Briefing Paper 4

Seismic Response of Concrete & Masonry Buildings

Part A: Ground Shaking and Earthquake Loads

Introduction

Briefing Paper 4, *Seismic Response of Concrete and Masonry Buildings*, consists of four parts. This Part A provides a brief overview of how earthquakes affect reinforced concrete and masonry buildings. Part B describes the detailed response of a floor (or roof) diaphragm to the horizontal forces generated within it, and how the forces are transmitted horizontally to the building walls and frames. Part C describes the vertical load path carrying the horizontal loads down the building walls and frames, through the foundations and into the ground. Part D explains that as well as providing the load paths, some specific components must have the ductility necessary to handle the large distortions from major earthquakes.

The objective of this Briefing Paper 4 is to facilitate improvements in design and construction quality by providing architects, engineers, building officials, plan checkers, and inspectors with an appreciation of the importance of earthquake-resistant design and construction of reinforced concrete and masonry buildings.

Earthquake Performance of Reinforced Concrete and Masonry Buildings

Masonry construction has been used for centuries, and reinforced concrete buildings have been around for about one hundred years. Such buildings use masonry or concrete walls or frames to carry vertical loads and to resist earthquake shaking. The floors and roof can be made of concrete or wood. Concrete buildings built to modern design standards are likely to perform well in earthquakes, whereas some older concrete buildings have seismic deficiencies. Modern reinforced masonry buildings are also expected to perform well in earthquakes. Unreinforced masonry buildings, often called URMs, built until 1933 in California and still being constructed in other parts of the nation, are dangerous in earthquakes.

Reinforced concrete and masonry buildings have dynamic properties (mass, stiffness, and strength) that affect how hard they shake in response to earthquake ground motion (see Figure 1). Just like a tuning fork, each building has a natural tendency

