Buildings

You are probably in a building when you read this document. From the perspective of the structural engineer, the building is meant to keep the structure safe from

- *D*: Gravity loads, also called dead loads, i.e., the weight of the building itself
- *L*: Live loads, i.e., the weight of the content and occupants of the building
- *W*: Wind loads
- *S*: Snow loads
- *E*: Earthquake ground motion

Notice in Figure 1 that some loads are considered, at least by building codes, to act either perpendicular to the surface of the building components, or on a vertical projection, or vertically per unit length of the component. The earthquake load, E, is a special case that is actually imposed as ground motion. However, Newton's second law, stating that force is equal to mass times acceleration, allows us to impose it as a distributed load on the building.

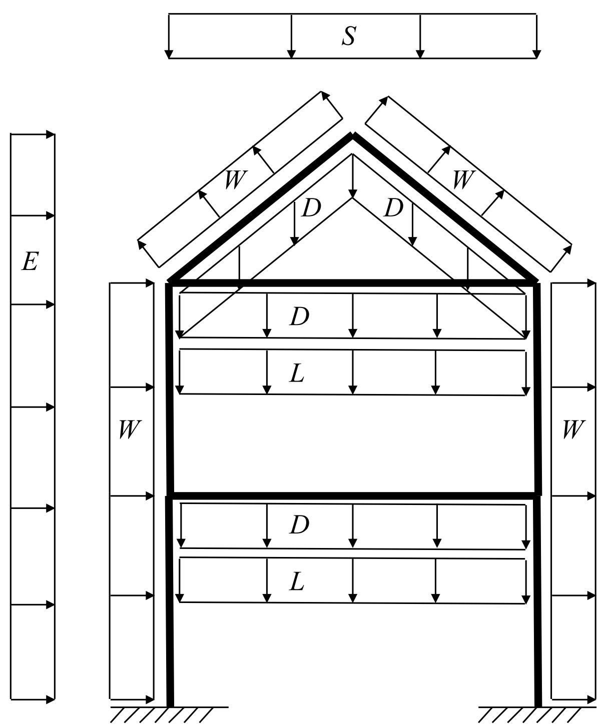

Figure 1: Load on a building.

Structural vs Non-structural

As you look around in the building in which you are located, most of what you see are "non-structural" components. From the perspective of the structural engineer, most partition walls and ceiling surfaces are not intended to carry any of the heavy loads that the building may be subjected to. Rather, it is the "structural components" of a building that are designed to carry load. Illustrated in Figure 2, that includes columns, beams, and "shear walls." Shear walls are particularly common in seismically active regions. That is because earthquakes are primarily considered to impart lateral, i.e., sideways load on buildings, and shear walls are intended to carry large lateral forces.

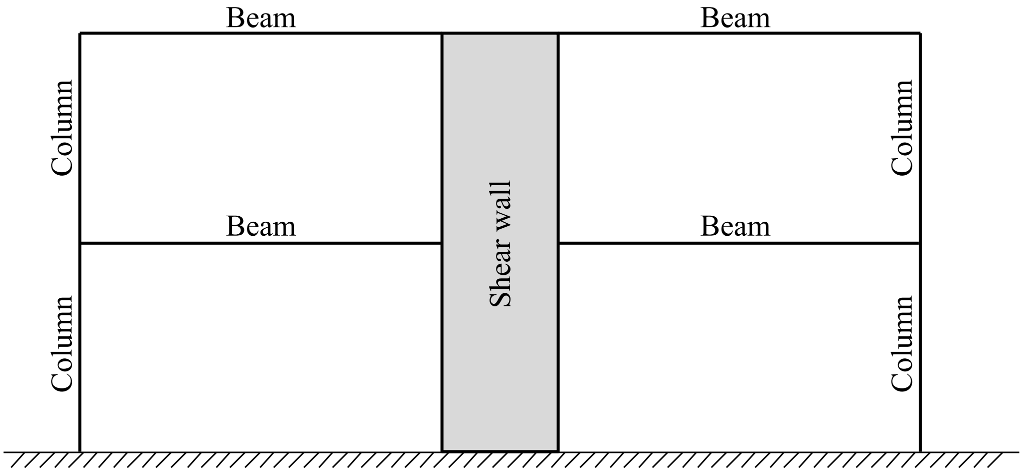

Figure 2: Structural components.

Codes

Academics tend to cite Hammurabi (Khammurabi), the sixth king of Babylon, when they talk about the first "building code." Hammurabi reigned until 1750 BC and erected a stone monument with the Code of Laws that included punishment for poor construction. Under those laws, different people had different worth, which was considered fair in the paradigm of those days. Two lives would not be worth the same, but the punishment of death could be meted out for poor construction. However, it may be said that the Great Fire of London in September of 1666, which destroyed two-thirds of the city, was a key impetus for building codes. It prompted Parliament to write the "London Building Act" over the following years, which is one of the earliest building codes. In present-day Canada there are many codes, or "standards," of interest to structural engineers. Perhaps the four most important ones are:

- **NBCC**: National Building Code of Canada. The NBCC essentially specifies the loads on buildings, and is published by the National Research Council of Canada, NRC-Can, and serves as the "model code" for all local building codes. In fact, the NBCC has no legal status until it is adopted by a jurisdiction that regulates construction. The British Columbia Building Code, BCBC, and the Vancouver Building By-law, CBO, abbreviated after the Chief Building Official, are nearly identical to the NBCC.
- CSA **O86**: Engineering Design in Wood. The Canadian Standards Association publishes this design standard, which prescribes a number of ultimate limit-states and serviceability limit-states for design of load-bearing structural timber components.
- CSA **A23.3**: Design of Concrete Structures. Same as O86, but for reinforced concrete components.
- CSA **S16**: Design of Steel Structures. Same as O86, but for steel components.

