SEMINAR: PROGRESSIVE COLLAPSE

PROGRESSIVE COLLAPSE OF 2D RC FRAME STRUCTURE CONSIDERING CATENARY ACTION

Sự sụp đổ dây chuyền của khung 2D bê tông cốt thép có xét đến hiệu ứng "biến dạng lớn"

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OUTLINE

1. Introduction
2. The methods of analysis
3. The study problem

1. INTRODUCTION

1.1. Collapse

-Collapse is a critical ultimate state for structure under extreme loads (for example: earthquake, bomb, fire…). A typical collapse mode is that yielding firstly appears at the weak part of structure and then results in large concentrated deformation and local failure.

1. INTRODUCTION

1.2. Progressive collapse

-Progressive collapse is defined in the commentary of the American Society of Civil Engineers Standard 7-05 Minimum Design Loads for Buildings and Other Structures (ASCE7-05) as “the spread of an initial local failure from element to element, eventually resulting in the collapse of an entire structure or a disproportionately large part of it”

1. INTRODUCTION

1.2. Progressive collapse

Fig 1.1. The Ronan Point apartment building

Fig 1.2. The Alfred P. Murrah building in Oklahoma

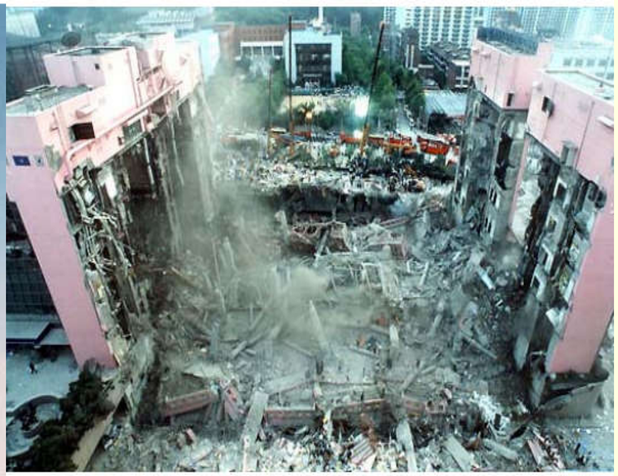
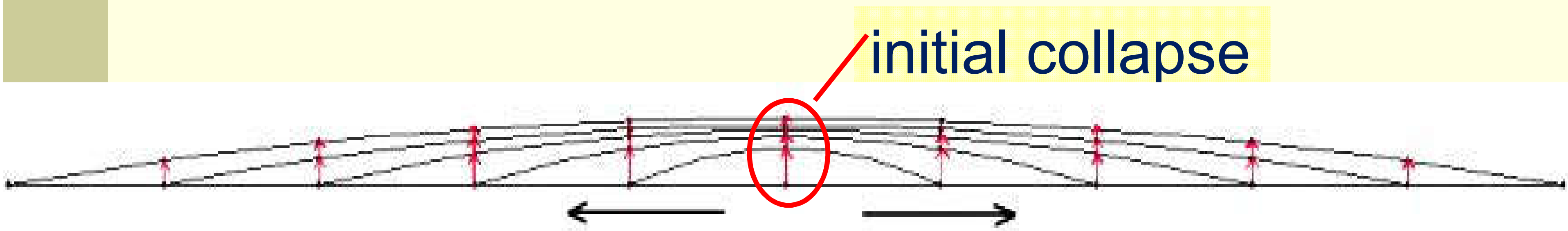
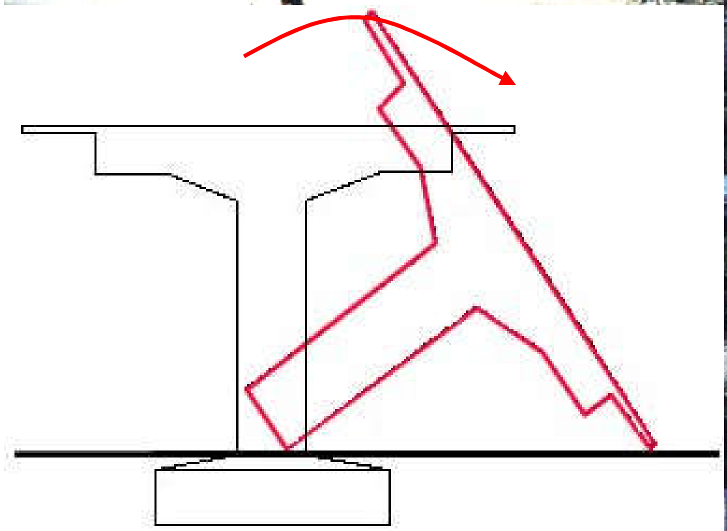


Fig 1.3. The Sampoong department store

COLLAPSE OF HANSHIN EXPRESSWAY – KOBE, 1995





Taiwan earthquake 1999

1. INTRODUCTION

1.2. Progressive collapse

Elevation of Crabtree Sheraton Hotel

2. THE METHODS OF ANALYSIS

2.1. Degisn method

According to GSA (*General Services Administration)* and UFC (*Unified Facilities Criteria), there are 3 methods to analyze and design:*

-Event control

-Indirect method

-Direct method

2. THE METHODS OF ANALYSIS

2.1. Degisn method

a. Event control

It is almost impossible to control a specific threat before it occurs because such threats (fire, aircraft impact, gas or bomb explosion, and vehicular collision) are arbitrary events. Furthermore, it would bedifficult for a structural engineer to analyze the magnitude of specific threats. Standoff distance, defined as the distance between the nearest structural component and the defended perimeter, is a good example of event control or reducing the impact of specific threats.

