GLOTMAN · SIMPSON
CONSULTING ENGINEERS

BCBC 2018 Code Changes – Structural Implications

Glotman Simpson Notes on Building Code Update

March 2020

Introduction

With the recent adoption of the 2018 BC Building Code by local jurisdictions including Vancouver, Richmond, Burnaby and others throughout the Lower Mainland, we felt that it would be helpful to provide a summary of the implications of the Part 4 code revisions as they relate to structural design requirements. These revised design requirements will directly affect building planning and construction complexity along with project timelines and costs.

This brief is intended to present a high-level summary of the structural design code revisions most pertinent to you as an owner, architect or contractor. If you'd like to learn more, Glotman Simpson would be happy to provide further information. Additionally, we would be happy to visit your office to present this information in a more detailed fashion and answer any questions you may have.

Content of Technical Brief:

<u>Items that may affect building geometry and architectural layouts as well as cost:</u>

Columns Supporting Transfer Slab Beams

Columns supporting transfer beams and slabs will now generally have increased load demands due to revised seismic drift assessment requirements. We estimate a 20% increase in size for columns that support transfer conditions. Keeping these column shapes closer to square, rather than rectangular, reduces these effects and locating them further from core walls is beneficial. See **Figure 1.** below illustrating this condition.

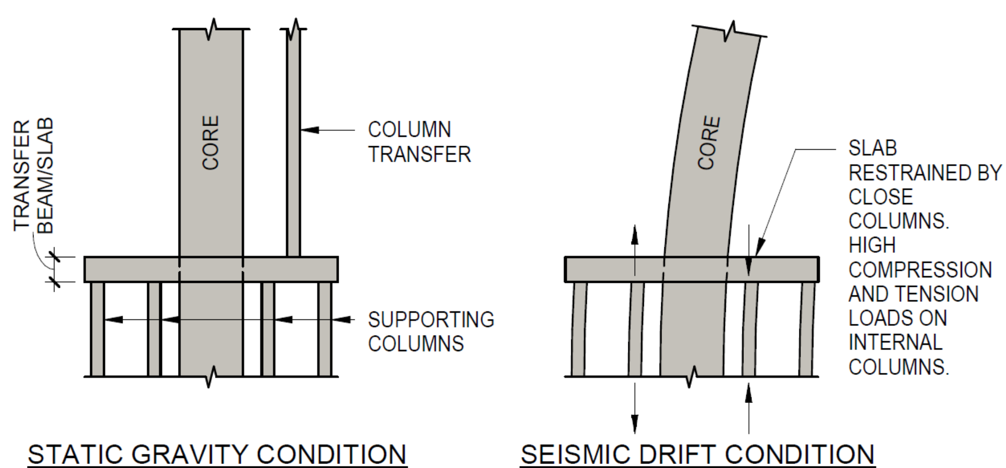

FIGURE 1. – SCHEMATIC SECTIONS AT TRANSFER BEAM/ SLAB CONDITION

When possible, columns supporting transfer beams and slabs should be placed away from the core (ideally 20 ft minimum). If columns are required close to the core, we suggest stopping the columns one level below the transfer as shown in **Figure 2.**

The intent of this measure is to reduce the stiffness of transfer slabs and beams under lateral loading and limit the force transfer from the core into the columns beneath the transfer. Short spans between supporting columns and the core tend to be very rigid and behave like a header beam or outrigger would. Longer spans between the core and adjacent columns increases the flexibility of transfer slabs and beams under lateral loading. Further distance between core and columns minimize the force transfer between these elements.