How Buildings Carry Load

Simply speaking, buildings carry vertical and lateral loads. The primary mechanism for carrying vertical loads is shown in Figure 3; namely, beam or plate action. Beams and plates transfer the vertical load into columns that carry the load into the ground.

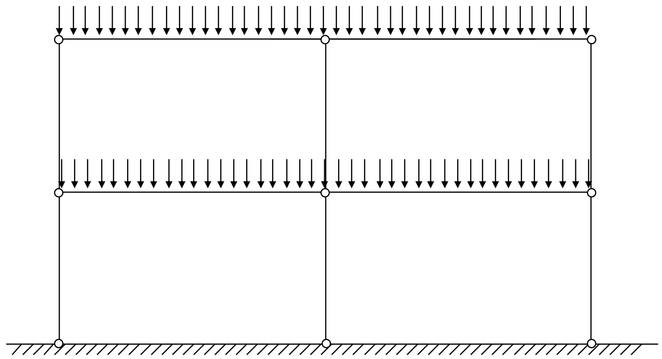

Figure 3: Techniques to carry vertical loads.

There are several ways that engineers contemplate carrying lateral loads into the ground. Some options are shown in Figure 4. Light wood-frame construction is not displayed there, in which plywood or other plates are nailed to studs made of dimension lumber, in order to carry lateral loads into the ground. The "post and beam" or "post and lintel" systems are similar to the moment-resisting frame system shown in Figure 4.

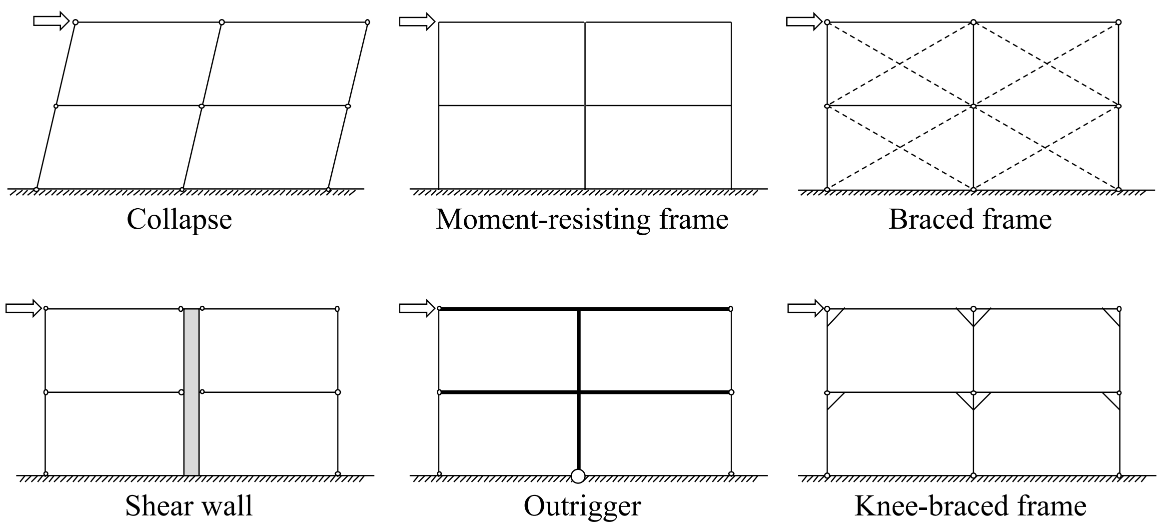

Figure 4: Techniques to carry lateral loads.

Construction Principles

Arbitrarily, a few construction principles are mentioned here. Platform construction is what I learned as a carpenter in Norway in the 1980s and balloon construction is the alternative. Both are shown in Figure 5. "Rain screening" with its air-layer between the rain-exposed cladding and the next surface of the building and the inside vapour barrier are additional aspects of construction that I learned as a carpenter on the west-coast of

Norway in the early 1980s. Deterioration by rot in wood, sound isolation, shrinkage of wood, and fire are additional concerns of engineers constructing a building.

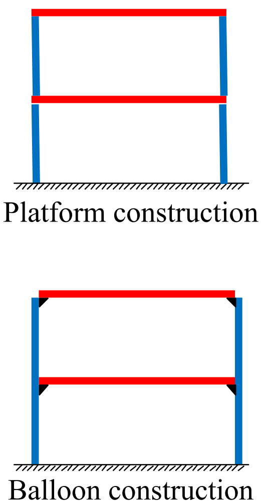

Figure 5: Platform vs. balloon construction.

Dimension Lumber

Often the expression "two by four" is heard, and it relates to building design. For reference, Table 1 displays the Canadian dimension lumber dimensions in millimetres.

Table 1: Dimension lumber in Canada.

Inches	Nominal [mm]	Dimension lumber [mm]	Sawn timber [mm]
2"	50	38	-
3"	75	64	-
4"	100	89	-
6"	150	140	140
8"	200	184	191
10"	250	235	241
12"	300	286	292
14"	350	-	343
16"	400	-	394

Seismic Design

To be written.