2. THE METHODS OF ANALYSIS

2.1. Degisn method

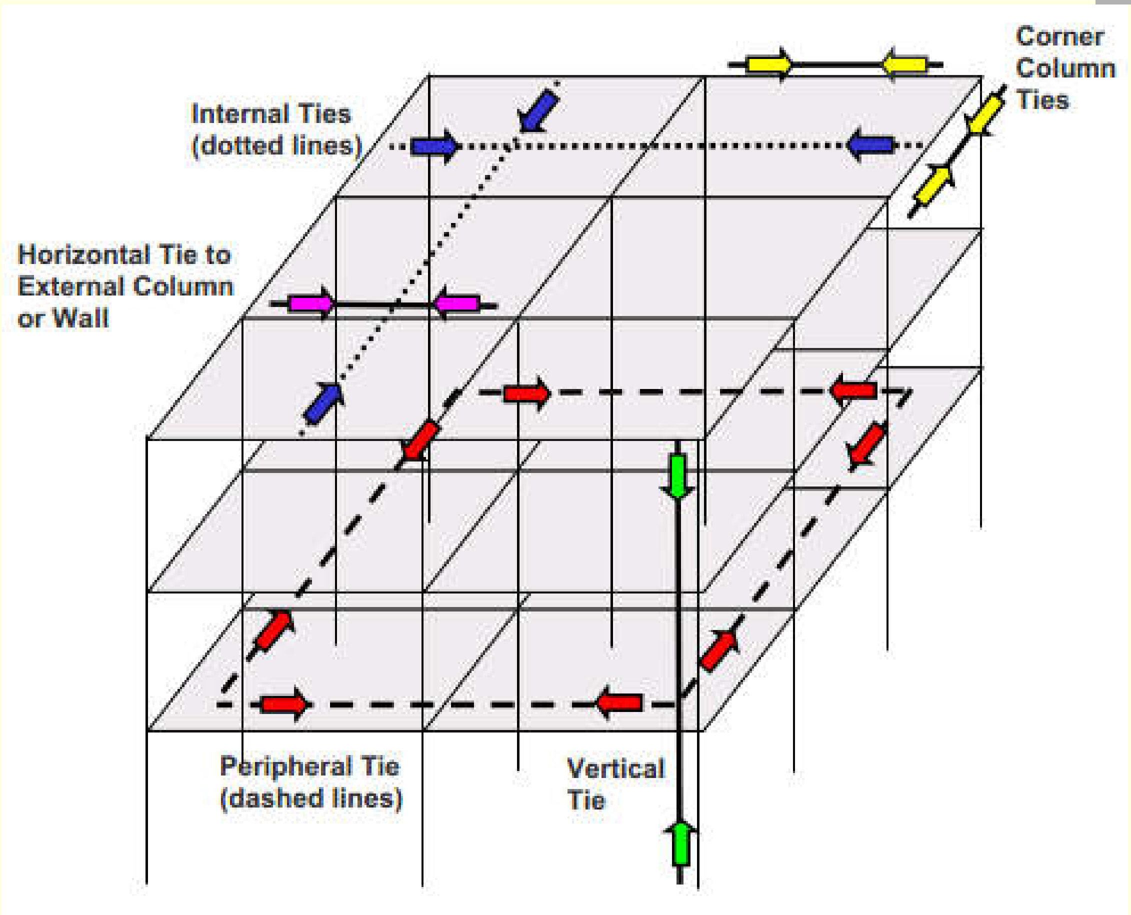
b. Indirect design: “tie forces”

This approach places minimum requirements on strength, continuity and ductility for providing resistance to progressive collapse.

For example, improving joint connections by special detailing, providing redundancy, and providing more ductility to a structure are all techniques that are considered with the indirect design approach.

2. THE METHODS OF ANALYSIS

2.1. Degisn method



2. THE METHODS OF ANALYSIS

2.1. Degisn method

c. Direct design:

c.1. The Specific Local Resistance Method

This method provides a means for reducing the risk of local failure. It requires that a critical structural element be able to sustain an abnormal loading. Thus, sufficient strength and ductility of the critical element must be considered during design. A drawback of this approach is that an extreme load event is assumed to be known a priori, and such knowledge may be difficult to ascertain given the uncertainty associated with such events. The simplest way to implement the specific local resistance method is to increase the design load factors so that additional strength and toughness of the designed element is obtained.

2. THE METHODS OF ANALYSIS

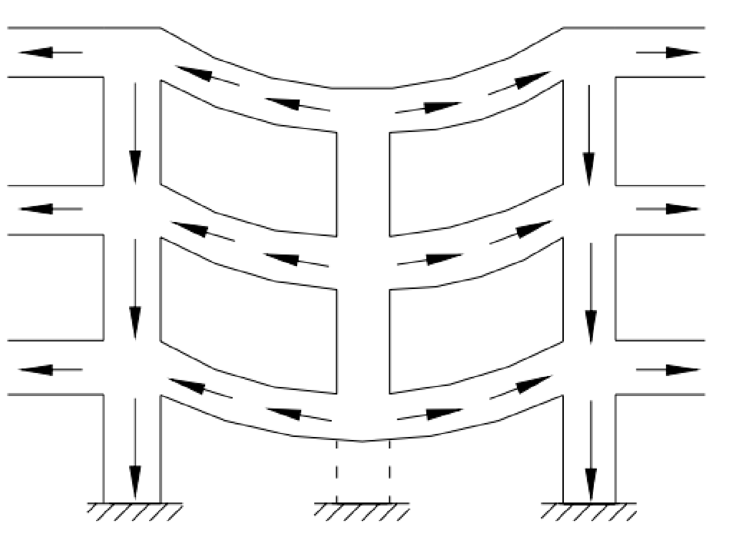
2.1. Degisn method

c.2. The Alternate Load Path Method

This method, in contrast to the previous one, considers the behavior of a structure after somefailed elements are lost, regardless of the cause. Of primary concern is the performance of an entire structure rather than that of a single element. In general, the alternate load path method is attractive not only because the overall structural performance of the damaged structure is considered but also, unlike the previous method, a specific abnormal load event need not be identified.

2. THE METHODS OF ANALYSIS

2.1. Degisn method



The basic concept of this method is that when one or more primary load-carrying elements fail, the remaining structure must be able to withstand the existing applied loads. This method will lead to a design in which a structure has the ability to absorb local damage, thereby reducing the likelihood of progressive collapse.

