New Acute Care Hospital and Skilled Nursing Facility

San Francisco, CA

Thesis Proposal

Tim Ariosto – Structural Option

Faculty Advisor - Dr. Richard Behr

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Executive Summary

The New Acute Care Hospital and Skilled Nursing Facility is an addition to the existing Chinese Hospital complex located in San Francisco, CA. The 7 story structure has been designed using a concrete slab on steel framing with a special moment frame lateral system.

In Technical Report 3, seismic loads were found to be the controlling load condition for both strength and serviceability. Since structures tend to deform beyond their elastic limits during major seismic events, fluid viscous dampers (FVD) will be investigated to determine a configuration which will be most efficient at absorbing and dissipating transient forces.

The addition of Fluid Viscous Dampers will be accompanied by a redesign of the lateral system. The lateral system will be redesign to stay within its elastic limits during a major seismic event using guidelines set forth in the NEHRP *Recommended Provisions* and *Seismic Provisions*.

In addition to this structural depth, two non-structural breadths will be undertaken. A cost and schedule analysis will be used to compare the effect of the FVD design to the original design in terms of time and economy. An architectural breadth will be undertaken to investigate the effects (both to the exterior façade and to interior rooms) of adding braces with FVDs to selected moment frames throughout the structure.

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Introduction

The New Acute Care Hospital and Skilled Nursing Facility will serve as an addition to the existing Chinese Hospital located in the historic Chinatown district of San Francisco (See Fig. 1). The site lies on the north flank of Nob Hill, at an elevation of approximately 110’ above sea level. Due to the slope of the site, the ground floor of the site is located partially below grade.

Figure 1: Site View of New Acute Care Hospital (blue) located adjacent to existing Chinese Hospital. Photo Courtesy of Google Maps.

This new addition will be connected directly to the existing Chinese Hospital, located at 845 Jackson Street. As part of the construction of this addition, the original portion of the hospital built in 1925 will be demolished. Then the new facility, which has seven stories above ground and one below will be constructed with a hard connection to a previous addition built in 1975. Therefore, the precast concrete panel exterior façade has been designed in a way that respects the 1975 design while providing a more modern look.

At approximately 92,000 SF, this new facility will provide additional patient rooms as well as well several new medical departments to serve the local community. Construction is expected to begin in 2010 and reach completion by Chinese New Year 2013.

Figure 2: Exterior view of New Acute Care Hospital and surrounding buildings

Existing Structure Overview

The structure of the New Acute Care hospital rests on a mat foundation and consists primarily of composite steel decking with steel framing. A perimeter moment frame system is used to resist lateral loading.

Foundation System

According to the geotechnical report provided by Treadwell & Rollo, the soil conditions on the site can be described as "very stiff to hard sandy clay and clay with gravel," which rests on "intensely fractured, low hardness, weak, deeply weathered shale." Because of this, the New Acute Care Facility has been designed to bear on a 36" mat foundation. Columns rest on concrete pedestals, typically sized at 3'-0" x 3'-0". Since the base of the structure will lie below the water table, the foundation was also designed for hydrostatic uplift.

The close proximity to nearby structures (see Figure 2), particularly the 1975 addition to the Chinese Hospital, provided a challenge to the designers. Underpinning was used to maintain the foundations of existing structures on either side of the building.

Framing System

The New Acute Care Hospital uses steel columns (See Figure 3) to support the buildings gravity loads. These columns range in size from W14x445 near the base of the structure to W8x40's near the roof level. As the columns rise vertically through the structure they are spliced together, usually at a distance of 22'-0". Aside from those used in the lateral system, most of the columns are connected to beams and girders using pinned connections.