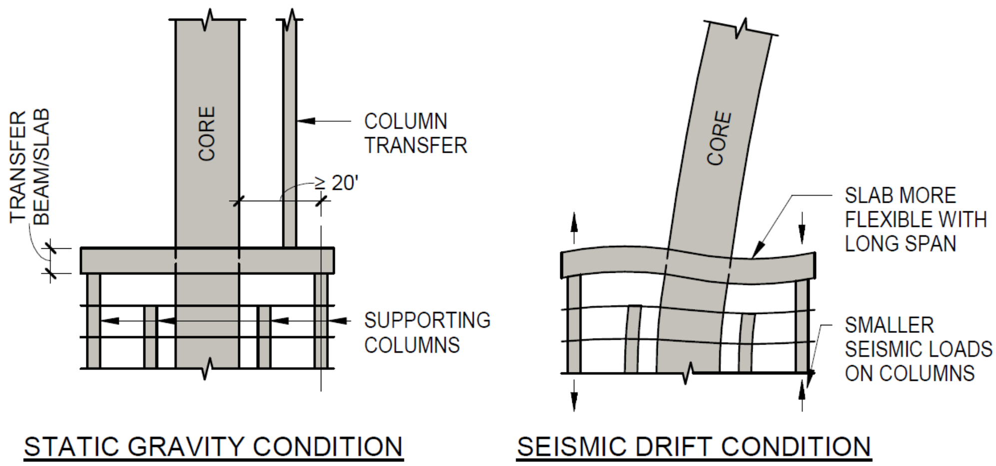

FIGURE 2. – SCHEMATIC SECTIONS AT TRANSFER BEAM/ SLAB CONDITIONS

Column thickness

The new code reduces the capacity of thinner columns. Columns 8" and 10" or less have 25% and 12.5% less stress capacity than 12" columns, respectively. These reductions are in addition to fire-rating overdesign factors which further reduces thin column capacities. As a general guide we suggest avoid using 8" columns that support 6-storeys or more and avoid using 10" columns that support 20-storeys or more.

The intent of this measure is to reflect research results showing the reduced ductile behavior of slender columns in a seismic event. More specifically, it was found that the narrow confinement area within the tied rebar cage resulted in higher stresses and lower rotational capacities. Columns with a lower aspect ratio of length-to-width were found to behave more robustly in a seismic event.

Long columns can also unintentionally behave as shear walls due to their stiffness and will attract lateral shear loads, which can quickly exceed the column capacity.

Core Wall Thicknesses

A new "higher mode effect" code clause increases shear loads in uncoupled walls, subsequently increasing wall thicknesses by approximately 20% from the previous code. The intent of this measure is to capture the increased shear demands beyond the first mode flexural yielding in tall cantilevered shear walls. See **Figure 3.** for general mode shapes for concrete core wall systems.

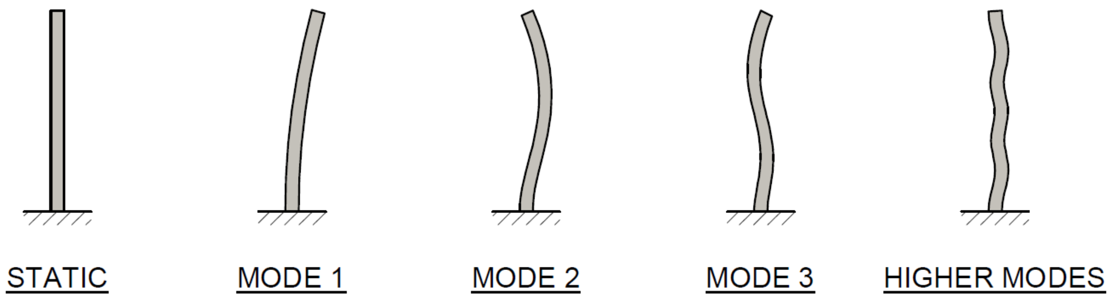

FIGURE 3. – MODE SHAPES FOR LATERAL RESPONSE OF CORE WALL SYSTEM

Affected walls are the cantilevered/uncoupled walls that aren't linked by coupling (header) beams and typically frame the back of the elevator bank, the side of the scissor stairs and the divider wall between the elevator shaft and stairs. See **Figure 4.** and **Figure 5.** showing these wall types (dark grey in Figure 4. depicts increase from previous code).