2. THE METHODS OF ANALYSIS

2.2. Technical analysis

- 4 methods: linear static, nonlinear static, linear dynamic and non-linear dynamic.

- Linear static: is the most simplified form of analysis. Neither geometric nor material nonlinearity is considered. This method of analysis is only capable of analyzing very simple structures because the dynamic and nonlinear effects must be estimated by user. The structure response is evaluated by demand to capacity.

The advance this method offers is that it can be completed quickly, providing simple, fundamental results. However, with linear static analysis it is nearly impossible to accurately predict the dynamic effect in progressive collapse or blast scenarios.

2. THE METHODS OF ANALYSIS

2.2. Technical analysis

-Nonlinear static: the nonlinear static method allows for nonlinear material properties to be define. The most common nonlinear material model is an elastic-perfectly plastic curve. This analysis method is a step above the linear static model because of its ability to consider changing material properties.
Nevertheless, this method still neglects the dynamic effects, so it provides little additional benefit in trying to understand a structures behavior.

2. THE METHODS OF ANALYSIS

2.2. Technical analysis

-Linear Dynamic: dynamic analysis, whether linear or nonlinear, compared to static analysis is much more complex. Dynamic analysis inherently accounts for dynamic amplification factors, inertia and damping forces. Thus, estimation of these parameters by the user is no longer required. The limitation with linear dynamic analysis is its inability to account for geometric and material nonlinearity.

Dynamic analysis demands significantly greater time compared to static analysis, but provides a substantial increase in the level of accuracy.

2. THE METHODS OF ANALYSIS

2.2. Technical analysis

-**Nonlinear Dynamic:** Nonlinear dynamic analysis is the most detailed and intricate analysis possible. It covers geometric nonlinearities, including second order effects such as P-delta…

It allows material models to be specified which can define properties such as yielding, strain hardening, and strain rate effects. The nonlinear capabilities combined with the dynamic capabilities described in the linear dynamic analysis section, make this the ideal analysis method for modeling structures subject to abnormal loads. The only disadvantage to this method is that it requires the greatest amount of time to create the model and the longest amount of time to execute the model.

3. THE STUDY PROBLEM

-Respone of beam element (with 2 fixed connections) considering catenary action:

The beam element model is very complex: concrete, steel, the bond between conrete and steel, cracking, catenary action, ect..

Concrete: Euler-Bernourli model or Mazar’s model

Steel: elasto-plastic

Bond: cohesive model

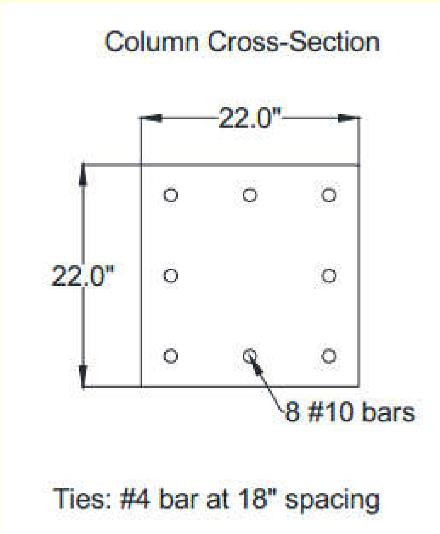
Cracking: smeared cracking

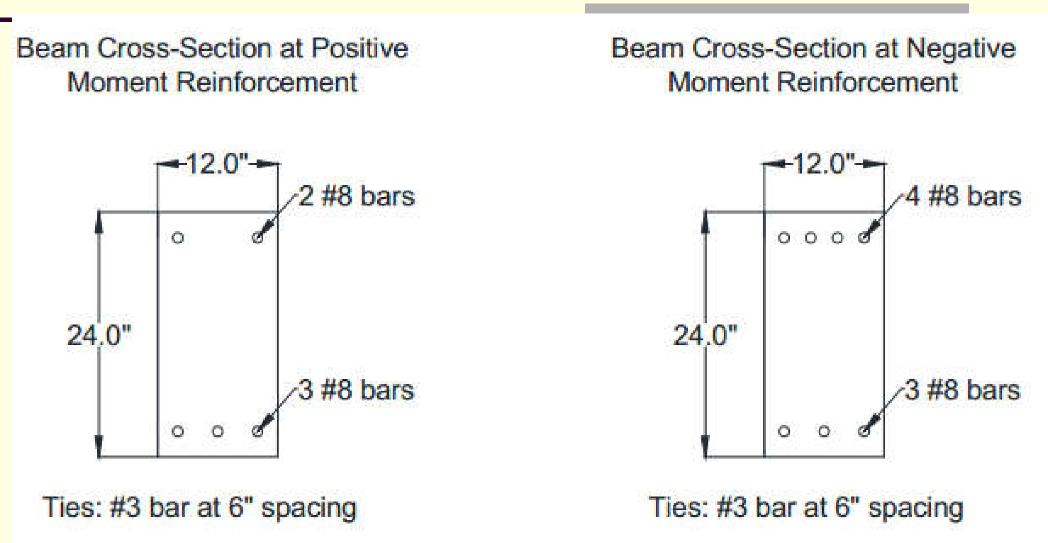
-Respone of 2D RC frame with nonlinear static analysis considering catenary action

