SECTION 1
INTRODUCTION

1.1 Motivation for this Study

The effect of gravity on the lateral force resistance of structures, known as the P-Δ effect, has been studied for a number of years. Modern design codes impose lateral drift limits to ensure that structural performance is minimally affected by P-Δ, especially in the elastic range. However, as inelastic behavior is relied upon to a greater extent in the dissipation of seismic input energy, the destabilizing effect of gravity becomes more significant in structural design. In addition, advances in construction technology are allowing the fabrication of more slender structures than in the past. As a result, it may be desirable to investigate the behavior of those structures in order to enhance our understanding of the condition ultimately leading to their collapse, and to ensure public safety during extreme events.

Strength and deformation capacities of elements and structures can be evaluated with reasonable confidence in the elastic range of response. However, excursions into the inelastic range of behavior complicate the process of calculating these ultimate capacities, and the maximum ductilities that can be developed. While many experimental studies and theoretical damage models support these calculated values, it remains that few experimental studies have pushed the shake table tests up to collapse.

This research attempts to provide some of that data through a program of shake-table testing of simple frames through collapse. Every effort was made to ensure that the experimental data is fully documented (geometry, material properties, initial imperfections, detailed test results, etc.) such that the tests can be used at a later time as a benchmark to which analytical models can be compared.

1.2 Research Objectives

There are two main objectives in this research: to perform dynamic testing through collapse of SDOF specimens; and, to make results available to researchers to assist in the development or validation of analytical tools to model the inelastic dynamic behavior of structures up to collapse.

Fifteen specimens having various properties were tested in an attempt to identify some of the general parameters responsible for trends in behavior due to P-Δ effects on SDOF structures.

1.3 Scope of Work

The scope of work in this research project contains the following steps:

- Set up experimental program of shake-table testing of columns to collapse
- Document the pretest condition of all specimens
- Perform testing on fifteen specimens each having four columns
- Present and summarize the test results
- Discuss the effect of material properties on the specimen dynamic properties
- Demonstrate by an example how to use the test data for analytical model verification
  - Discuss the effect of differing damping estimates on analysis accuracy
  - Compare a series of tests with a simplified SDOF analysis
- Investigate trends in the specimens behavior due to P-Δ effects
- Compare the ultimate behavior of the specimens with proposed limits for minimizing P-Δ effects in bridge piers

1.4 Outline

In Chapter 2, a brief review of past research on P-Δ effects is presented, along with some basic concepts of P-Δ analysis.

In Chapter 3, details of the experimental setup, data acquisition systems, and instrumentation used during the tests are presented and described. The preliminary design, fabrication, and properties of the specimens are documented. The SDOF shaking table and input ground motion used in these tests are also described.

In Chapter 4, the test results are presented. Material properties extracted from tension tests, dynamic properties measured from free vibration tests, and shake table test results, are presented. The peak response parameters extracted from each test are described.

In Chapter 5, the test results are discussed. An example is presented of how to use the specimen test data for the purpose of comparison with an analytical model. The effects of damping estimates on analysis results are discussed. A preliminary investigation of behavioral trends of the shake table results is presented. Peak responses are compared with limits proposed to minimize P-Δ effects in bridge piers. Specimen behavior is investigated with respect to axial-moment strength and stability interaction limits.

Conclusions and recommendations for further research are presented in Chapter 6.