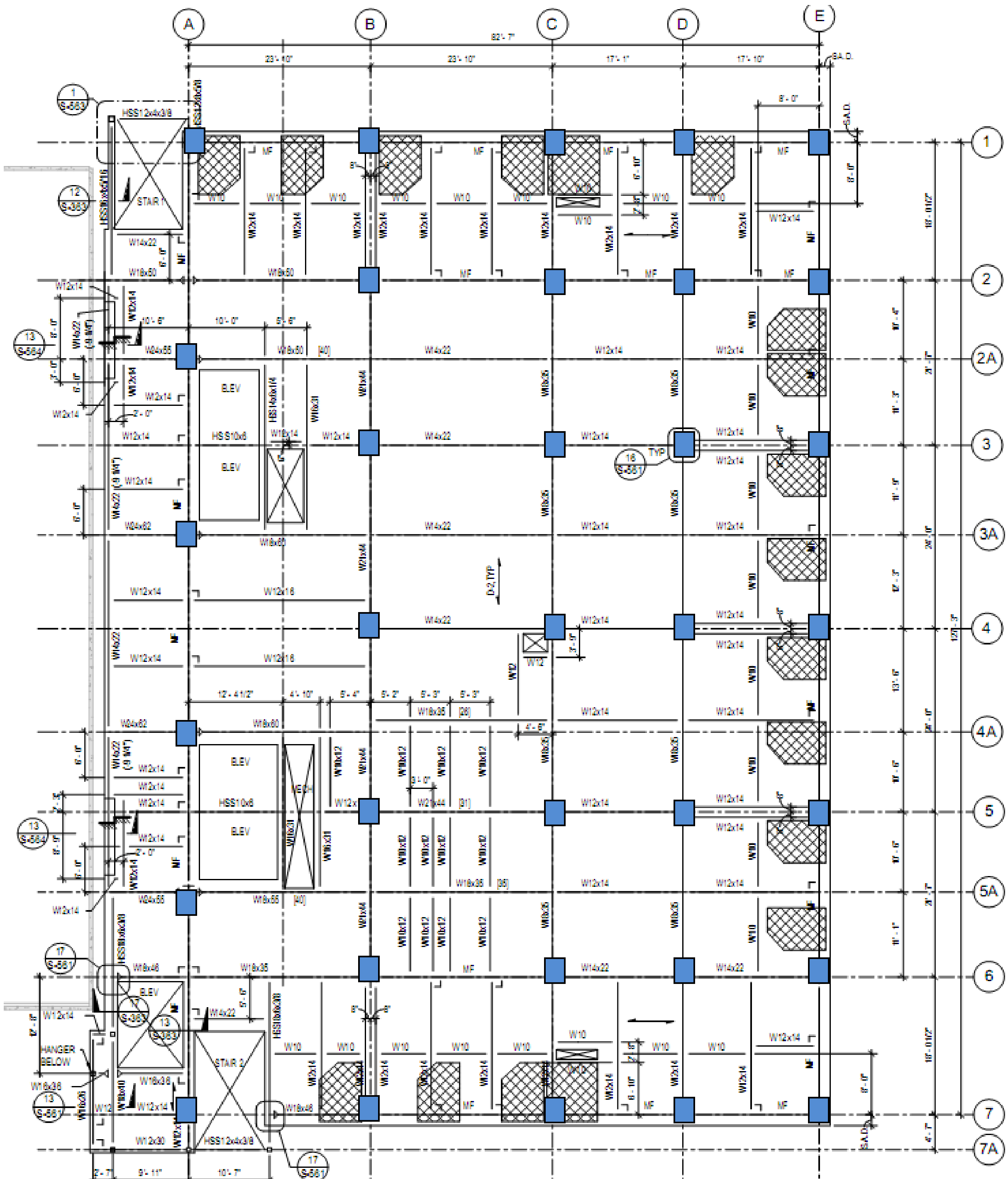


Figure 3: Typical Framing Plan with columns highlighted

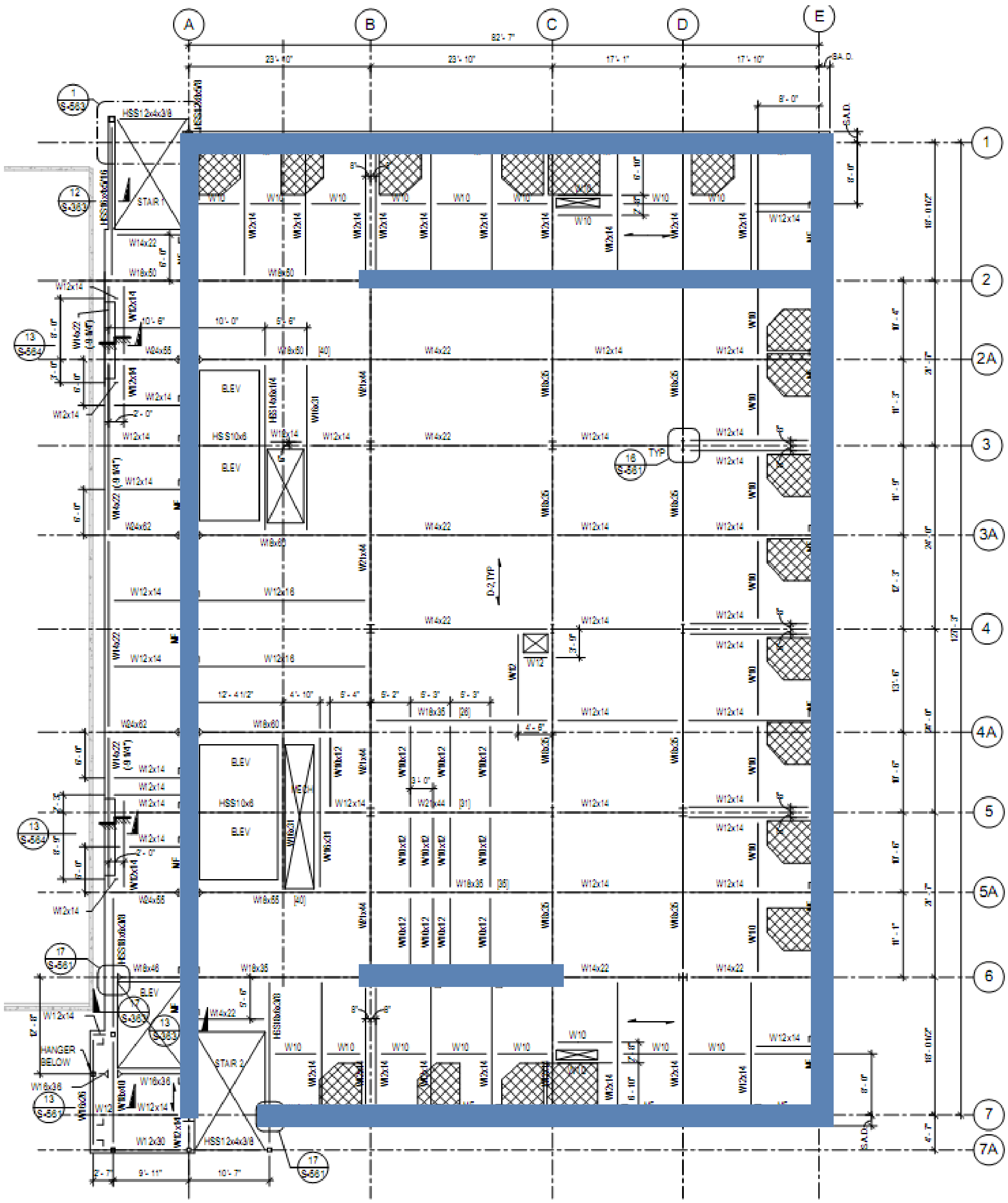


Figure 4: Typical Framing Plans with lateral system highlighted in blue

Floor System

The floor system consists of a composite floor system using a 3" Verco W3 Formlock deck with an additional 3 ¼" of concrete resulting in a total thickness of 6 ¼". This slab then rests on W-shapes ranging from W10x12's used as beams to sizes as large as W24x207's which also serve in the buildings lateral system. ¾" Ø shear studs were used to achieve composite action.

There are several different bay sizes used in the New Acute Care Hospital. Larger bay typically exist towards the plan east side of the building while smaller bay sizes are typically used in the western portion of the structure. In most cases, the bays varied from approximately 18'-0"x 17'-0" to 23'-10"x24'-0".

Lateral System

Lateral loads are transmitted through the structure primarily through the use of a series of special moment frames. There are 4 special moment frames running east-west, and 2 running north-south. One of the EW frames, located along gridline 2, terminates at the third floor level.