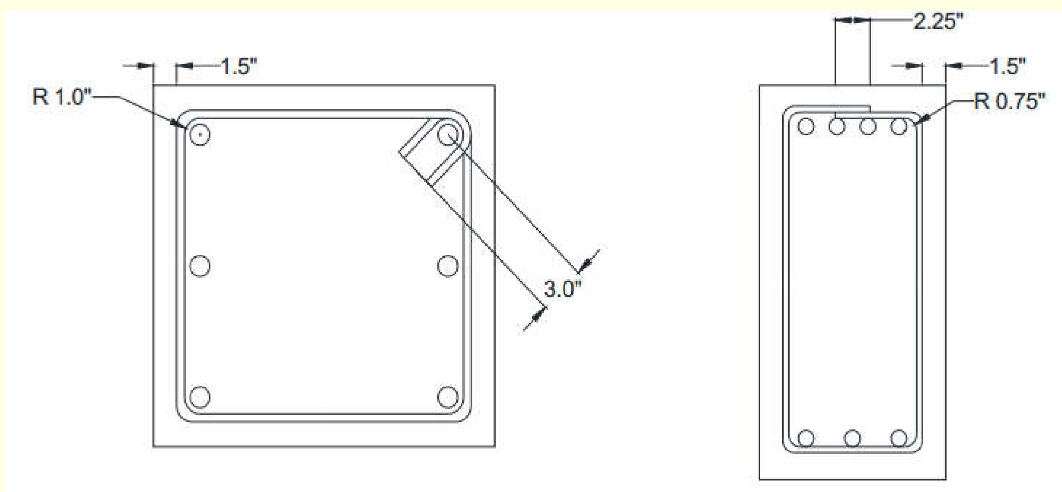
-Respone of 2D RC frame with nonlinear dynamic analysis considering catenary action

3. THE STUDY PROBLEM

3.1. EXPERIMENTAL STUDY







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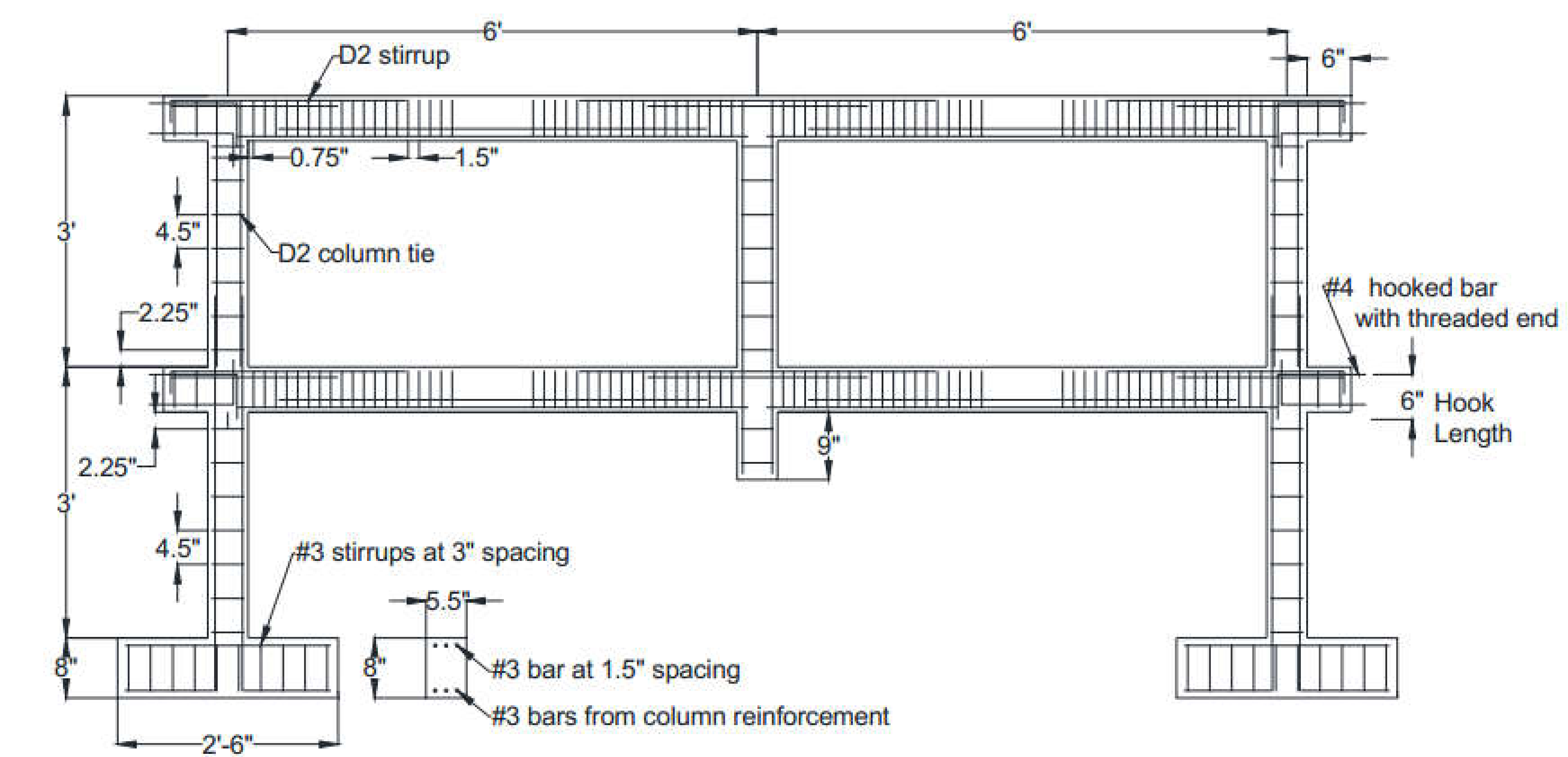

