CHAPTER 1 INTRODUCTION

1.1 Research Overview

A new hybrid structural steel system called Knee-Braced Moment Frame (KBMF) has recently been developed [1]. The key features of moment resisting frames and eccentrically braced frames are combined in KBMFs. This system relies on stocky knee braces in combination with rigid moment frames without diagonal bracing members to resist seismic forces. For seismic applications, KBMFs can be designed such that the braces will buckle and yield followed by plastic hinging of beams at the ends of the beam segments outside the knee portions. The design concept is based on increasing the energy dissipation through axial yielding or buckling of the knee braces and flexural yielding of the beams beyond the beam-connection zones. Figure 1.1(a) illustrated the yield mechanism of KBMF.

In this research, an improved version of the KBMF system is presented. Partially restrained (PR) connections are used in connecting the beams to the columns in the KBMFs system. Although welded connections have long been popularly used for seismic steel designs, after the Northridge earthquake in 1944, the vulnerability of welded moment connections in steel frames has been widely recognized [2]. Afterward, many alternative connections have been proposed. Experimental and analytical studies about the feasibility of using bolted connections for seismic resistance have been developed. For this study, bolted top and seat angle connections with double web angles were used. This type of PR connections is designed based on actual moment-rotation behavior of joints. Properly detailed, these connections exhibit large ductility and energy dissipation capacity [3-5]. These PR connections made erection of the frame relatively simple and, after an earthquake, they allow the frame to be repaired. In addition to the use of PR connections, two different types of knee braces were also considered in this study, regular buckling braces and buckling-restrained braces (BRBs). The improved version of the KBMF system is shown conceptually in Figure 1.1(b).

This framing system represents a future generation of a high performance structural system. The system has not been conceived or used before. Thus, to study the behavior of this system, an appropriate analytical model was developed. The analysis results from the model were compared with experimental results of a prototype test specimen under cyclic loading. The hysteretic behavior of the frame using two different types of braces, as mentioned earlier, were studied, compared, and discussed.

Finally, dynamic behavior of KBMFs with PR connections is then analytically studied. A three story building frame was used as a study case. Nonlinear static and dynamic analyses of KBMFs using two different types of braces which are regular buckling braces and buckling-restrained braces (BRBs), were carried out to evaluate and compare the behavior.

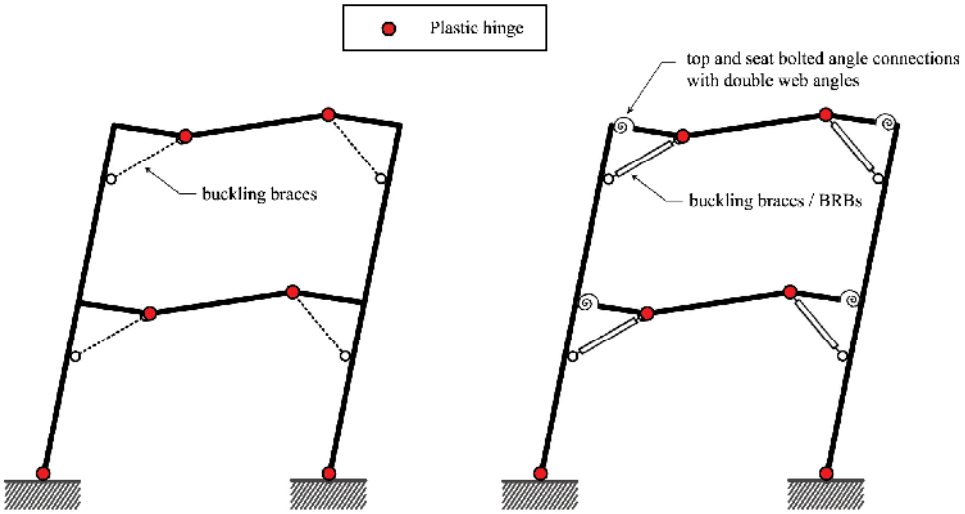

Figure 1.1 (a) Yield Mechanism of KBMFs,
(b) Mechanism of Improved KBMFs.

1.2 Objectives

This research focuses on the simulation and dynamic behavior of a new structural system to resist seismic forces called Knee-braced Moment Frame with Partially-Restrained connections. The Objectives of the study are:

1. To study and model the behavior of PR connections under cyclic loads using a mechanical model.

2. To develop 2D Analytical Models for KBMF frames for two different types of knee braces including regular buckling braces and buckling-restrained braces (BRBs).

3. To confirm the accuracy of computer models with the experimental test results for KBMFs with PR connections.

4. To evaluate hysteretic behavior for KBMFs system using two different types of braces which are regular buckling braces and buckling-restrained braces (BRBs).

5. To study the dynamic behavior of low-rise KBMFs with PR connections using two different types of knee braces under gravity and seismic loads.

1.3 Scope of Research

This research involves the development of 2D computational models for partially restrained connections (PR connections) and knee-braced moment frames with partially restrained connections (KBMFs with PR connections). Two different types of knee braces which are regular buckling braces and buckling-restrained braces were used to evaluate the dynamic behaviors of the system. The scopes of the research are:

1. The study focuses on low-rise structures. Three story building frames were used to study cases.

2. Nonlinear static and nonlinear dynamic analyses were used to study the dynamic response of the frames. Two levels of ground motion based on ASCE 7-10 were used as the basis for evaluation.