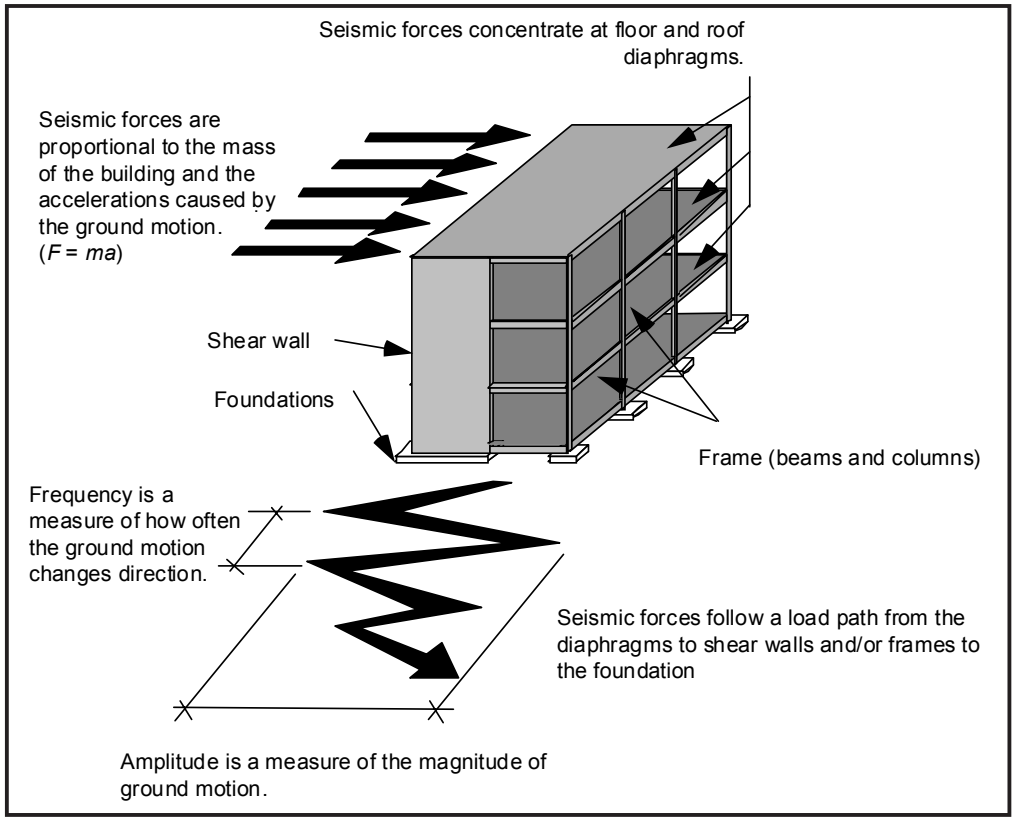

Figure 1. The effects of earthquake shaking on concrete and masonry buildings

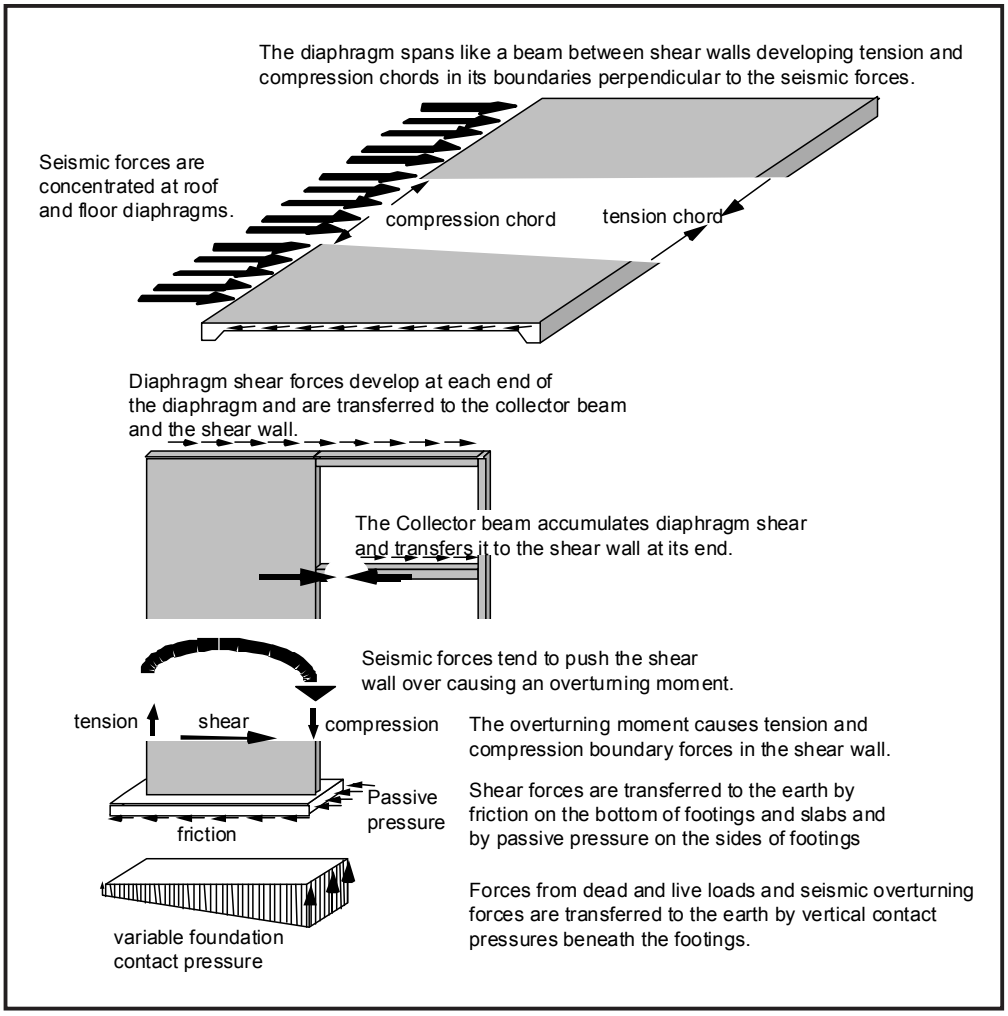

Figure 2. The load path for seismic forces in concrete and masonry buildings

to vibrate at its fundamental frequency. If one of the frequency components of the ground motion is near the fundamental frequency of the building, accelerations (and forces) are amplified as the building is forced to resonate. As the ground motion changes direction, the forces within a building also change direction, causing shaking or vibrations in the building.

A well-designed and well-built reinforced building has a reliable load path (see Figure 2) that transfers these forces through the structure to the foundation where the soil can resist them.

Because the floor and roof elements (diaphragms) are relatively heavy, a large portion of the building mass is concentrated in these elements. For structural analysis purposes, the mass of other building components, including the walls, beams, columns, furniture, and other building contents, are normally presumed concentrated at the floor and roof levels. Horizontal earthquake forces are usually resisted by either walls or frame elements. At the base of wall and frame elements, foundation components transfer the earthquake forces to the earth.

The diaphragms, walls, frames, and foundations of a building are the key elements along which engineers visualize a load path through the structure. The key links between these elements are also important components of the chain that makes up the horizontal and vertical load paths for the horizontal loads. The earthquake resistance of a building is only as strong as the weakest link in the load path.

About this Briefing Paper Series

Briefing papers in this series are concise, easy-to-read summary overviews of important issues and topics that facilitate the improvement of earthquake-resistant building design and construction quality.

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