Since brittle failure of connections in moment frames tends to be a problem in regions of high seismic activity, the moment frame beams have been designed using Reduced Beam Sections (RBS). These RBS sections help to insure that yielding occurs in the reduced section of the beam rather than in the connection itself. See Figure 5 below.

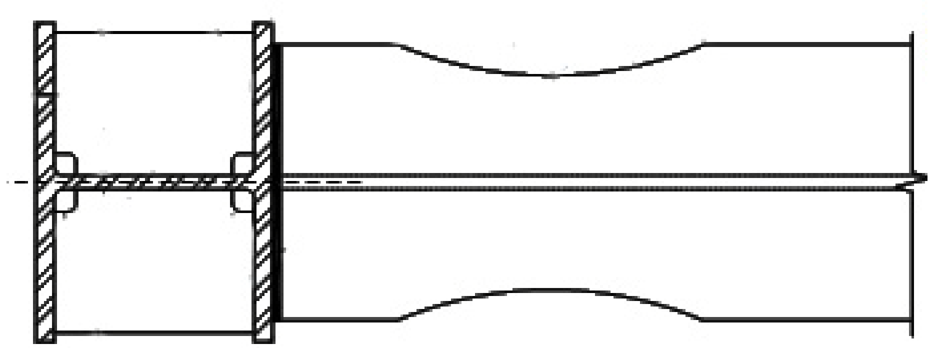


Figure 5: Reduced Beam Section

In addition to the steel moment frames, the basement walls also serve as shear walls for the basement level. These walls are 18" thick and composed of 4ksi concrete.

Roof System

The roof system is supported in a similar manner to the floors below, with a concrete filled metal deck supported by beams and girders. However, beams at this level are typically spaced much closer together, at a distance of approximately 10-12 feet. The sizes of these roof beams generally vary from W10x12's to W24x104's.

Other Features

One of the unique structural features of the New Acute Care Hospital is its connection to the existing Chinese Hospital. The structures are connected with a seismic gap that allows the two structures to act independently. This size of this gap varies with story height so that a greater amount of movement is allowed at the upper floors.

A second unique feature of the New Acute Care Hospital is a result of the tight floor plan. There are several areas in which partition walls lie directly on beams. Since plumbing would normally be routed through these partition walls, a system of two, parallel beams spaced at 16" were used to create a gap for the plumbing system. See Figure 6 below.

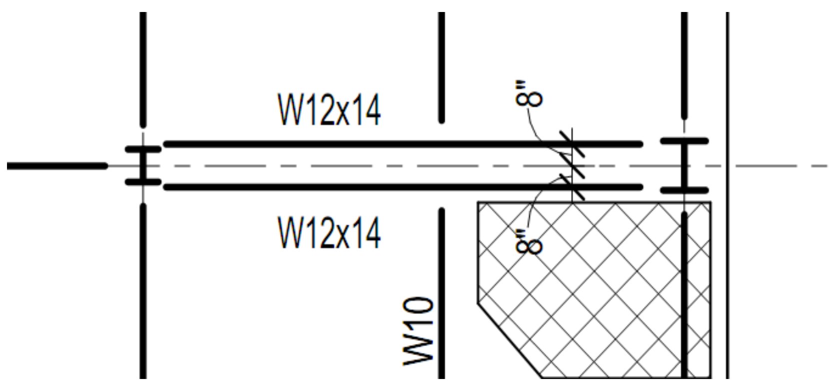


Figure 6: Parallel beams used for plumbing

Applicable Codes

Original Design Codes Used

In addition to the following codes, the California State Government requires that all new government and hospital buildings are approved by the Office of Statewide Health Planning and Development (OSHPD).

