Structural Engineering Documents

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# Use of Timber in Tall Multi-Storey Buildings

International Association for Bridge and Structural Engineering (IABSE)

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# Preface

Much has been written in the last few decades about the relative merits of alternative materials for building construction. As part of such efforts, this Structural Engineering Document (SED) provides guidance to engineers on how to properly design multi-storey buildings that incorporate timber and timber-based products as superstructure elements. The scope encompasses traditional systems for buildings up to 10 storeys made from conventional timber products and innovative systems that employ modern timber-based composites, as well as emerging possibilities for using timber elements in very tall buildings.

Poor building performance is usually accompanied by a failure to integrate design across all aspects of a project; or a failure to link design concepts with the realities of local construction and maintenance practices. For example, if timber elements are not properly protected from wetting (i.e. more than occasionally wetted at rates that exceed ambient drying rates), they are unlikely to be durable. However, if they are protected adequately, timber elements are likely to retain their initial properties for centuries. This document emphasises attainment of Total Performance Goals on a cradle to grave basis, taking account of structural and non-structural considerations. In the contemporary parlance, structural design decisions must support attainment of Total Performance Goals from cradle to grave. Even though the lifespan of most buildings are indeterminate at the time of their conception, their design and construction must address issues like capability of the fabric to retain integrity up to and beyond the likely lifespan and eventual dismantling.

The intended audience for this SED is structural engineering practitioners, construction professionals, academic researchers, code drafting bodies, and students. However it is hoped that there will be ancillary audiences amongst architects, property developers, town planners, and governmental policy makers.

**Ian Smith**
**Andrea Frangi**

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# 1 Introduction

***Summary:*** *Since the dawn of civilization, timber has been a primary material for achieving great structural engineering feats. Yet during the late 19th century and most of the 20th century it lost currency as a preferred material for construction of large and tall multi-storey building superstructures. This Structural Engineering Document (SED) addresses a reawakening of interest in timber and timber-based products as primary construction materials for relatively tall, multi-storey buildings. Emphasis throughout is on the holistic addressing of various issues related to performance-based design of completed systems, reflecting that major gaps in know-how relate to design concepts rather than technical information about timber as a material. Special consideration is given to structural form, fire vulnerability, and durability aspects for attaining desired building performance over lifespans that can be centuries long. This chapter discusses the historical use of timber as a high-performance construction material and lays the groundwork for detailed discussion of modern practices and possibilities in other chapters.*

## 1.1 Historical use of timber for construction

Evidence has been found that in Neolithic China the pre-human species "Peking Man" constructed "nest residences" from branches and thatch. Earth was compacted around thick timber struts, and it is speculated that this was to prevent them from catching fire [1]. Although the practices were crude, this arguably means that timber engineering (structural use of timber) and fire engineering (control of fire risk) were born between 300 000 and 1 million years ago and predate humans. Similarly, carpentry skills that are the basis of modern ability to interconnect timber members have ancient origins. Stone Age people created load-bearing building systems that interconnected timbers using mortise-and-tenon joints that are the direct forerunner of traditional Chinese architecture [1].

From antiquity onwards, urban utilization of construction materials has been shaped by their fire performance when assembled into buildings. City-wide or district-wide conflagrations were the impetus for prescriptive building regulations that date back to the Roman Empire [2]. More modern catastrophes like The Great Fire of London in 1666 and The Boston Fire in 1872 have reinforced fear of urban fires, and many specific building code restrictions created between 17th and 19th centuries are recognizably alive today in some jurisdictions (e.g. not allowing timber buildings to have more than four storeys above ground). Historical building regulations

## Structural Engineering Documents

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