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Beyond the Code: How to Restrain Non-Structural Components

Nicole A. Babuik[1*] and Monrit K. Chatha[2]

[1]Associate Engineer, Read Jones Christoffersen Ltd., Vancouver, BC, Canada
[2]Project Engineer, Read Jones Christoffersen Ltd., Vancouver, BC, Canada
[*]nbabuik@rjc.ca (Corresponding Author)

INTRODUCTION

Currently, in both the local and international consulting community, the conversation around earthquake engineering and structural design is often focused on the base building structure including the gravity and lateral elements of a building. As the focal point of the conversation, design standards and code requirements have advanced over the last few decades for base building structural elements. As a result of these advancements, design objectives are now changing from life-safety based building code design to a focus on building performance and resilience.

In engineering practice resilient base building design stems from these code advancements, and abundant research continues to lead to improvements in lateral design of building structures for earthquake loads. However, there is generally less focus on the earthquake performance of non-structural components (NSCs), or operational and functional components (OFCs) as they are referred to in Canadian Standard CSA S832 [1].

When we consider the building as a whole, including NSCs like the building envelope and architectural, mechanical, and electrical contents, and take into consideration performance parameters such as repairability, down time, and functionality, it is evident that non-structural components are the leading cause of financial losses and down time risks. This is not a new insight, for some time research has shown that it is common for losses associated with damage to NSCs to outweigh losses associated with damage to the structural system [2].

In Canada, the lack of clearly defined code requirements for performance-based seismic restraint design of NSC leads to restraint detailing being an afterthought in most new construction projects. At the same time, upgrading NSCs in existing buildings is deferred to Code Commentary in most jurisdictions, meaning it is rarely done unless considered a priority by an Owner.

While strides are being made in the international community to bring more attention to seismic performance of NSCs, Canada has catching up to do. There is a connection between research, policy and code development, and engineering practice, and in Canada improvements are needed on all three fronts to achieve better outcomes for NSC seismic restraint. This paper outlines current codes and practices used in Canada for NSC seismic restraint design, and provides recommendations for approaches to go beyond code minimums to improve implementation of seismic restraint design.

CODES AND PRACTICES BACKGROUND

The National Building Code of Canada (NBCC) [3] provides the static force and displacement design requirements for seismic restraint of NSCs, but that is it. Unlike ASCE-7 [4], the minimalism of the NBCC requirements leaves room for interpretation at both ends of the spectrum: for seismic restraint exemptions, as well as enhanced requirements for dedicated seismic systems.

As such, local engineering practitioners taking responsibility for NSC seismic restraint must look to other established standards for guidance, such as:

- Canadian Standard CSA S832
- ASCE-7 (Chapter 13)
- FEMA E-74: Reducing the Risk of Nonstructural Earthquake Damage – A Practical Guide
- SMACNA Seismic Restraint Manual: Guidelines for Mechanical Systems
- ECABC Seismic Restraint Standards Manual
- ASTM E580: Standard Practice for Installation of Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels in Areas Subject to Earthquake Ground Motions

Current practice in the industry is for each consultant (e.g. the project Architect, Mechanical, or Electrical consultant) to request the seismic restraint of NSCs to be designed and reviewed by the respective Contractor/Trade's engineer. Unless specific design standards or performance objectives are referenced in the project contract documents, the result is often inconsistent execution of the work, and gaps in the level of restraint provided. It also typically means, the default scenario is the minimum possible bracing, at the lowest cost.

We have seen braces for architectural finishes, or electrical and mechanical services and equipment that were installed poorly; for example, in isolation of gap, or other interaction hazards between elements. There is typically no authority on a project to assess interaction, thereby causing the interaction concern to fall on deaf ears. This is just one example, of how deferred design does not leave room for incorporating best practices.

The goal of this presentation is to present the importance and benefits of an integrated design approach for the seismic restraint of NSCs. We will review the Canadian standard, CSA S832, which forms the fundamental methodology for analyzing the seismic risk of operational and functional components and advocate for it to be explicitly referenced in the Building Code.

SEISMIC RESTRAINT DESGIN

We will discuss the benefits of designing based on best practices, and coordinating to avoid interaction hazards which will ultimately lead to our recommendation of advancing building codes to include requirements for performance-based design of NSC seismic restraint. As the leading cause of financial and down time risks following a seismic event, emphasis should be given to these building systems to ensure a more resilient community response.

The following two case studies showcase the benefits of and moving away from deferred design and towards an integrated design approach.

CASE STUDY 1

Pre-Fabricated Modular Frame for Multiple Services, Ontario

The first case study will focus on a new construction project where we were engaged at the design development phase as part of the base building multi-disciplinary consultant team. Our scope of work included the design and detailing for all the non-structural components.

Being involved from the initial stage of the project allowed us to integrate the design requirements and coordinate closely with other disciplines on the team. The ability to coordinate from the start of the project lead to the design of a pre-fabricated modular frame system that could support all of the services throughout the main building corridors. This allowed us to take into consideration the interactions between building services, partitions, and ceilings.

3D BIM modelling allowed for coordination between trades, early clash detection, and addressing the Contractors constructability concerns. See Figure 1 below for an isometric view of one of the pre-fabricated modular frame sections.

The Contractor expressed the financial benefits of this integrated design approach which resulted in efficient construction sequencing and review of the modular frame.

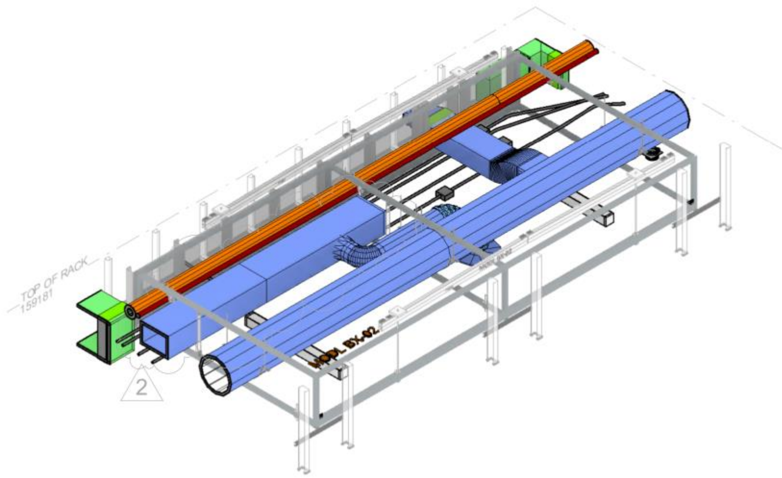

Figure 1. Isometric view of a pre-fabricated modular frame section.

CASE STUDY 2

Post-Secondary Institution, British Columbia

The second case study will review a mitigation program for the seismic restraint of existing non-structural components that was completed to improve the seismic resilience of an existing institutional facility. Although retroactive, this client understood the importance of reviewing all existing suspended services and finishes to reduce the falling hazard risk following a seismic event.

We will review how local standards and international guidelines were referenced to develop a tailored program that achieved the functionality and resilience goals of our client.

CONCLUSIONS

Our goal is to reduce the knowledge gap in the engineering community around the importance of non-structural component seismic restraint with a focus on their impact to financial and down time risks.

REFERENCES

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