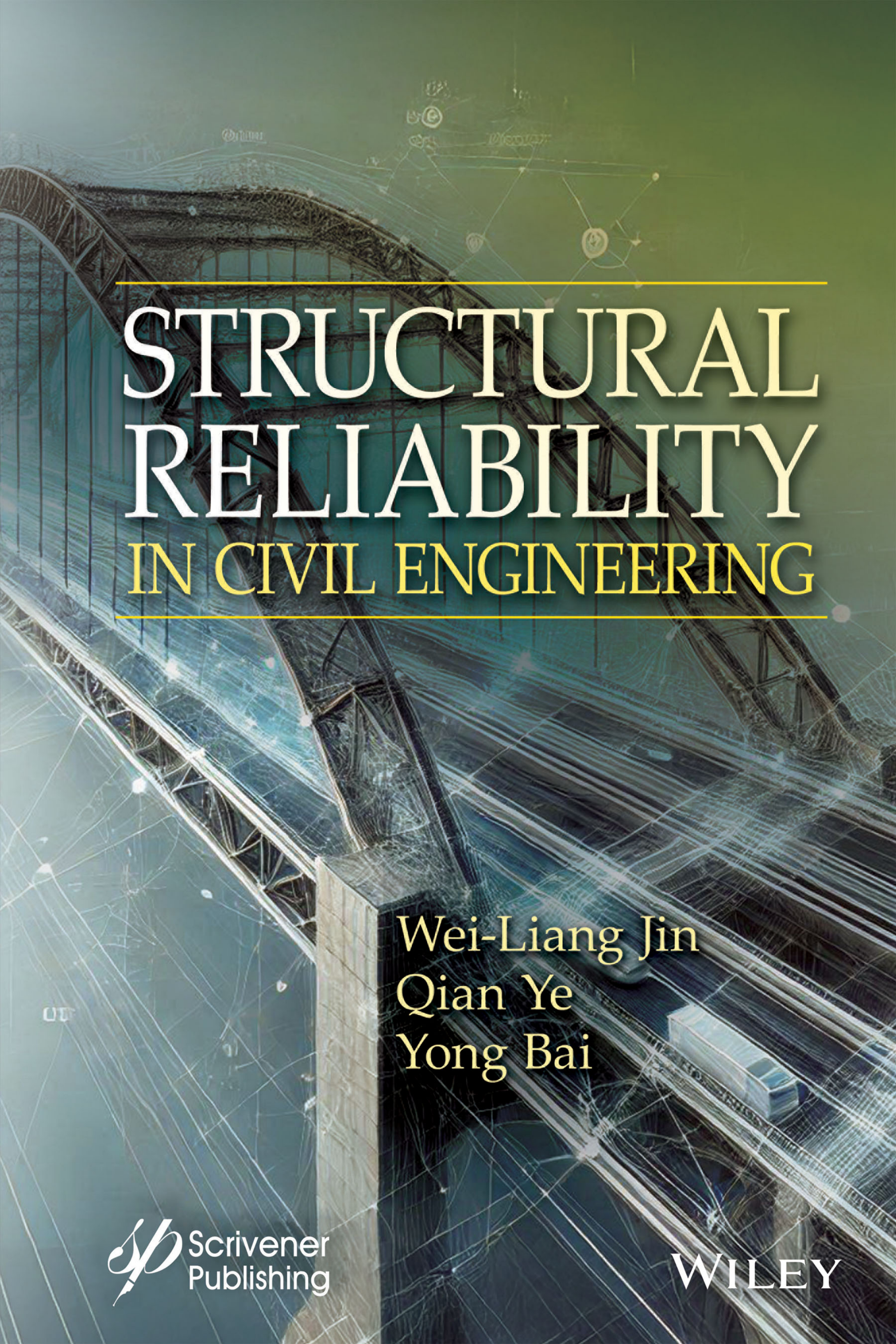

STRUCTURAL RELIABILITY IN CIVIL ENGINEERING

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Preface

Engineering structural reliability refers to the ability of a structure to complete predetermined functions within a specified time and under specified conditions, while the degree of structural reliability is a mathematical measure of reliability. According to the definition, the reliability of engineering structures should include three aspects: the first is the part of the structure itself, including structural resistance, structural type, and structural reuse; the second is the external effects that the structure is subjected to, including direct, indirect, and combined effects on the structure; the third involves the basic methods of structural reliability, including the calculation method of reliability, analysis of system reliability, and calculation of dynamic reliability. Therefore, the reliability of engineering structures mainly involves the basic methods of reliability, which is also the main content of this book.

The theoretical research on structural reliability flourished in the 1970s with the transition of structural design codes from the allowable stress design method to the probability-based limit state design method, while the domestic research work was relatively synchronized with the foreign research. However, in terms of basic theoretical research on structural reliability, there is a significant gap between the domestic research and the foreign research, which is basically modified according to the foreign regulatory systems, which means it is in a "running" stage compared to similar international research. With the continuous deepening of understanding and research on structural reliability theory in the domestic academic and engineering communities, especially the great discussion on structural reliability in the 1990s, it is necessary to consider both the theoretical system of structural specifications based on reliability and the practical functional requirements of structures in the application of engineering structures. This is mainly reflected in the formulation of unified standards for structural design reliability in the early 20th century. Changing "the structural reliability" to "the degree of structural reliability" is the biggest highlight of the unified standard formulation, which means it is in the "parallel" stage with similar international research. With the continuous progress of research on structural reliability theory by Chinese scientific and technological workers, and the deepening understanding of engineering structural reliability issues by engineering technicians, the establishment of China's regulatory system and the application of engineering structural reliability will be more perfect, and it is fully possible to achieve a "leading" stage compared to similar international research. This is also the purpose of writing this book.