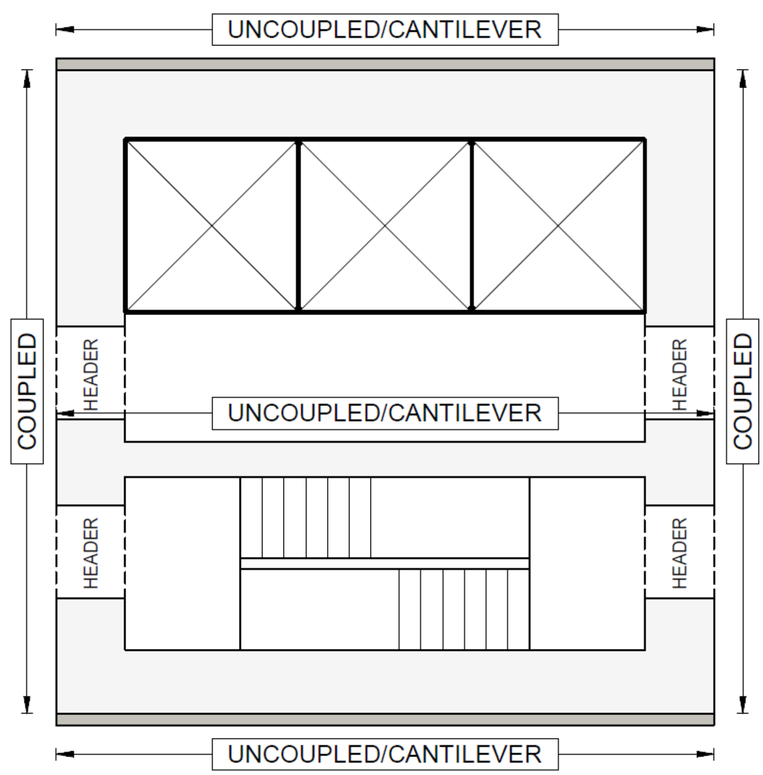

FIGURE 4. – PLAN VIEW OF SCHEMATIC CORE WALL ARRANGEMENT

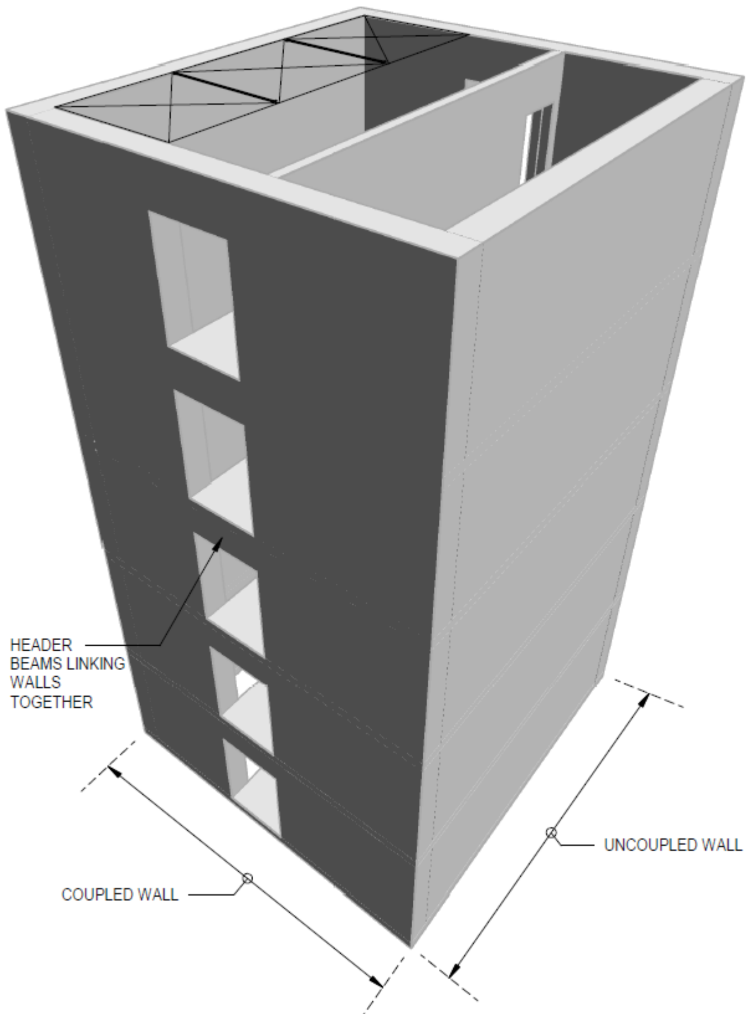

FIGURE 5. – ISOMETRIC VIEW OF SCHEMATIC CORE WALL ARRANGEMENT

Additional Items that affect cost of structure (in addition to core walls and columns noted above):

