Chapter 71
Significance of Structural Dynamics in Engineering Education in the New Millennium

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ABSTRACT

Structural Dynamics has gained prominence recently due to (i) vibration problems in slender structures that have emerged as a result of new materials technology and aesthetic requirements, (ii) ageing bridge structures whose health needs to be monitored and appropriate retrofitting carried out to prevent failure and (iii) increased vulnerability of structures to seismic, impact and blast loads. Knowledge of structural dynamics is necessary to address these issues and their consequences. In recent times, structural dynamics research has generated considerable amount of new knowledge to address these issue, but this is not readily available to practicing engineers as very little or none of it enters the class rooms. This paper argues for the need to include structural dynamics and the new research knowledge into the syllabus of all civil engineering courses, especially those with a major in structural engineering. This will enable our future structural engineers to design and maintain safe and efficient structures.

INTRODUCTION

Structural Dynamics is the study on the response of structures to loads that vary with time with respect to one or more of (i) position, (ii) direction or (iii) magnitude. This important topic, however has not received much attention in the engineering curricula until recent times. For several decades, structural engineering students have been taught (only) static methods to analyse and design structures such as building, bridges, pipelines, multipurpose towers, etc. This was because knowledge of structural dynamics was not common and the subject was difficult to teach. The effects of dynamics were included through Dynamic Load Allowances, (DLAs), Impact Factors (IFs) or Dynamic Amplification Factors (DAFs). For example, the bridge design codes provide charts which relate the DLA to be provided with respect to the first flexural natural frequency of the bridge. The first

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natural frequency is estimated in the absence of dynamic analysis. In the design of crane girders, structural engineers use an IF to allow for the dynamic effects due to the crane movement. These simplified procedures in education and application obviously do not promote best practice. With the advent of advanced computing facilities and sophisticated experimental methods, there has been an increase in knowledge on the behaviour of structures subjected to dynamic loads. The time has hence arrived for structural dynamics to be included in engineering curricula and be taught in universities. In addition, there are three major issues with structural engineering in the new millennium. They are: (i) vibration problems in very tall and/or slender structures which have emerged as a consequence of new materials technology and aesthetic requirements (Thambiratnam et al., 2012), (ii) increased vulnerability of structures to random loads such as impact, blast and seismic loads (Thambiratnam & Perera, 2012; Jayasooriya et al., 2011; Thillakarathna et al., 2010) and (iii) safety concerns of aging structures, which suffer deterioration and/or subjected to increased loading (Chan & Thambiratnam, 2011). Real world examples of the consequences of these three issues are illustrated in Figures 1, 2, 3 and 4. Figure 1 shows the slender and aesthetically pleasing Millennium footbridge bridge in London. This bridge was closed on its opening day as it exhibited high levels of (lateral) vibration which the design engineers did not expect. It has since then been retrofitted with dampers at a cost similar to the cost of original construction. Figures 2 and 3 show the building damage caused by an earthquake and the damage of a bridge column by vehicular impact respectively. Figure 4 shows the aging (almost 70 year old) Story bridge in Brisbane which needs

Figure 1. Millennium bridge London

Figure 2. Seismic damage of buildings

Figure 3. Impact damage of bridge column

Figure 4. 70 year old (aging) story bridge, Brisbane