This book consists of eight chapters, mainly introducing the development overview and basic concepts of the basic theory of reliability, uncertainty analysis methods, reliability calculation methods, simulation methods of reliability, system reliability analysis, time-varying structural reliability, load and load combination methods, the application of reliability in specifications, and the application of reliability theory in practical engineering.

This book can be used as a textbook and teaching reference for graduate and senior undergraduate students majoring in civil engineering, water conservancy, highway, railway, port, ship and ocean engineering in higher education institutions. It can also be a professional reference book for engineering technicians and scholars engaged in research and design in the fields of civil and industrial architecture, municipal facilities, bridges, roads (highways and railways), port and ocean engineering.

Acknowledgments

I would like to express my gratitude to Professor Guofan ZHAO of Dalian University of Technology in China for introducing me to the research field of structural reliability theory and application. In the future, he will continue to provide strong support and assistance in researching the reliability of marine structures, the durability of concrete structures, and other engineering structures, which I will never forget.

Thank you to Professor Eberhard LUZ from Stuttgart University in Germany for providing me with a relaxed and enjoyable working environment during my Humboldt research work from the autumn of 1991 to 1993, which enabled me to conduct research on uncertainty and numerical simulation of reliability in structural reliability.

Thank you to Professor Torgeir MOAN from Norwegian University of Science and Technology during my Norwegian Research Council's research work from 1994 to 1995. His extensive knowledge and working environment in marine engineering structures have enabled me to find new breakthroughs in the theory and application of structural reliability.

Thank you to colleagues from China National Offshore Oil Corporation (CNOOC) and the Engineering Reliability Committee of the Chinese Civil Engineering Society (CCES) for achieving reasonable application of structural reliability in structural design specifications, effectively promoting the development of structural reliability theory and application.

Since 1996, when I officially joined Zhejiang University, I have opened a research direction in structural reliability, established a new course called "Structural Reliability", and trained many doctoral and master's students. They all play important roles in their respective positions. This book also reflects their research achievements in the field of structural reliability. Here, I would like to express my heartfelt gratitude to them through this book.

I would like to express my special gratitude to Dr. Qian YE and Professor Yong BAI for their joint efforts and writing, which ultimately led to the formation of this manuscript.

The work of this book has received strong support from projects such as the National Natural Science Foundation of China (NSFC) and the Ministry of Science and Technology (MOST) of China; thank you to the teachers and graduate students of the research team on structural reliability at Zhejiang University, as well as to friends from all walks of life for their strong support and assistance in the publication of this book.

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Notations

a	Current crack length in Fracture mechanics model
A	Deflection of structural systems; Experience adjustment coefficient
a_a	The limit on crack length under certain functions after bearing secondary cyclic loads within its designed service life
A_{eff}	Effective sample area
A_{limit}	Maximum deflection of structural system
a_0	Initial crack length
A_q	Gross area of pile tip
A_s	Surface area of pile body
A_{whole}	Sampling area
B	Proposition supported by new experimental results
$b(X)$	Stress at any position in the structural system
B_Q	Deviation coefficient of Q
B_{SC}	Deviation coefficient of SC
C	Test constants in Fracture Effect coefficient for converting load into effect The specified limits for the structure or component body to meet the requirements for normal use
C_{kX}	Kurtosis coefficient
C_L	Lift coefficient of wave force
C_{sX}	Skewness coefficient
d	Truncated values in truncated distribution functions
D	Fatigue damage Outer diameter of pile Effects caused by dead load
$\bar{D}$	Effects caused by the average value of dead load

D_f	Structural damage area
d_{ij}	Fatigue damage due to wave, low or high frequency combination stress S_i under the sea case i and the wave direction j
D_S	Safety region of stochastic process in the whole life of structure
d^e	The displacement vector of all nodes in the element
E	Standard value effect of seismic loads
EF	Error factor
E_i	Subjective uncertainty
e_{jk}	Error term due to spatial averaging
E_k	Plastic failure of the first failure mode
f	Surface friction force per unit area
$f(\boldsymbol{X})$	Joint density function of variables $\boldsymbol{X}(=(x_1,x_2,\ldots,x_n))$
$f_{Gray}(z)$	The built-in function of gray variable
f_{Hi}	Zero crossing rate of high-frequency mooring force
f_i	Average zero crossing rate
F_i	i^{th} failure mode
f_k	Standard values of material properties
f_{Li}	Zero crossing rate of low-frequency mooring force
f_{wi}	Wave zero crossing rate
f_t	Concrete tensile strength
F_{ij}	i^{th} failed component in the j^{th} failure mode
$F_{max\ X}$	Cumulative distribution function of **X** at maximum value
$F_{Mi}(x)$	Cumulative distribution function for maximum load effects of various combinations
$F_N(n)$	Cumulative distribution function in time integration method
$f_R()$	Probability density function for the whole structure
$f_R(t)$	Instantaneous probability density function of structural time-varying resistance
$f_{Ri}()$	Probability density function of the strength of the i^{-th} link
$f_{rsf}(x)$	Response surface function