AN OVERVIEW OF MAJOR ASPECTS OF THE AIRCRAFT IMPACT PROBLEM

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SUMMARY

The state-of-the-art with regard to aircraft impact hazard investigations is still in its infancy and is not developed to the stages that have been achieved in engineering for other dynamic effects. The aircraft impact loading is a unidirectional, high-magnitude, short-duration impulsive loading, with a wide range of frequencies extending into the higher frequency zone, and includes a variety of wave forms. To determine the response of a structure subjected to an aircraft impact loading, it is important to consider the behavior of the local impacted area as well as overall behavior of the remainder of the structure. The local behavior may generally be nonlinear due to the high magnitude of the load, while the overall behavior may remain linear. The frequencies and the forces transmitted through the nonlinearly behaving local impacted area into the remainder of the overall structure are generally significantly different than if the local impacted area behaves linearly.

This paper identifies the major aspects of the aircraft impact problem, resolves some of the basic issues underlying these aspects, and spotlights the major and most relevant topics for future investigations. The emphasis is on three main topics: (1) modeling techniques (2) influence of nonlinear behavior of structures on their response, and (3) importance of damping in the dynamic response analyses for aircraft impact loading.

Results are presented from brief studies involving response of linear and nonlinear simple systems to short-duration impulsive loadings of the aircraft impact type. For linear elastic cases, the transient and free vibration components are studied separately for simple systems with different natural periods. The nature of decay of free vibrations provides a general indication of the influence of damping on the dynamic response of systems. The influence of damping on floor response spectra is also studied for simple systems, both in the form of peak values as well as the corresponding frequency shifts.

The Fourier spectrum for a typical aircraft impact loading function is presented and the influence of very high frequency components in the form oi sharp corners in the loading function is discussed. For nonlinear simple systems, ranges of required ductility ratios for a typical aircraft impact loading are presented and compared against available ductility ratios for typical wall and slab panels. It is shown that potential for severe local failure or damage is very high for conventially designed structures.

In addition to the above brief studies, an extensive literature survey was carried out on several major topics pertinent to the aircraft impact problem, encompassing various disciplines of civil, mechanical, and aeronautical engineering. Results and discussions on the basis of this literature survey are presented for some of the major topics. For example, a critique is presented on the validity of finite-element techniques applied to the wave propagation problem associated with aircraft impact analyses. Also presented is a discussion of the variation of damping with frequency, and the influence of nonlinear behavior on structural response. The paper concludes with findings and recommendations.