- 2007 California Administration Code
  - Part 1, Title 24, CCR
- 2001 California Building Code
  - Part 2, Title 24, CCR
  - (1997 UBC and 2001 CA Amendments)
- 2004 California Electrical Code
  - Part 3, Title 24, CCR
  - (2002 NEC and 2004 CA Amendments)
- 2001 California Fire Code
  - Part 4, Title 24, CCR
  - (2000 UMC and 2001 Amendments)

Design Codes Used in Thesis Analysis

- American Society of Civil Engineers (ASCE)
  - ASCE7-05, Minimum Design Loads for Buildings and Other Structures
- International Building Code, 2006 Edition
- American Institute of Steel Construction (AISC)
  - Steel Construction Manual, Thirteenth Edition (LRFD)
- American Concrete Institute
  - ACI 318-08, Building Code Requirements for Structural Concrete
- NEHRP
  - Recommended Provisions for New Buildings and Other Structures (2003)
  - Recommended Seismic Provisions (2009)

Problem Statement

In Technical Report 3, seismic loads were found to be the controlling load condition for the structure of the New Acute Care Hospital. Seismic Loads, in comparison to wind loads, are generally considered to be a primarily a strength issue, rather than a strength and serviceability issue. This presents a unique challenge to structures controlled by seismic loads. While it is of primary importance that the structure survives the seismic event long enough for the buildings occupants to get to safety, it is also important that the structure can still be used afterwards. One means by which this can be accomplished is through the use of Fluid Viscous Dampeners.

Proposed Solution

When major seismic events occur, structural elements tend to deform beyond their elastic limits, which can potentially result in failure or collapse of these individual elements. Fluid Viscous Dampers (FVDs), which absorb energy from sudden jerks and movements, work like shock absorbers in a car. When applied as a supplement to a structure, they can be designed to absorb and dissipate the energy from a major seismic event; thus protecting the rest of the structure.

The purpose of this thesis investigation will be to redesign the lateral system of the New Acute Care hospital to make use of Fluid Viscous Damper technology. The lateral system will first be designed to remain elastic for static loading conditions.   Fluid Viscous Dampers will then be used to meet drift requirements.   A Time History Analysis will be undertaken using ETABs to aid in the design.

Four types of Fluid Viscous Dampers will then be compared.   The configurations that will be investigated are dampers on diagonal braces (See Figure 7); concentrically braced chevrons with dampers on diagonals (See Figure 8), concentrically braced chevrons with horizontal dampers (See Figure 9) and a toggle brace damper system (See Figure 10). . The criterion for this comparison will be overall drift and the flexural rotation of connection elements, as well as component cost.