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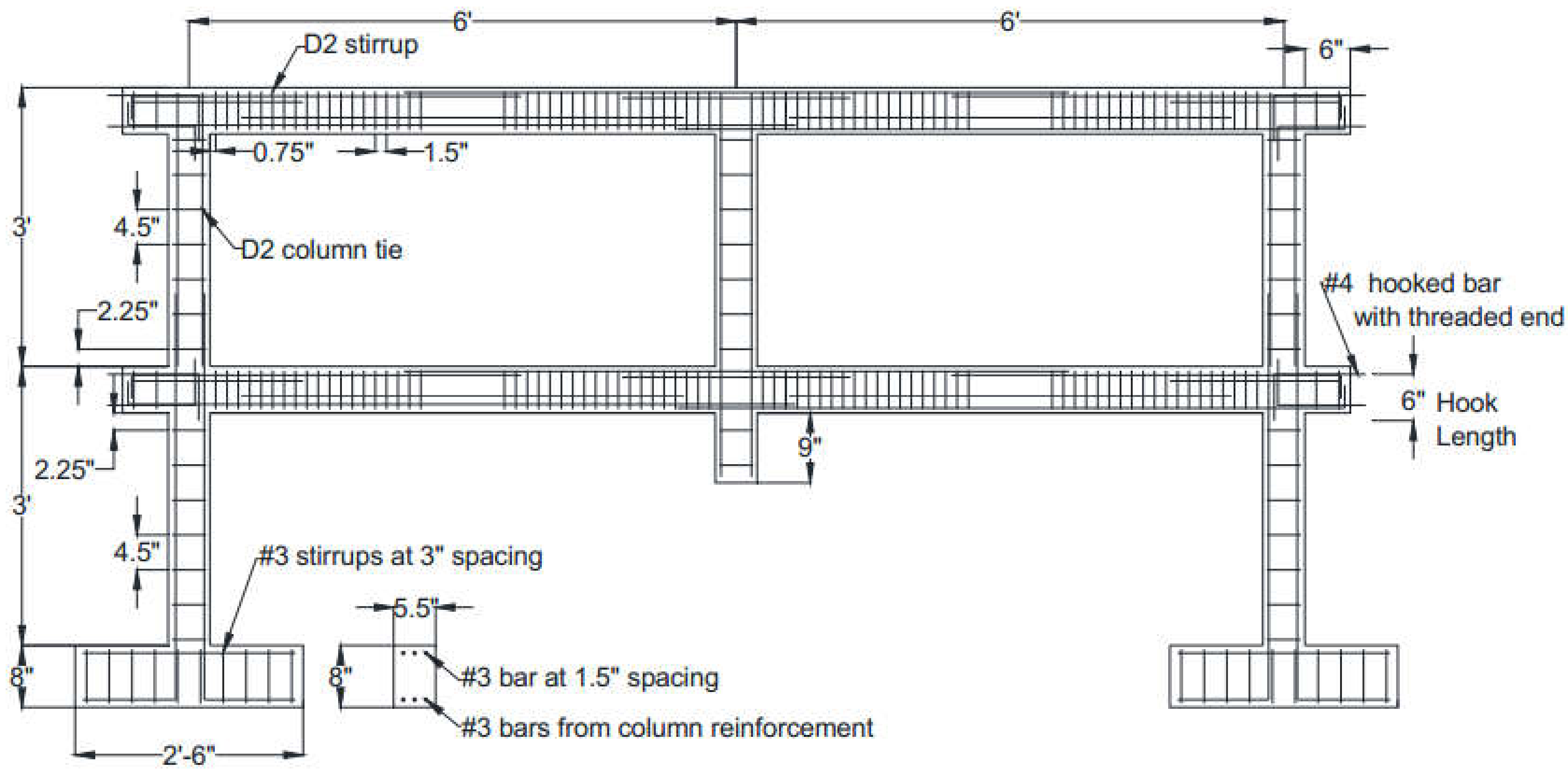

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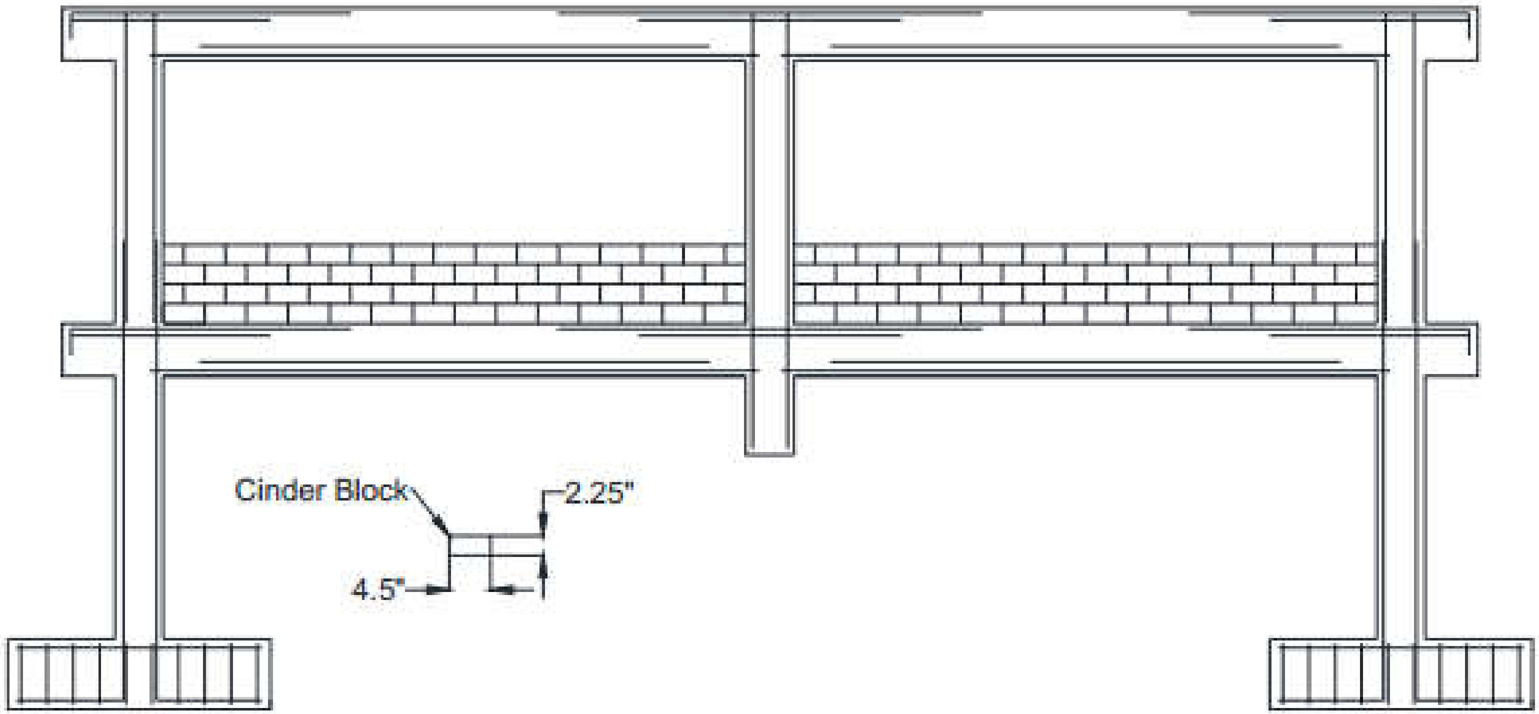

