
Table of Contents

PREFACE	ix
CHAPTER 1. UNCERTAINTY	1
1.1. Introduction	1
1.2. The optimization problem	3
1.3. Sources of uncertainty	4
1.4. Dealing with uncertainty	6
1.4.1. Reliability optimization	11
1.4.2. Robust optimization	12
1.4.3. Multi-object optimization	13
1.4.4. Stochastic optimization	14
1.4.5. Worst-case scenario based optimization	14
1.4.6. Non-probabilistic optimization	15
1.4.7. Interval modeling	15
1.4.8. Fuzzy sets	15
1.5. Analyzing sensitivity	16
1.5.1. Local sensitivity analysis	16
1.5.2. Global sensitivity analysis	16
CHAPTER 2. RELIABILITY IN MECHANICAL SYSTEMS	17
2.1. Introduction	17
2.2. A structure reliability problem	18
2.3. Modeling a structure reliability problem	18
2.3.1. A deterministic mechanical model	18
2.3.2. Risks and probabilistic modeling	18
2.3.3. Types of failure in a structure	19
2.3.4. Probability of failure in a structure	19
2.4. Calculating the probability of failure in a structure	20

2.4.1. Calculating the probability of failure using the Monte Carlo method	20
2.4.2. Calculating the probability of failure using a reliability index	21
2.5. Reliability indices	21
2.5.1. The Rjanitzyne–Cornell index	21
2.5.2. The Hasofer–Lind index	22
2.5.3. The FORM method	23
2.5.4. The SORM method	25
2.6. Overview of the resistance–sollicitation problem	26
2.6.1. Probability of failure	27
2.6.2. Reliability indices	28
2.7. System reliability in mechanics	33
2.7.1. Combinations of types of failure	34
2.7.2. Assessment of the failure probability of a system	35
2.8. The finite element method and structural reliability	36
2.8.1. Context and objectives of the problem	36
2.8.2. Discretization and modeling random fields	36
2.8.3. Mechano-reliability coupling	37
2.8.4. Surface response coupling	41
CHAPTER 3. OPTIMAL STRUCTURAL DESIGN	43
3.1. Introduction	43
3.2. Historical development of structural optimization	44
3.3. Classifying structural optimization problems	44
3.3.1. Dimensional optimization	45
3.3.2. Topological optimization	45
3.3.3. Shape optimization	47
CHAPTER 4. MULTI-OBJECT OPTIMIZATION WITH UNCERTAINTY	51
4.1. Introduction	51
4.1.1. Choice of an optimization method	52
4.1.2. Classifying optimization methods	52
4.2. User classification	53
4.3. Design classification	54
4.4. Multi-objective genetic algorithms	54
4.5. Robust multi-objective optimization	56
4.5.1. Robustness criteria in multi-objective optimization	56
4.6. Normal boundary intersection method	57
4.6.1. Description of the NBI method	58
4.7. Multi-objective structural optimization problem	66
CHAPTER 5. ROBUST OPTIMIZATION	69
5.1. Introduction	69

5.2. Modeling uncertainty	69
5.2.1. Parametric methods	70
5.2.2. Non-parametric methods	71
5.3. Accounting for robustness in optimum research	73
5.4. Robustness criteria	74
5.4.1. Defining uncertainty in design parameters	74
5.4.2. Robustness criteria in multi-objective optimization	75
5.5. Resolution method	76
5.6. Examples of mono-objective optimization	77
CHAPTER 6. RELIABILITY OPTIMIZATION	79
6.1. Introduction	79
6.2. Overview of reliability optimization	80
6.3. Reliability optimization methods	81
6.4. The reliability indicator approach	81
6.5. The single-loop approach	82
6.6. The sequential optimization and reliability assessment approach	87
CHAPTER 7. OPTIMAL SECURITY FACTORS APPROACH	93
7.1. Introduction	93
7.2. Standard method	93
7.3. The optimal security factors (OSFs) method	95
7.4. Extension of the OSF method to multiple failure scenarios	99
CHAPTER 8. RELIABILITY-BASED TOPOLOGY OPTIMIZATION	113
8.1. Introduction	113
8.2. Definitions in topology optimization	114
8.3. Topology optimization methods	115
8.4. Reliability coupling and topology optimization	118
8.5. Illustration and validation of the RBTO model	120
8.6. Application of the RBTO model to mechanics	122
8.6.1. Static analysis	122
8.6.2. Modal analysis	123
BIBLIOGRAPHY	125
INDEX	131