Evaluating Structural Steel for Reuse through Field Monitoring

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Summary

While reuse of structural steel would greatly reduce the environmental impact associated with civil construction, this practice is rare. The research described in this paper is aimed at addressing one of the primary reasons for this: uncertainty regarding the structural integrity of reused members. Specifically, in addition to providing an overview of the environmental benefits of reusing structural steel, this paper will review the components of a wireless instrumentation plan of a steel-framed building, which includes traditional strain gauges as well as innovative carbon nanotube-based sensing skins with the intended capability of recording the full strain history of a member from its arrival at the construction site through a significant portion of its service life. The design of the instrumentation plan is motivated by the premise that the greatest concerns regarding future structural integrity in a reuse application are during construction and in the vicinity of connections.

Keywords: structural steel, sustainable buildings, reuse, laboratory testing, construction, field testing, strain, residual stress, wireless sensor network, carbon nanotubes.

1. Introduction

There is a well-known need for sustainable structural engineering practices, as evidenced by statistics such as carbon footprints associated with current manufacturing and construction practices and known fossil fuel reserves. One simple framework for achieving sustainable practices is a waste management hierarchy whereby first consumption is reduced or minimized, then a material should be reused as many times as possible, and then, only at the end of an object's useful service life, perhaps after uses in several discrete applications, should the material be recycled. In considering this framework relative to current steel construction practice, the opportunities for minimization and recycling are well exploited. For example, modern design practices result in highly optimized designs with the minimum use of materials to meet the design objectives. Similarly, recycling of structural steel is common in the developed world, with Yellishetty et al. [1] reporting 2007 recycling rates between 50 and 90% in Japan, USA, Australia, Brazil, Europe, and China.

However, the current practice focused on minimal material use and recycling overlooks the more preferred option of reuse. Reuse of structural steel is so rare that sources were found to report such information only for the UK and Canada, with these rates being 13% and 10%, respectively [2, 3]. Rates in the rest of the world are likely far less than this. Gorgolewski et al. [3] enumerate several reasons for this with a primary concern being the liability associated with uncertain structural integrity of reused steel. Thus, a current research project is underway to record the full strain history of a member from its arrival at the construction site through a significant portion of its service life.

This paper first reviews the potential environmental benefits of reused structural steel. Then the current state of practice with regards to structural steel reuse is discussed. Next, the key components of the instrumentation plan (which includes a wireless sensing network (WSN) of strain gauges and accelerometers as well as innovative carbon nanotube (CNT) sensing skins) as employed on laboratory specimens is discussed. Subsequently, the field instrumentation plan is discussed. This plan is motivated by the premise that the greatest concerns regarding future structural integrity in a

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