DESIGN OF WOOD FRAME AND PODIUM STRUCTURES USING LINEAR DYNAMIC ANALYSIS

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ABSTRACT: In this paper, a method to assist designers to perform a linear dynamic analysis (LDA) for wood-framed structures is provided. Determination of input parameters upon which a LDA can be performed for a wood-based shear wall system with most commercial software is presented. A design example is used to demonstrate the steps required to perform LDA. Comparison of the results from the LDA to the worked example using mechanics-based approach is also given.

KEYWORDS: Linear dynamic analysis, shear walls, wood frame construction, podium structures

1 INTRODUCTION

Utilizing Linear Dynamic Analysis (LDA) for designing steel and concrete structures under seismic load has been common practice over the last 25 years. Once preliminary member sizes have been determined for either steel or concrete, building a model for LDA is generally easy as the member sizes and appropriate stiffness can be easily input into any analysis program. However, performing a LDA for a conventional wood frame structure has been, until recently, essentially non-existent in practice.

With the change in allowable building heights for combustible buildings from 4 to 6 storeys under an amendment to the 2006 BC Building Code [1], it has become important that designers consider more sophisticated methods for the analysis and design of wood-based shear walls to ensure that a building is properly detailed to meet the Code objectives. The use of LDA could provide useful information as well as streamline the design of wood-framed structures. For wood frame structures, the biggest challenge is that the stiffness properties required to perform a LDA for a wood-based system are not as easily determined as they are for concrete or steel structure. This is mostly due to the complexities associated with determining the initial parameters required to perform the analysis.

2 LINEAR DYNAMIC ANALYSIS

Although there may be different methods available to designers, the following steps could be used as a rational approach for performing LDA for wood structures, similar to common practice for both steel and concrete structures.

1. The first step requires performing an initial analysis and design such that the properties of each wall forming part of the lateral system can be determined. This will allow design engineers to obtain the necessary information required to determine a shear wall’s stiffness, and deflection characteristics.

2. The second step utilizes the information developed from the preliminary analysis determined in Step 1 to generate input data for use in a LDA for a multi-level structure.

2.1 STEP 1 – INITIAL ANALYSIS AND DESIGN

Below is a recommended method for the initial design:

1. Determining the building seismic forces at each level using Equivalent Static Force Procedure in accordance with the National Building Code of Canada (NBCC) [2] and provincial building codes.

2. The seismic forces can be determined using either the building period Ta (based on the empirical formula in the Code) or period T determined by mechanical methods, with an upper limit of 2Ta.

3. Determining the initial distribution of forces to each wall based on an assumed distribution. Initial assumptions could include assuming the diaphragm to be flexible, rigid or a combination of the two methods. Regardless, the minimum design forces at this stage will need to be re-adjusted if the forces are found higher once the LDA has been performed.

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2.2 STEP 2 – DETERMINATION OF INPUT PARAMETERS FOR LDA ANALYSIS

Figure 1 shows a generic cross-section of a wood-framed shear wall. The basic wood shear wall section includes the following components:

- Chord members (in this case, wood posts in compression and steel rods in tension)
- Sheathing (generally Plywood or Orientated Strand Board) on one or two sides
- Nailing (perimeter nail spacing / interior nailing)

For the purpose of LDA, a shearwall can be represented as a standard beam in most commercial software. The following parameters can be used to determine both the flexural and shear stiffness for use in a Linear Dynamic Analysis [3].

\[ b = L \]  \hspace{1cm} (1)

\[ t_{eq} = \frac{12I_{tr}}{L^3} \]  \hspace{1cm} (2)

\[ E = E_{c,eq} \]  \hspace{1cm} (3)

\[ G_p = \frac{1.2}{t_{eq} \left( \frac{1}{B_r} + 0.0025 \frac{E_{c,eq} \cdot S}{V_n} \right)} \]  \hspace{1cm} (4)

Details of deriving the above equations, including transformed moment of inertia, \( I_{tr} \), and equivalent MOE in compression, \( E_{c,eq} \), are provided in the paper.

3 DESIGN EXAMPLE AND ANALYSIS

Figure 2 shows a floor plan along with the preliminary shear wall locations for a 6-storey wood frame building to be analysed. Details of shear wall properties based on initial design are provided in the full paper. The design example will be analysed using LDA and mechanics-based approach respectively.

4 DISCUSSION AND CONCLUSIONS

The results using LDA and mechanics-based approach are compared. It is concluded that the input parameters developed in this paper for LDA captures the characteristics of a wood-based shearwall system and makes it feasible for designers to perform a linear dynamic analysis for such a structural system. Details of the results and conclusions will be provided in the paper.

REFERENCES