Foundations

Increased shear demand requirements will increase footing depths, and subsequently concrete volumes by approximately 25% from the old code (as shown in dark grey in Figure 6). For comparative purposes, **Figure 6.** shows a footing designed under the old code and new code, with the exact same column load.

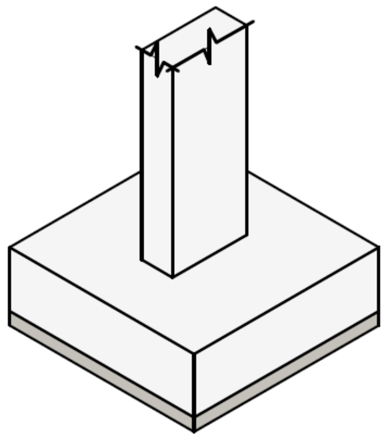

FIGURE 6. EFFECT OF NEW CODE PROVISIONS FOR FOOTINGS

Reinforcing weight will also increase due to the increased concrete volume, but not at the same rate. Overall, the ratio of reinforcing to concrete volume will likely be less than previous, but there will still be approximately a 20% increase in weight on average from previous code designs.

The intent of this measure is to provide for a more robust shear response in foundations in general. This is not a change that is related to a seismic risk or geography, rather a change in design philosophy of the Building Code Committee.

Below Grade Basement Walls

The podium/below grade structure now requires seismic rebar detailing. This means that the below grade exterior basement walls now generally require two faces of reinforcing steel in each direction (vertical and horizontal each face), resulting in approximately a 60% increase of reinforcing from previous code designs. See sections shown in **Figure 7.**

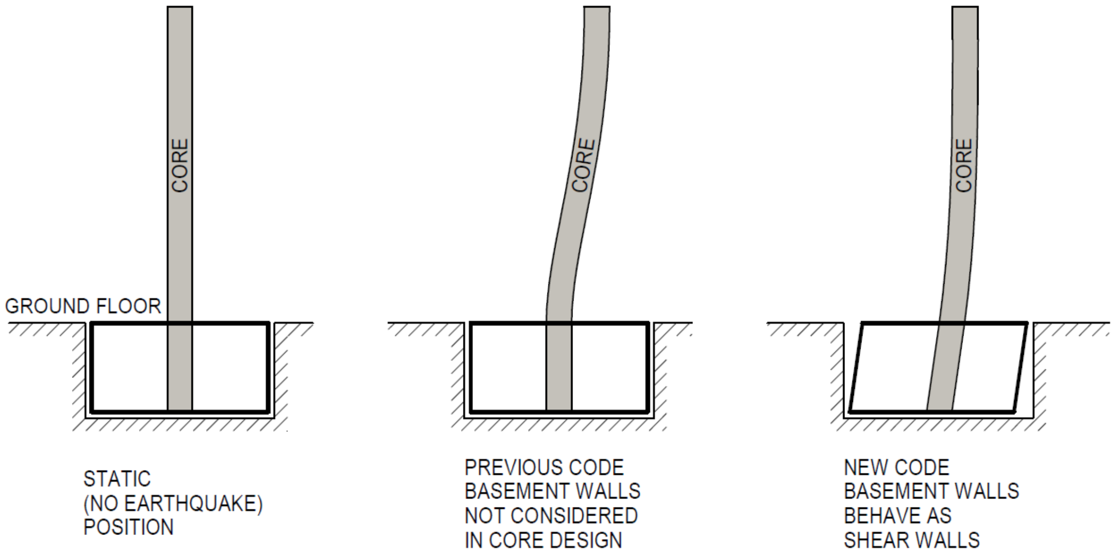

FIGURE 7. – EFFECT OF PODIUM AND BELOW GRADE WALLS ON CORE WALLS

The intent of this measure is to reflect newer research and studies suggesting that the stiffening effects of podium and below grade walls were not adequately addressed in prior code iterations. Research suggests that the participation of these longer (and often deeper basements) provide a significant stiffening effect and shunt load from the balance of the lateral building system at the base of the structure. Prior codes did not provide a clearly dictated strategy of assessing these walls whereas the new Building Code does.

