Preface

The static and quasi-static behaviors of concrete have been the subject of so many works that we often consider that they are quite well known and mastered as far as modeling with a view to structure calculations is concerned. However, the same is not true of concrete's dynamic behavior, because of the complexity of the tests needed to reach pertinent loading rates.

The subject matter of Chapter 1 is divided into two parts: it presents the most widely used experimental techniques to study the dynamic behavior of concrete, drawing attention to the difficulties in interpreting the results of tests designed to identify its intrinsic parameters. It also offers a synthesis of properties that have been published in the literature dealing with concrete (chiefly its traction and simple compression strengths), as well as values for reinforced or fiber-reinforced composites. An extensive bibliography enables the reader to refer to the relevant original articles.

Dynamic loadings can generate non-linearities and a range of deteriorations in concrete (failure from bending and/or shear, traction, mechanical spalling, tearing, compression, compaction and hole perforation, etc.), all of which have to be carefully modeled to enable prediction of the behavior of a specific structure under a violent action. The variety of responses has generated several unique modeling approaches. Depending on the phenomenon under consideration, we use either the *damage approach* for cracking, the *plasticity or viscoplasticity approach* for shear, or the *still volume-pressure influence approach* for compaction. The theoretical contexts are discussed in Chapter 2, before the essential elements of several "conventional" models are described, along with their strengths and weaknesses.

In Chapter 3, the subject matter turns to the particular category of dynamic oscillations associated with earthquakes. As an introduction, Chapter 3 deals with the way seismic movement measurements – which generate the data used for structure reaction calculations – are made. Besides presenting the addresses of databases of signals measured in different countries, this chapter also introduces the concept of *spectral representation*, which plays a key role in engineering practice. A geophysical interpretation of seismic movements in connection with subjacent phenomena is proposed, which integrates the contributory effects of the site and the topography of the environment around the structure.

Though typical practice involves calculating the reaction of a structure submitted to an earthquake by considering its base to be totally embedded, the nature of some soils, coupled with the exceptional character of some structures (like dams and nuclear reactors), demands that the behavior of the structure is modeled in a particular environment. This problem is called structure-soil interaction, and forms the subject of Chapter 4. To solve this problem, it is necessary to have a model of the soil's behavior under cyclic loading. Different models exist, depending on the nature and amplitude of the loading. After modeling, the interaction problem can either be treated by superposition, by considering the soil and the structure separately for linear cases, or globally for non-linear situations.

The difficulty of conducting structure tests on full-sized models led to the development of experimental methods employing scale models. Vibrating tables, which reproduce earthquakes on a small scale, were designed for this purpose. The subsequent development of fast and powerful computers gave birth to the pseudo-dynamic method, in which the purely dynamic effects of an earthquake are simulated using calculations. These complementary techniques both have their own advantages and disadvantages. The quality of the results they can produce depends mainly on the quality of model implementations, which are described in detail in Chapter 5.

Chapter 6 is concerned with experimental techniques on large structures. Experiments play an essential role in obtaining realistic data about a structure's dynamic signature; mechanically-controlled vibration tests are not easy to implement, but they are a crucial source of information. This chapter shows how an excitation with rotating masses, coupled to adapted instrumentation and measurement processing, gives access to a vast amount of key information concerning natural modes, frequency damping, damage indications and coupling effects between the structure and its environment. This forms an invaluable database that model-makers need to calibrate their models, which is a pre-requisite of any realistic analyses of the seismic response of an existing structure.

Chapter 7 examines the structure-modeling field as applied to the seismic analysis of concrete buildings. The chapter focuses on approaches that allow engineers to simulate reactions to the application of an earthquake by exploring the non-linear field and collapse modes.

In this context, three model families are considered: global, semi-local and local models. The first rely on empirical behavior descriptions, gathering phenomena at the level of a single section or structural element with occasional brief discretization. The second type of model works out global laws from phenomenological local models, with discretization made at the multi-fiber or multi-layer beam level. The third type of model is more sophisticated and takes the responses of a building's constituent materials and their bindings into account. These demand very thorough discretization, their main disadvantage being that they are very time-consuming to implement.

Validation analyses are proposed based on experiments carried out on shaking tables or reaction walls. The results show that that modeling has reached such a sophisticated stage of development that it allows complete experimental and experiment-feedback analyses, and is therefore ready for transfer to everyday engineering.

Chapter 8 introduces a quite promising analysis procedure: probability analysis. It is clear that the uncertain nature of seismic loading must be taken into account for the dimensioning of large structures. However, though sophisticated methods are used (seismic movement correlation, structure-soil interaction, behavioral non-linearity, etc.), the models remain "deterministic".

This chapter shows that the determinist approach can sometimes lead to erroneous predictions, and that better control of phenomena makes it necessary to take into account the probabilistic character of the problem. Probabilistic seismic analysis is a new field of research that should lead to significant advances in paraseismic engineering.

Chapter 9 considers the craft aspect of engineering in the field of seismic building analysis. The subject of this chapter, experiment feedback and regulations, is important, as engineers are ultimately responsible for the safety of people as well as buildings, despite the fact that building science is not a totally exact science. Numerous theories can help analyze the behavior of structures, but the limits of the problems faced by engineers in that field remain "fuzzy" (action characterization, structure complexity, local behavior facts, soil-structure interaction, etc.). Regulations can provide a framework that makes the analysis concepts reliable. Experiment feedback gives an indication of those approaches that have worked and those that have not, and considering this when developing regulations obviously assists progress in safety control. This is the subject of this chapter, which also gives an excellent account of the spirit in which the paraseismic design of various concrete structures should be approached.

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