst}$	design value for effects of destabilizing actions
$E_{d,stb}$	design value for effects of stabilizing actions
E_D	absorbed hysteretic energy
E_s	modulus of elasticity of reinforcement
E_t	tangent modulus of steel
F	force
$F_{b,Rd}$	bearing resistance of bolts
F_{cr},F_{crit}	critical concentrated load, buckling load
F_d	design value of an action, force of a diagonal
F_{Ed}	imposed design load
$F_{f.Rd}$	bottom flange strength under concentrated load
F_k	characteristic value of an action
$F_{p.C}$	preloading force of bolts, design shear force of bolts
$F_{s.Rd}$	slip resistance of bolts
F_T	force on a T-stub

$F_{t.Rd}$	tension resistance of bolts
$F_{v.Rd}$	shear resistance of bolts
F_W	wind force, force on weld
G	weight, shear modulus, permanent action
G_1	self-weight of the structure
G_2	self-weight of non-structural elements
G_{inf}	permanent actions with favorable effects
G_{sup}	permanent actions with unfavorable effects
H	horizontal force, lateral force, altitude
HB	Brinell hardness
H_{Ed}	design horizontal loading
I	second moment of area (moment of inertia),
I_{eff}	second moment of area of effective part
I_{net}	second moment of area of net section
I_p	second moment of area of plate, polar second moment of area of a stiffener
I_t	torsion constant
I_w	warping constant
I_y	second moment of area around strong axis
I_z	second moment of area around weak axis
J	creep function, impact energy, torsion constant
K	stiffness , drive force
K_G	geometric stiffness matrix
L	length, span, longitudinal force
L_e	distance between zero moments
L_{eff}	effective length for resistance to concentrated forces
L_f	influence length
L_Φ	determinant length
M	bending moment, mass
$M_{a,el,Rd}$	elastic design moment resistance of steel girder
$M_{c,Rd}$	design bending resistance
M_{Ed}	design moment
M_{el}	elastic moment of a cross-section
$M_{el,Rd}$	elastic design moment resistance
$M_{f,Rd}$	design bending resistance of cross-section consisting of the flanges only
$M_{N,pl,Rd}$	design bending resistance of cross-section allowing for axial forces
$M_{N.y.Rd}$	design strong axis bending resistance allowing for axial forces
$M_{N.z.Rd}$	design weak axis bending resistance allowing for axial forces
M_{pl} ,M_p	plastic moment of a cross-section
M_{pN}	plastic moment allowing for axial forces
$M_{pl,Rd}$	design plastic bending resistance
$M_{pl.u.Rd}$	strong axis plastic design bending resistance for angles
$M_{pl.v.Rd}$	weak axis plastic design bending resistance for angles
$M_{pl.V.Rd}$	design plastic bending resistance allowing for shear forces
$M_{p.link}$	bending plastic resistance of a link
$M_{pl.y.Rd}$	plastic design bending resistance, strong axis
$M_{pl.z.Rd}$	plastic design bending resistance, weak axis

M_r	torque for tightening of bolts
M_R	bending resistance
M_{Rd}	design bending resistance
M_{sh}	primary shrinkage moment
$M_{T,Ed}$	design torsional moment
M_w	bi-moment
M_x, M_t	torsional moment
M_{xp}	primary torsional moment
M_{xs}	secondary torsional moment
$M_{y.Ed}$	design strong axis moment
$M_{z.Ed}$	design weak axis moment
M_I	moment from first order theory
M_{II}	moment from second order theory
N	axial force
$N_{b,Rd}$	design buckling resistance
N_c	axial force in concrete
$N_{c,el}$	force in concrete at elastic resistance of steel girder
$N_{c,f}$	force in concrete for full shear connection
N_{cr}	Euler buckling load, axial force at cracking of concrete
$N_{cr,y}$	critical buckling forces for major axis
$N_{cr,z}$	critical buckling forces for minor axis
$N_{c,Rd}$	design resistance to compression
N_E	critical Euler buckling load
N_{Ed}	design axial force
$N_{Ed.G}$	design axial force due to the non-seismic loads
$N_{net.Rd}$	design yielding resistance at net section
N_{pl}, N_p	plastic axial force
$N_{pl.Rd}$	plastic design resistance force
N_R	resistance to axial force
N_s	axial force in reinforcement
N_{sh}	primary shrinkage axial force
$N_{t,Rd}$	design resistance to tension
$N_{u,Rd}$	design ultimate resistance to tension for sections with holes
P	load, force, prestressing
P_e	limit elastic force
P_p	limit plastic force
P_{Rd}	shear resistance of shear connectors
P_u	ultimate force
Q	variable action, imposed load on buildings
Q_k	variable load, concentrated load, characteristic value
Q_{max}	maximum value of the characteristic vertical wheel load
$Q_{r.min}$	minimum load per wheel of the unloaded crane
R	resistance
R_d	design resistance
R_{fy}	resistance of a dissipative member
RH	relative humidity

S	static moment (first moment of area), snow load, fatigue class of a crane, force applied by the guidance means of a crane wheel
Sa	blast cleaning class
$S_{a,d}$	design response spectrum, design spectral acceleration
S_B	spring constant of a buffer
S_e	elastic response spectrum, elastic spectral acceleration
S_j	rotation stiffness of a joint
S_v	shear stiffness
T	temperature, vibration period, transverse force, total torsional moment
T_{Ed}	design torsion moment
T_L	design life
T_R	return period of an event
T_t	St Venant torsion moment
$T_{t.pl.Rd}$	plastic Saint Venant torsion resistance
T_w	warping torsion moment
U	class of crane related to the total number of cycles
V	shear force, vertical load, total potential
$V_{b,Rd}$	shear buckling resistance
$V_{bf,Rd}$	design shear resistance-contribution of the flange
$V_{bw,Rd}$	design shear resistance-contribution of the web
V_L	force due to longitudinal shear
$V_{p.link}$	plastic shear resistance of a link
V_{Ed}	design shear force, design vertical loading
$V_{pl,Rd}$	plastic shear resistance
V_{Rd}	design shear resistance
W	section modulus, wind load
W_{eff}	elastic section modulus of effective cross-section
W_{el}	elastic section modulus
W_{pl}	plastic section modulus
$W_{pl.u}$	strong axis plastic section modulus for angles
$W_{pl.v}$	weak axis plastic section modulus for angles
X	material property
Z	through thickness property
Δ	erection or manufacturing tolerance
$\Delta\delta$	deflection variation
$\Delta\sigma$	normal stress variation
$\Delta\sigma_c$	fatigue resistance against normal stress variation
$\Delta\tau$	shear stress variation
$\Delta\tau_c$	fatigue resistance against shear stress variation
$\Sigma\mathrm{Q}_r$	sum of all wheel vertical loads of a loaded crane
Φ	Coefficient to determine the reduction factor χ, diameter of bars
Ω	ratio N_{Rd}/N_{Ed} or M_{Rd}/M_{Ed}