<u>Items that may affect structural design and permitting:</u>

Podium and Below Grade Seismic Design

Entire podium and below grade structures now need to be designed and detailed to handle design level seismic drifts. In most instances, the entire structure needs to be included in a lateral model then ‘pushed’ to design level drifts. This process typically adds a few weeks of additional analysis and design time when compared to the old code.

The intent of this measure is outlined in the item above (“Below Grade Basement Walls”). It is reiterated here to point out that there is an impact on the building design, which will require more design time in general. This needs to be taken into consideration when determining the project design schedule.

Gravity Induced Lateral Demand (GILD)

A new structural seismic irregularity condition has been added to address framing conditions that induce horizontal loads on the lateral force resisting system. These gravity lateral demands are typically a result of offset or sloping columns that require lateral resistance to maintain stability. The gravity induced lateral forces are resisted by the core/shear wall systems and are in addition to the design earthquake lateral forces. See **Figure 8.**

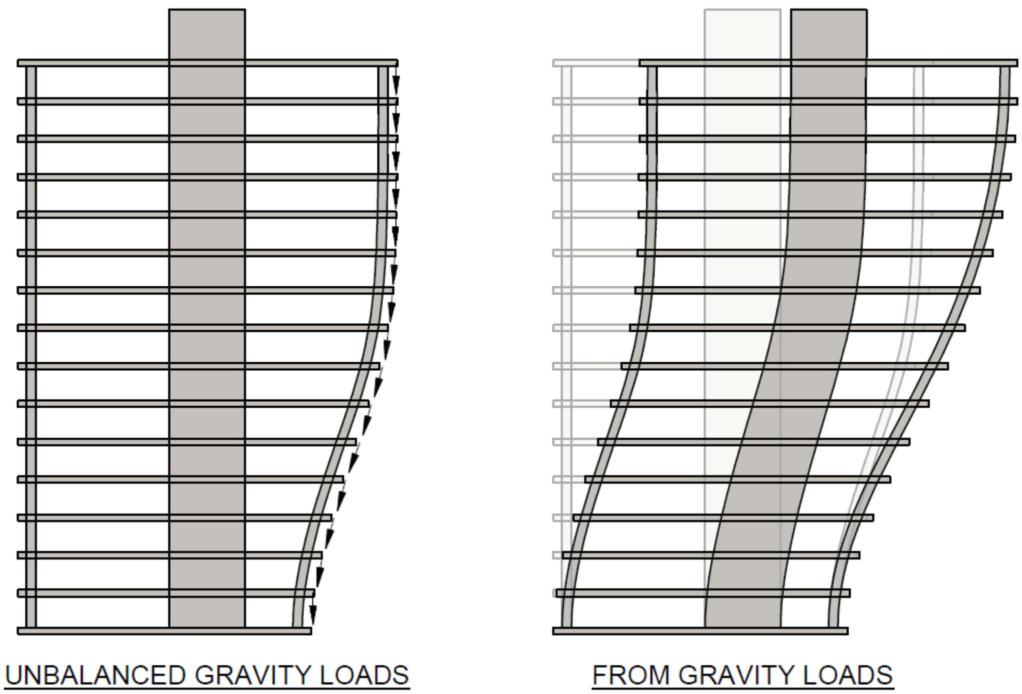

FIGURE 8. – UNBALANCED GRAVITY INDUCED LATERAL DEMAND (GILD)

When the induced shear and overturning moments from GILD loading exceed the capacity of the core/ shear walls by a range of 6% to 20% (depending on the system), then non-linear time history studies are required to verify the core wall designs. This is what many of the jurisdictions in California and Washington State require for tall building design. This process also includes a panel of structural and geotechnical engineers with experience in seismic analysis and design who independently review the lateral design. This design and review process typically takes upward of a year from start to sign off. It should be noted that this review process may not be fully adopted by the City of Vancouver and, in our opinion, they are likely to adopt a hybrid review process that is streamlined to work with the current development and permitting process. Only time will tell what this process will require.