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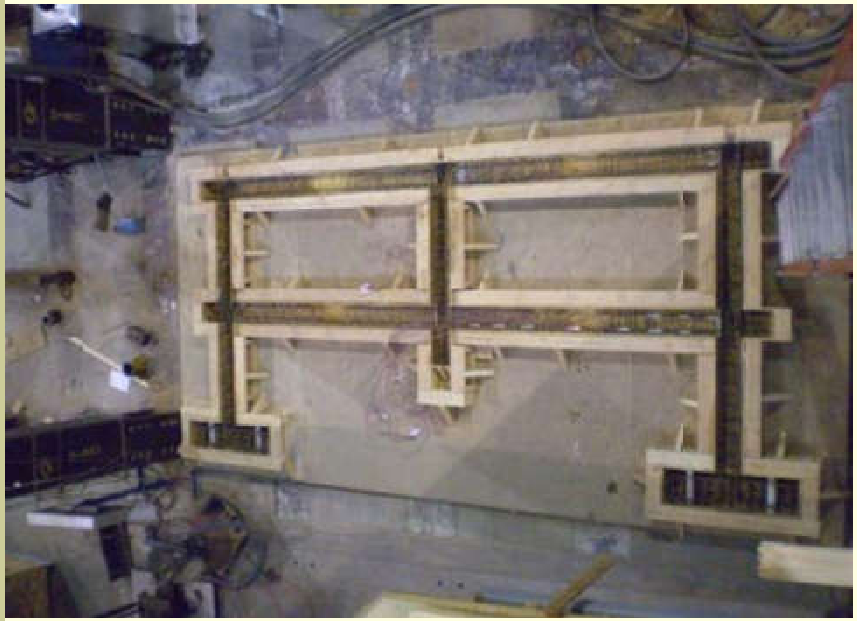

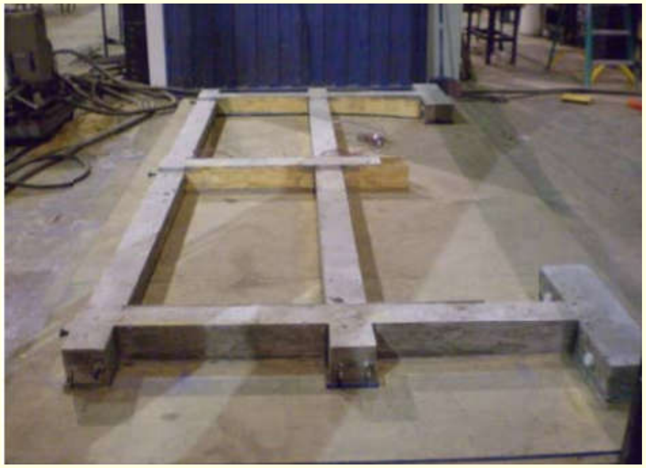

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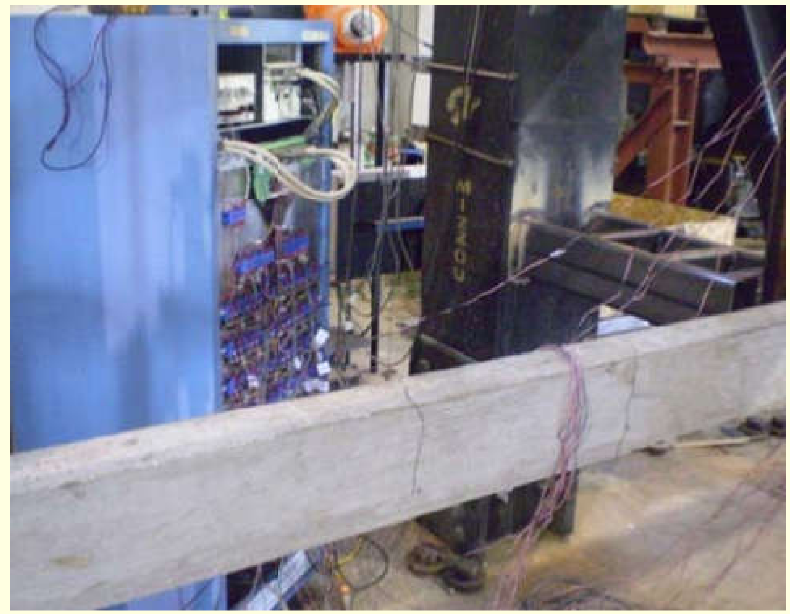