Figure 7: Diagonal Brace FVD Configuration

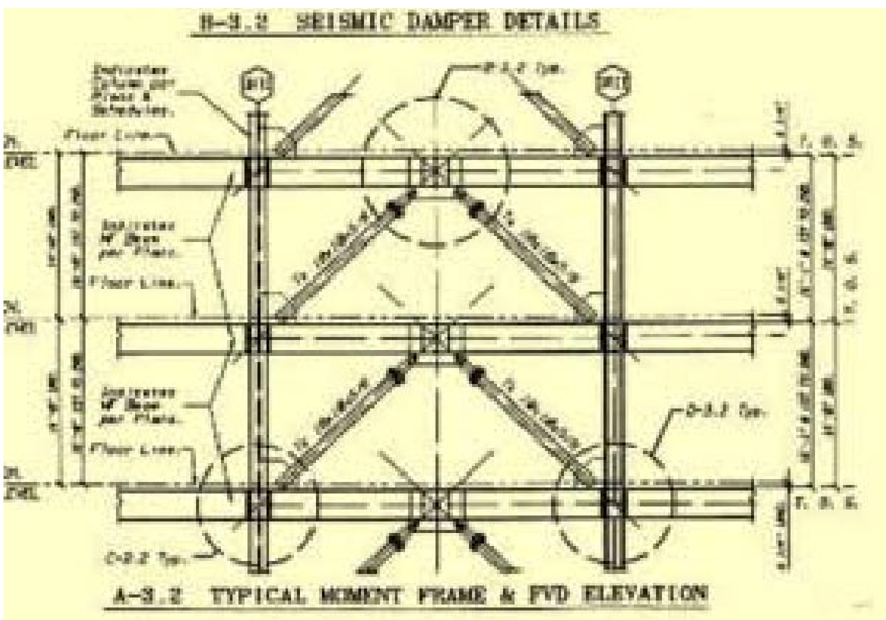


Figure 8: Diagonal FVD's on Chevrons

Figure 9: Horizontal FVDs on Chevrons

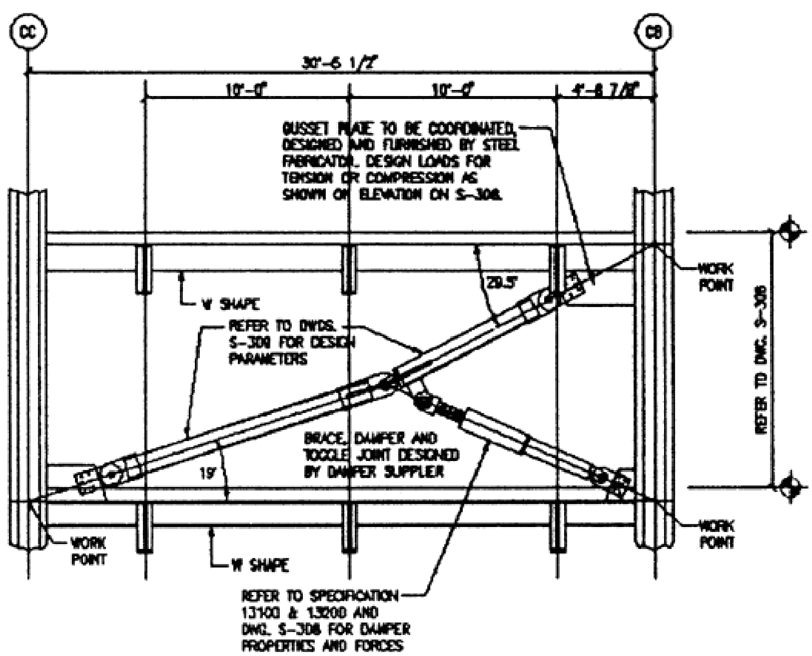


Figure 10: Toggle-Brace Damper System

Breadth Topics

Construction

Due to the addition of FVDs and the redesign of the lateral system; a cost and schedule impact will also be undertaken to determine the effects of the changes. Included in this breadth will be estimates on the prices of FVDs as well as installation costs for the new system. The price of the FVDs will then be compared with the cost reduction of reducing the size of the lateral system. Since the expected completion date of Chinese New Year 2013 is important symbolically to the project, it will be important to determine whether that deadline would still be met.

Architectural

The current structural system of the New Acute Care Hospital is made of moment frames, which offer a considerable amount of freedom for the architecture. If these braces are added to the interior moment frames, they will have an impact on the floor plan. If they are added to the perimeter frames, then the exterior façade will have to be modified. Therefore, an architecture breadth will be included which will detail the impact of the FVD additions as well as propose a solution to that impact.

Methods

The investigation into Fluid Viscous Dampers will begin by determining the optimal locations for the FVDs in the 6 moment frames. This will need to be accomplished through consulting with faculty members and industry professionals, evaluating architectural criteria, as well as independent research of literature.

After the optimum brace location is determined, the lateral system will be redesigned to remain elastic under the lateral loading condition. Once the lateral system has been redesigned, the damper system design forces will be determined based on floor deflection, story drift and story velocity.

The four FVD configurations will then be modeled using independent ETABs models for each case. The optimal configuration will be determined based on a comparison of story drift, flexural rotations, and cost.

Tasks

Task 0

Revise Proposal

Task I

Determine the optimum location for FVD braces in each moment frames based on consultation of faculty members and industry professionals, a thorough literature investigation, and the impact of each location on the existing architecture.

Task 2

Research the proper methodology for undertaking a Time-History Analysis using ETABs.

Task 3

Redesign the lateral system according to the provisions of NEHRP *Seismic Provisions: Structures with Damping Systems.*

Task 4

Develop a simplified model for each frame using the equivalent properties of each real frame using NONLIN.

Task 5

Use the simplified model to determine the amount of damping needed to drift requirements.

Task 6

Model the four types of FVDs previously determined and select the best type.