If and when sloping and/or offset columns are required by either architectural design/expression or site constraints, we would strive to offset/slope opposing columns to balance the lateral gravity load. See **Figure 9.** illustrating this concept. Other mechanisms for addressing uneven vertical/lateral loading can involve vertical prestressing of lateral elements or uneven sizing of lateral elements to achieve more equitable stressing of those elements.

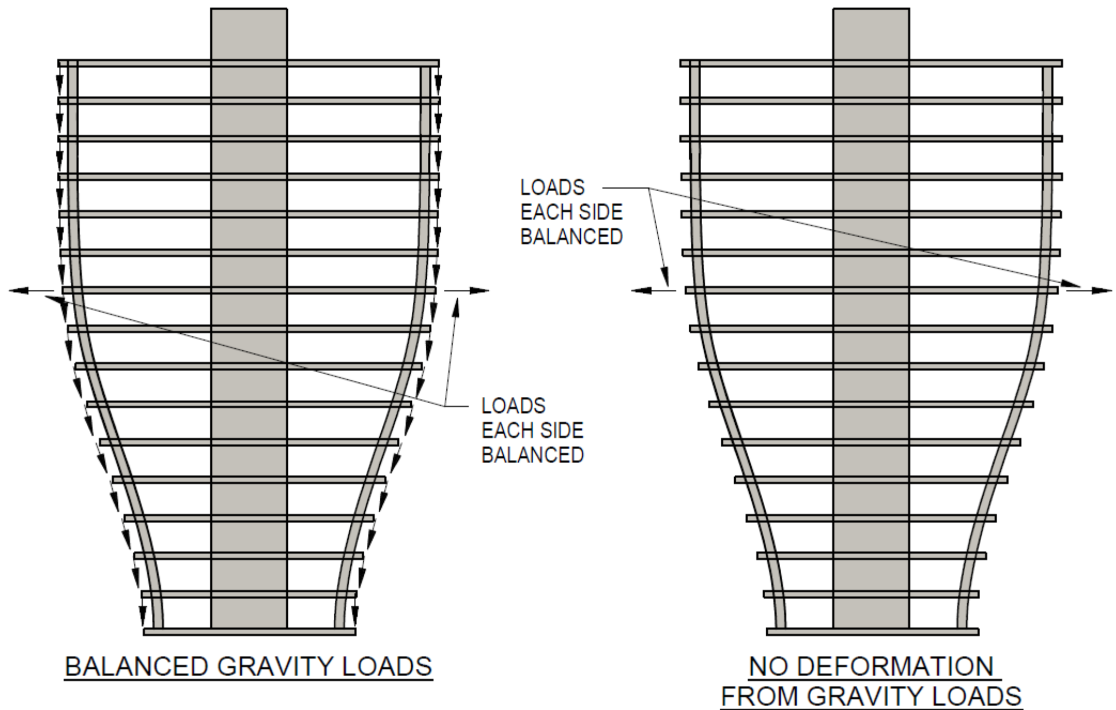

FIGURE 9. – BALANCED GRAVITY LATERAL LOADING (GILD)

The intent of this measure is to reflect the heightened attention, analysis, and scrutiny that is deserved of structures where lateral forces imparted by the gravity system can play a prominent role in the seismic performance and response of a building. Prior codes tended to disassociate the lateral and vertical performance of a more conventionally designed building. However, this Building Code iteration reflects the complexity of more contemporaneous building elements, and the significant interaction between the induced gravity and seismic loads.

In conclusion:

With the associated changes to the structural design requirements by the 2018 BC Building Code already adopted by local jurisdictions, we hope that this high-level summary can serve as a helpful resource to use when planning and budgeting future projects, in order to avoid potential challenges related to building planning and costs.