Embodied Carbon Reduction

Floor Loading Assumptions – the Low-Hanging Fruit!

February 26, 2022

1. **Topic.**

   An innovative, modern approach to reliability-based design live loads will be a catalyst for improved safety, enhanced consistency, and reduction of carbon footprints.

2. **CPF Mission.**

   While occupancy live loads have been the subject of research over the past one hundred years, there has never been a systematic approach and consideration of reliability-based scenarios for specified floor loadings. There are many reasons for this, and the current imperatives are clear, as explained below. The expertise is at hand "to advance innovation in the design …of buildings." Our industry has the opportunity to lead with improved concepts for design, creating more consistency while preserving valuable resources and embodied carbon for safe, reliable buildings. It is time for an innovative approach to conceptualizing and calibrating design floor loads.

3. **Industry Need.**

   The public expects, and our industry demands, that code-specified loads are reasonable, safe, and substantiated. This is necessary to maintain universal trust and uphold the codes of ethics in our profession. Indeed, the Preamble to the 2020 revision of the American Society of Civil Engineers Code of Ethics states, "…and above all else protect and advance the health, safety, and welfare of the public…," and, "create safe, resilient, and sustainable infrastructure." Much later, the Code states "use resources wisely while minimizing resource depletion."

   This prioritization, therefore, has led to a tendency of overdesign in some cases. One such example is Assembly floor loading. Without a reliability- and performance-based approach, loads such as the Assembly loading requirements have continued unchanged since their first pre-code promotion in 1893[1]. While the reasons for this are many, there are three important factors for this:

   1) Due to historically heavy construction dead loads, the code requirement for live loads was not as significant a design factor.

   2) surveys could not capture the situations that led to crowded conditions for assembly, and without such survey data there was a reluctance to speculate on maximum assembly loads over a building's design lifetime; and

   3) Fixed layouts of building use meant designing only limited areas for the heavier assembly loads.

All three factors have changed. Lighter designs have increased the ratio of design live loads to dead loads, logical[1] probability-supported scenarios have paved the way for reliability-grounded, performance-based design, and flexible design and nonstructural partitions have increased the demand for adaptable future usage of building space.

The critical benchmark of success for this initial research will be a more consistent, reliable, and economic design load for assembly areas in buildings, enacted first through the ASCE/SEI 7 Standard[2], and subsequently by adoption into the International Building Code and materials standards. It will thus have impact throughout the U.S. building industry.

Upon the successful completion of this initial research, additional floor loading requirements we also be re-examined, including:

- General Office Loading
- Decks and Balconies
- Hospitals, Operating Rooms, and Laboratories
- Assembly Areas
- Diversity of Live Loading in Stadiums and Arenas

4. Proposed Research.

The vast majority of the research on live loads in the United States occurred over 40 years ago[3], and even recent live load research[4] relies solely on survey results. While providing insight, this does not result in statistically meaningful results. A more rigorous approach is required. One such approach, which was used to assess the live loads in ANSI A58.1 (now ASCE/SEI 7), is the Delphi Method. This method incorporates anonymous expert opinion whose outcome, when complete, results in statistically meaningful results[5].

This research will conduct a thorough review of prior load surveys and theoretical models from the viewpoint of assembly loads. We will then conduct a Delphi to establish the live

---

[1] Blackall, C.H. (1893). “Live Loads in Office-Buildings,” American Architect and Building News, XLI (922), August 26, 129-131.
[2] ASCE/SEI 7 (2016). Minimum Design Loads and/Associated Criteria for Buildings and Other Structures, American Society of Civil Engineers, Reston Virginia.
[3] Corotis, R.B. and Doshi, V.A. (1977). "Probability Models for Live Load Survey Results," Journal of the Structural Division, ASCE, 103 (ST6), June, 1257 1274.
[4] MEICON (2018). “Minimizing Energy in Construction; Survey of Structural Engineering Practice Report,” Engineering and Physical Sciences Research Council, Universities of Cambridge and Bath, EP/P033679/2, July 24, 103p.
[5] Corotis, R.B., Fox, R.R. and Harris, J.C. (1981). "Delphi Methods: Theory and Design Load Application," Journal of the Structural Division, ASCE, 107 (ST6), June, 1095 1105.

loads for the various assembly loading scenarios that we are interested evaluating. The Principal Investigator for this proposed research is the same one who conducted the Delphi for ANSI A58.

A key aspect of this research initiative is to clearly demonstrate the scenarios being evaluated (e.g., live load in office "assembly" spaces, "diversity" of live load in venues such as stadiums). In addition to preparing floor plans that describe the live load scenarios, simulations will depict the scenarios. Simulation software is available that can be utilized for this purpose.

A parallel research effort is being coordinated with IStructE in the UK to address complementary topics. Research outcomes will be shared benefiting both the US and UK and Euro Codes.

5. Dissemination Plan.

As described under the Proposed Research, the ultimate goal for this research is the revision of floor design loads in buildings and other structures. The research team has obtained coordination support from the current ASCE/SEI 7 Dead and Live Load Committee. We will present our results to the committee at one of their meetings. We also will offer to assist them with the revised standards as they make presentations to the main ASCE/SEI 7 Committee and the International Code Committee.

6. Principal Investigator.

Ross B. Corotis, PhD, NAE, PE, SE, F.EMI, F.SEI, Dist.M.ASCE
Denver Business Challenge Professor of Engineering
Department of Civil, Environmental and Architectural Engineering
University of Colorado Boulder

7. Contact Information.

Professor Ross B. Corotis
UCB 428, Department of Civil, Environmental and Architectural Engineering
University of Colorado, Boulder, CO 80309-0428
M: 303-596-3428; O: 303-735-0539; H: 303-449-1235
corotis@colorado.edu