Task 7

Architectural Impact Breadth

Task 8

Cost and Schedule Impact Breadth

Task 9

Prepare for Final Presentation

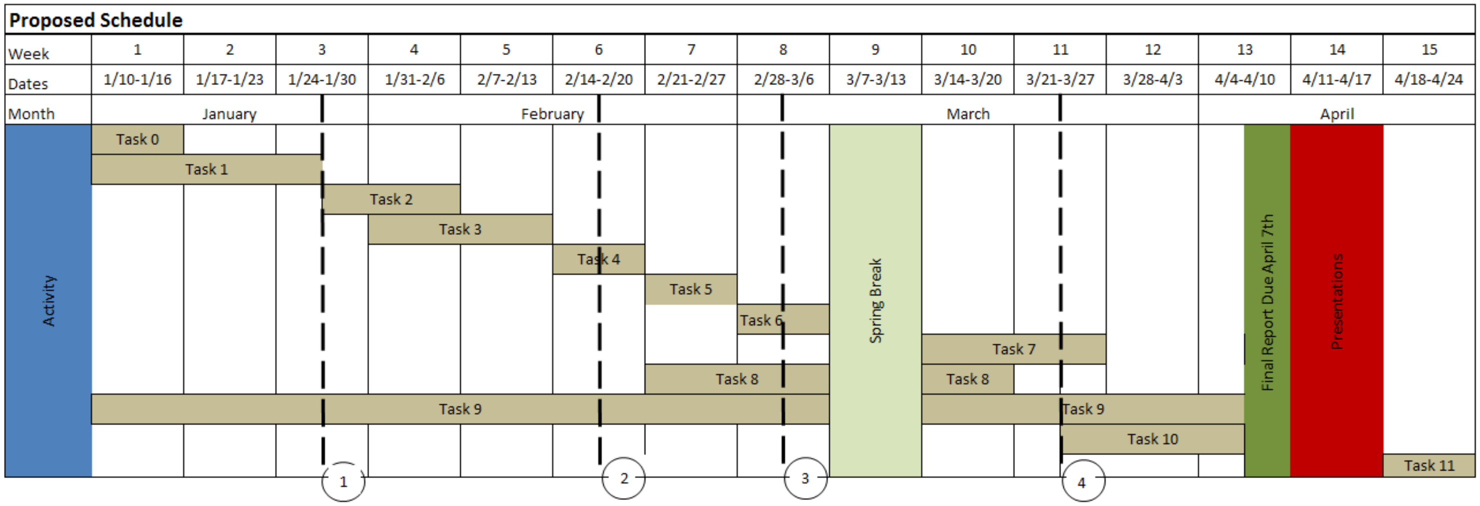
Task 10

Write paper, making revisions as necessary.

Task 10

ABET Evaluation and CPEP update

Timetable



Task 0: Revise Proposal and Post to CPEP

Task 1: Determine the optimum location for FVD braces in each moment frames based on consultation of faculty members and industry professionals, a thorough literature investigation, and the impact of each location on the existing architecture.

Task 2: Research the proper methodology for undertaking a Time-History Analysis using ETABs.

Task 3: Redesign the lateral system according to the provisions of NEHRP Seismic Provisions: Structures with Damping Systems.

Task 4: Develop a simplified model for each frame using the equivalent properties of each real frame using NONLIN.

Task 5: Use the simplified model to determine the amount of damping needed to meet drift requirements.

Task 6: Model the four types of FVDs previously determined and select the best type.

Task 7: Architectural Impact Breadth

Task 8: Cost and Schedule Impact Breadth

Task 9: Write Paper, making revisions as necessary

Task 10: Prepare for Final Presentation

Task 11: ABET Evauluation and CPEP Update

<u>Milestone Activity List</u>

Milestone #1 - 1/29/2010 - Determine FVD location in structure

Milestone #2 - 2/17/2010 - Develop NONLIN models for 2 frames
- Complete initial draft of report of work completed

Milestone #3 - 3/5/2010 -Model 4 FVD systems

Milestone #4 - 3/24/2010 - Architectural Impact is determined

Conclusions

An in-depth investigation will be undertaken into the use of Fluid Viscous Dampers to absorb and dissipate the large lateral forces generated during a major seismic event. The existing lateral system will be redesigned to behave elastically, and the damping system will be designed for drift requirements. Four configurations, diagonal braces, concentrically braced chevrons with dampers on diagonals, concentrically braced chevrons with horizontal dampers, and a toggle brace damper system.

In addition, two non-structural breadths (cost/schedule impact and architectural impact) will be included.

APPENDIX

Appendix A: References

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