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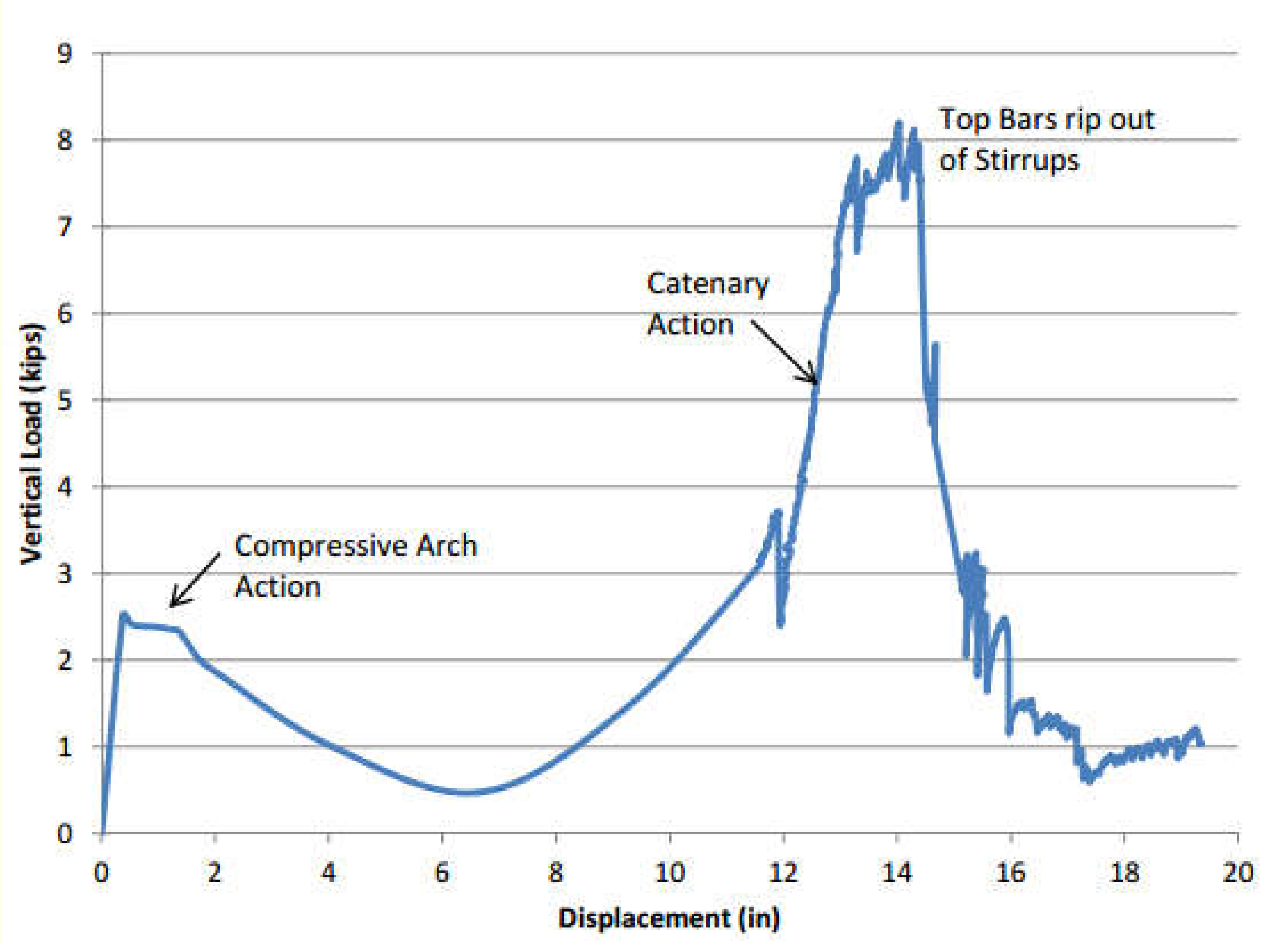

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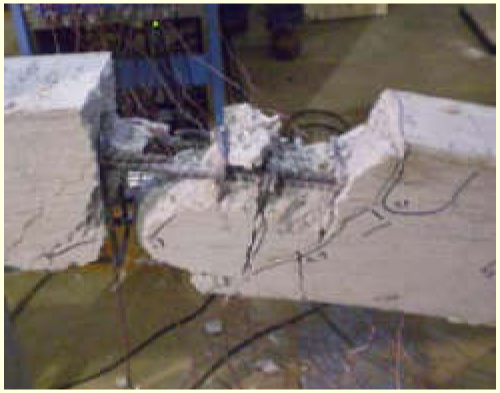


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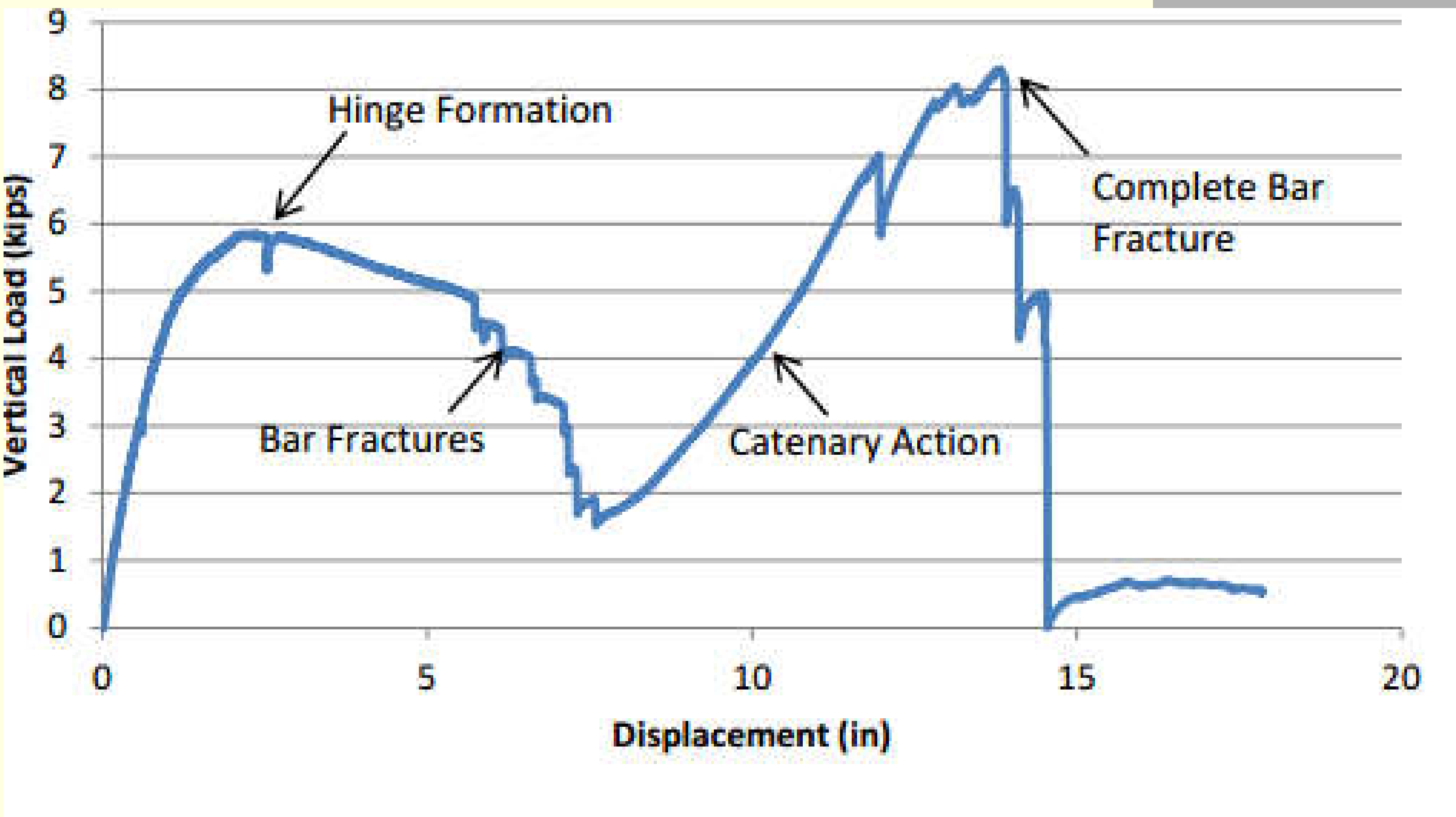

