Preface

The proposed manuscript, *Probability Based High Temperature Engineering: Creep and Structural Fire Resistance*, bridges the disciplines of aerospace engineering (AE), structural engineering (SE), materials science engineering (MSE), and fire protection engineering (FPE) by offering a screening tool that can be used by engineers to perform the assessments of high-temperature creep as a structural fire resistance factor and its impact on structures. In many cases this type of analysis requires establishing creep models based on the design fires and the fuel packages and running these models to estimate the degradation of strength of structural components. A proper understanding of the uncertainties involved in the modeling of creep process is quintessential for safe and sustainable construction. The gap between the available laboratory standard fire test data and the typical real fire scenario further aggravates the situation. The broad scope of composition, mechanical, and environmental parameters characterizing each creep test in the database calls for the use of stochastic models. As the first step, stochastic models for all the required input parameters as well as the correlation fields are needed to properly calibrate safety factors for creep, as well as to provide the basis for realistic probabilistic assessment of reliability. The internationally available literature contains many, more or less involved, theories and models that have been developed to predict engineering creep.

All structures contain various uncertain properties. Modern standards customarily represent uncertainties in terms of semi-probabilistic checking concepts. By contrast, a full probabilistic reliability analysis can be performed, which determines the failure probability of the system based on the applied probability methods for specified limit states. This limit states are described by a given set of deterministic functions and analyzed independently from the random parameters used in the correspondent probabilistic reliability analysis. Standard methods in a reliability analysis compute results of this limit state function in order to estimate the failure probability, independent of the type of problem definition. This independency permits a separate implementation of the reliability analysis. Therefore, the correspondent probabilistic reliability analysis would be applicable for different fields of interest, such as dynamical reliability problems or design in foundation engineering.

Safety, reliability, and risk are key issues in a world of increasingly complex engineering facilities and infrastructure. The existence of natural and man-made hazards calls for the consideration of safety and risk in both the design and the preliminary stages. This book is focusing on providing solutions for practical applications and dealing with the practical challenges involved in incorporating structural safety and reliability in engineering practice. While there is an underlying theoretical framework in the areas of structural safety and reliability, translation from theory to practice in engineering is still urgently needed.

Despite the great development of research on creep of various materials and designs now, almost no books are devoted to the phenomenological theory of creep that is uniting disparate theories developed in relation to the calculation of various types of structures and facilities under the influence of thermal load from fire or any other high-temperature loads.

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This book is focusing on providing solutions for practical applications and dealing with the practical challenges involved in incorporating structural safety and reliability in engineering practice. The main attention is paid to approximate methods (exact analytical solution in this case is not required, since the ultimate goal is to solve the creep constitutive equations in a probabilistic formulation) of solution of integral and differential equations considering creep effect of the high temperature from fire. Keeping in mind mainly engineering applications and practical calculations, the author did not seek large mathematical rigor and cared more about the visibility and accessibility of presentation, without, however, being overly simplistic. To achieve this goal the author has decided to include in each chapter a large number of examples to illustrate the theoretical basis of the material presented. The worked examples have all been programmed using simple POLYMATH software to insure their accuracy. Hence the numerical outputs quoted in this book are taken directly from POLYMATH solutions and the numbers have been rounded to the approximate number of significant figures at each output. The final solutions quoted in this book can therefore be compared directly with those obtained using other computer software (for instance MATHCAD or MATLAB). An in-depth explanation is presented through examples (that are presented in a simple step-by-step computational form) of computing the ultimate strength capacity of standard structural systems.

The main objective of this book is to provide the intelligent structural engineer practitioner with the approximate analysis of creep deformations and its effect on structural analysis and design. The results show that the developed approach is capable to reproduce basic features of high-temperature creep processes in engineering structures. The book contains a significant amount of original material, as well as substantially revised from previously published by author.

This book is similar to the previous book of the author ("Probability Based Structural Fire Load" and published by the Cambridge University Press in 2014) by the method of determining the statistical data for solving creep problems through the use of methods of applied probability theory. Namely, similar to the previous book integral dimensionless constitutive creep equation, first solved by numerical methods in a deterministic setting, and then declaring one of the dimensionless parameters included in the creep equation as a random variable, we obtain the discrete solutions of this equation, which, in turn, are realization of a random creep process.

Well-developed methods for approximating the failure probability are FORM and SORM (First-Order and Second-Order Reliability Methods). These are analytical solutions converting the integration into an optimization problem. In order to simplify the calculation the distribution functions of the random variables and the limit state function are transformed into a standardized Gaussian space. This transformation is defined via the cumulative distribution function $\Phi^*(z)$, where z is the transformed and standardized Gaussian variables. This leads to a simplified formulation of the failure probability $P_f \approx \Phi^*(-\beta)$, where β is the so-called reliability index.

This book will be a useful tool to aerospace engineers, structural engineers, materials science engineers, and fire protection engineers. It also has practical application in academia for AE, SE, MSE, and FPE students. The book will be used as guidance tool to determine the effect of high-temperature creep on structural fire resistance and which model variables require a greater degree of analysis. This can help in determining the most economical structural design for a given fire scenario.

This book will serve a wide range of readers, in particular, graduate students, professors, scientists, and engineers. Thus, the book should be considered not only as a graduate textbook, but also as a reference handbook to those working or interested in areas of applied probability in continuum mechanics, stress analysis, materials science, and fire protection design. In addition, the book provides an extensive coverage of great many practical problems and numerous references to the literature.

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