

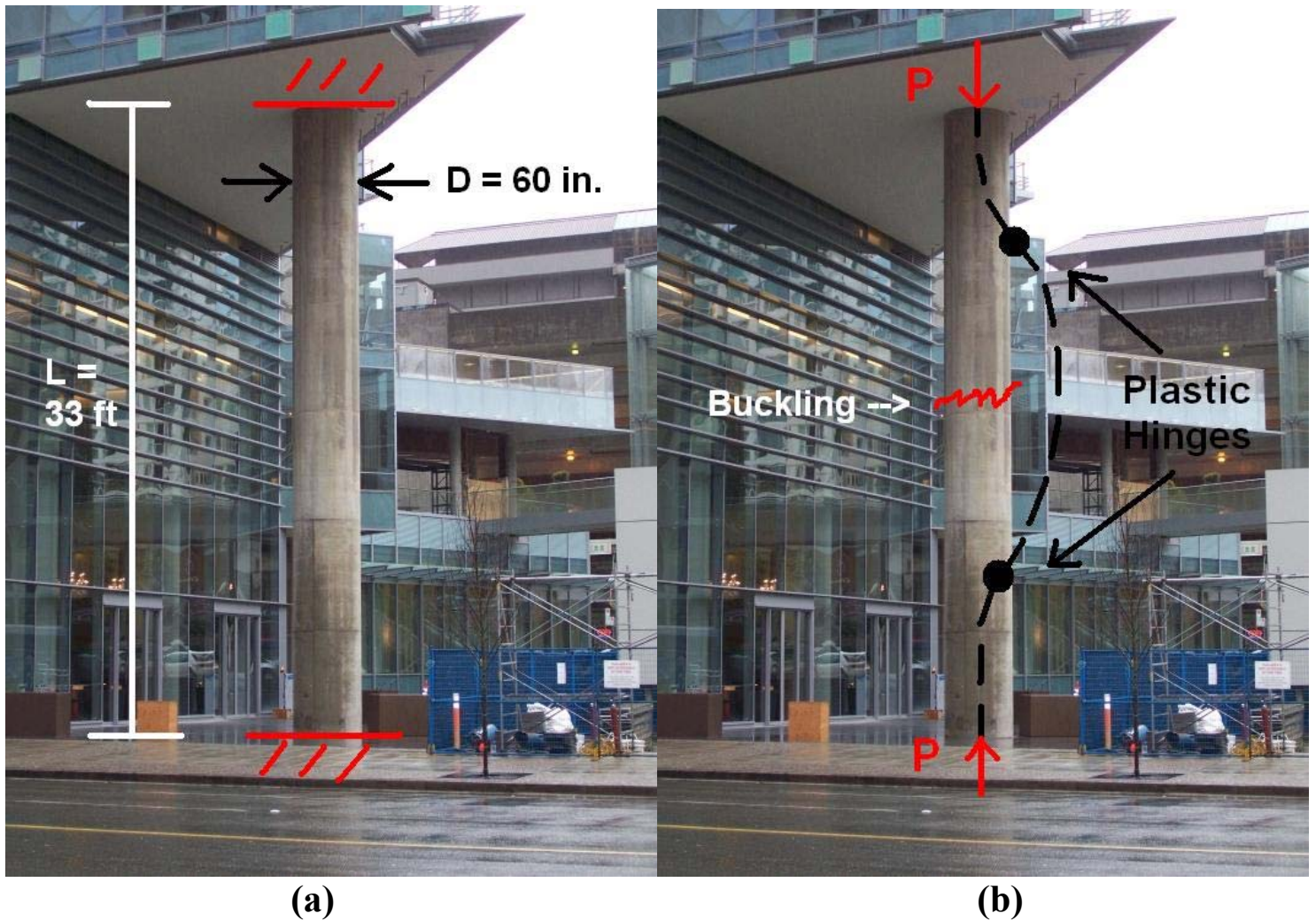
CIVL 231  
Photo Contest 3

Living Shangri-La, Vancouver, BC



Living Shangri-La during construction, January 2008 (photo by Jake Plut)

Jake Plut  
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**Figure 1: (a) Living Shangri-La exterior column dimensions and boundary conditions, (b) Failure mode, plastic hinge (in fact, points of inflection not plastic hinges) locations, and deflected shape.**

**(Photos by Jake Plut)**

The Living Shangri-La is currently Vancouver’s tallest completed building, standing 659-ft into the sky. The building is occupied by the Shangri-La Hotel Vancouver on the lower floors with residential apartments filling the rest of the building. The exterior of the building contains a large, 60-in. diameter cylindrical column of high-strength concrete reinforced by steel rebar. The column is approximately 33-ft in length and is fixed at both ends (Figure 1a). The high-strength concrete is designed to withstand compressive forces greater than 10,000 psi [1].

One possible failure mode of the column is **buckling**, shown in Figure 1b. Once the applied load  $P$  (the load of the building) acting on the column at its ends reaches a critical level ( $P_{cr}$ ), the column will buckle at or near its center. Prior to buckling, plastic hinges will form at approximately the locations shown in Figure 1b.

The critical load  $P_{cr}$  at which the column will buckle may be calculated using the following method:

**Physical properties of cylindrical column:**

Length of column (L) = **33 ft**

Diameter of column (D) = **60 in**

Moment of inertia =  $I = (\pi d^4)/64 = (\pi(60\text{in})^4)/64 = \mathbf{636173 \text{ in}^4}$

**High-strength concrete:**

Compressive strength ( $f'_c$ ) = **10,000 psi**

Weight of concrete ( $W_c$ ) = **160 lb/ft<sup>3</sup>**

→ **Elastic modulus of concrete :**  $E_c = W_c^{1.5} * 33(\text{SQRT}(f'_c))$

$$= (160 \text{ lb/ft}^3)^{1.5} * 33(\text{SQRT}(10,000 \text{ psi}))$$

$$E_c = \mathbf{6678730 \text{ psi}}$$

→ **Buckling load :**  $P_{cr} = (\pi^2 EI)/L_e^2$ , where  $L_e = 0.5 * L$  for a fixed-ends column.

$$= (\pi^2(6678730 \text{ psi})(636173 \text{ in}^4))/(0.5*(33\text{ft})*(12\text{in/ft}))^2$$

$$P_{cr} = \mathbf{1.07 \times 10^9 \text{ lb}}$$

**Citations**

[1] <http://www.livingshangri-la.com/documents/ShangriLaSpecs.pdf>