Retrofit of Heritage Structures: Sustaining Environment and Culture

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Abstract

Retrofitting and reusing existing structures instead of demolishing and rebuilding them is an environmentally sensitive way to deal with aging building stock. The carbon footprint of the former action can be shown to be significantly smaller than that of the latter. When the buildings in question have historic significance, there is the added question of sustaining cultural heritage. Retrofit approaches in seismically active California, USA, are presented and two examples of heritage building renovations that adopted very different seismic retrofit strategies are presented.

Keywords: Embodied carbon; seismic retrofit; heritage buildings; Environmental Analysis Tool™.

1 Introduction

The total carbon emissions associated with the construction of a building has been shown to be between 15% and 50% of its life-cycle carbon emissions [1]. This carbon is often referred to "embodied carbon". The rest of the life-cycle emissions are those primarily associated with the operation of building environmental systems. Embodied carbon, simply put, comprises the carbon emitted in connection with building material production, carbon emitted in connection with actual building construction processes, and, in seismically active regions, the probabilistic carbon emissions associated with damage likely to occur in expected earthquakes and corresponding repairs. Estimates of embodied carbon associated with different construction scenarios such as the use of different structural materials or structural systems, can be arrived at using tools such as the Environmental Analysis Tool™ (EA Tool) [2]. These estimates can then be used to compare various structural alternatives from the environmental sustainability viewpoint to help with system selection. Use of the tool, as will be further discussed, has shown that the embodied carbon associated with the seismic retrofit and renovation of existing structures in California is smaller than that associated with construction of equivalent new structures even without considering demolition costs. When the buildings in question are historic in the US context, retrofitting and renovating them instead of demolishing and replacing them yields cultural dividends that add to their effective sustainability rating. While there is no objective measure of cultural sustainability, the subjective value of sustaining cultural heritage is self-evident.

The requirements for seismic retrofit of existing buildings are contained in Chapter 34 *Existing Structures* of the California Building Code (CBC) [3]. The code limits the amount of change that is permitted to occur in components of an existing structure's lateral system as a result of planned alterations and additions. When these limits are exceeded, requirements for seismic retrofit are triggered.

The CBC provides prescriptive requirements for the design of seismic retrofit systems. These are typically based on elastic analysis procedures and

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