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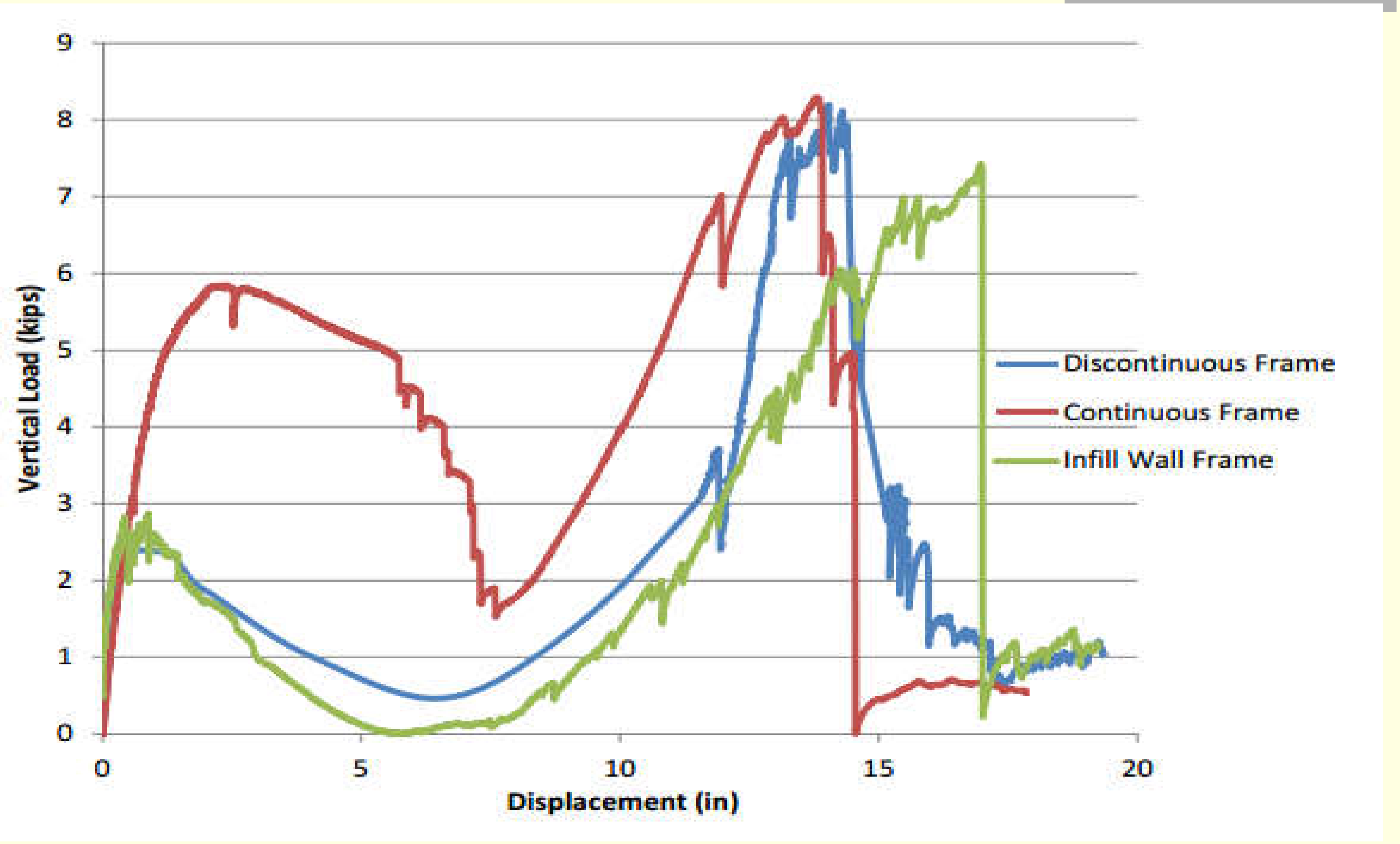

3. THE STUDY PROBLEM

3.1. EXPERIMENTAL STUDY

	Peak Catenary MTS Load (kips)	Peak Compressive Arch MTS Load (kips)	End of Compressive Arch Phase (in)
Discontinuous Frame	8.19	2.34	6.70
Continuous Frame	8.30	5.81	7.60
Infill Wall Frame	7.42	2.87	5.76

3. THE STUDY PROBLEM

3.2. THEORY STUDY

THANKS FOR YOUR ATTENTION