Temecula Medical Center

Temecula, CA

SENIOR THESIS

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Architectural Engineering – Structural Option – B.A.E.
Senior Thesis Project

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Temecula Medical Center

Temecula, CA

Project Team:

Owner	Universal Health Services of Rancho Spring, Inc.
Design Architect	HKS Architects
Structural Engineer	HKS inc.
Civil Engineers	Lopezgarcia Group
MEP Design Engineers	CCRD Partners

Building Stats:

Building Size	295,000 sq. ft.
Levels	6
Cost	Const. on hold*
Delivery	Design-Bid-Build
Occupancy	Medical
Zoning	Commerical

MEP Systems:

- Electrical and Mechanical systems feature standard equipment
- Due to limitations, the actual specifications of these systems can not be released.

Architecture:

- Trademark of Temecula, CA
- 6 stories @ 107'
- Facade predominantly portland cement plaster with pre-finished metal panels
- Roof consisted of coping caps matching plaster as well as rust colored roof panels
- Follows California/West Coast architectural motif

Structural System:

- Concrete flat-plate two-way slabs in 6-story bed tower
- Precast double tees hold up the 2-story D&T
- Slab thicknesses vary from 6" on top of the double tees to 10" two-way slabs
- Roof system supported by various steel W-shapes.
- Lateral forces resisted by thick concrete shear walls
- Concrete shear walls typically anchored with 6' deep footings and reinforced with #9's at 9" o.c.
- 26x26 cast-in-place as well as 20x20 precast columns

Sean Beville - Structural

www.engr.psu.edu/ae/thesis/porfolios/2009/sfb5000

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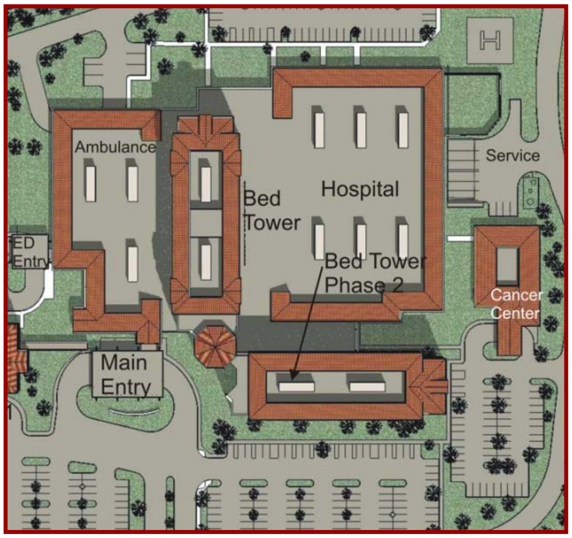
Executive Summary

The Temecula Medical Center is a proposed 6-story hospital which features a 2-story Drug and Therapy center (D&T) as well as a 6-story bed tower. Labs and research space is located in the D&T while the examination and patient rooms are placed throughout the 6-story tower. Parking is located around the hospital, leaving space for future development of the area. As designed, the hospital would include 295,100 sq. ft. of space and rise 106'-8" above grade. While the design was approved in May, 8th, 2008, economy and budget problems have forced the construction to be put on hold. Shown in the image is the site plan which includes the proposed building as well as possible future additions.



The structure of the Temecula Medical Center was designed as a two-way, flat-plate concrete system, with a series of concrete shear walls to resist the strong west coast lateral loads. This report investigates the feasibility, cost, and schedule changes associated with changing the bed tower structure from concrete supported to a composite steel system with concentric braced frames. Many conservative assumptions were taken during the original design of the structural system, predominantly because of the location as well as hospital category.

The new composite system was designed using ASCE 7-05 and IBC 2006, with the assistance of a RAM structural model. The results consisted of W16 beams framing into W18 girders on typical floor layouts. The loads from the floors were carried to the foundation through W10 and W12 columns. Braced frames to resist the heavy lateral loads consisted of wide-flanged columns (W12) and beams (W8 and W16). Rectangular hollow structural sections were used as concentric diagonal bracing, with HSS14"x6"x3/8" being the typical size used. While this size would normally be considered small, the multiple locations help resist the horizontal loads.

A construction management breadth study was performed in order to determine the cost and schedule implications of the new steel structure. The new system was estimated to cost approximately $1.69 million less than the original concrete system, while being completed almost three months sooner.

Original plans for the Temecula Medical Center consisted of small windows surrounded by a plaster façade on the exterior. An architectural breadth study explained later in this report detailed a change from the existing façade to a predominantly glass curtain wall. Glass would allow more light into the interior as well as reduce heating requirements in the short winters. Due to the hot climate in Temecula, CA, extensions will need to be added between floors to help shade rooms from the intense summer sun rays.

Building Overview

Function

The Temecula Medical Center has six floors, grouped by level to serve a particular function. The first floor serves as the entrance level and includes various exam rooms, emergency rooms (E.R.), and offices. This floor also contains a drive-through delivery area for ambulances or emergency services. Levels two and three house the intensive care units (I.C.U.) as well as various offices placed throughout the perimeter. Finally, levels four through 6 are almost identical in consisting of standard patient rooms as well as offices. Besides the entrance floor, all levels share a common theme of rooms/offices around the perimeter with a core consisting of nurse stations and elevators.

Architecture

The Temecula Medical Center is designed as a trademark medical facility for the city of Temecula and the surrounding region. It has 6 stories and is approximately 107' tall with its most predominant feature being the circular tower on the south side. The south tower serves as the main vocal point with large banded windows as well as 4 distinct column points. The exterior facade is made up of mostly portland cement plaster but also features porcelain wall tile (lining parts of the ground level exterior), and pre-finished metal panels (on lower floors).

The roof system of the medical center consists of pre-formed, pre-finished sheet metal coping caps to match the plaster as well as sloped rust colored roof tile.

Being located in California, the Temecula Medical Center maintains many architectural motifs originating on the west coast. This style is brought out in the numerous small windows on the facade, as well as the rust colored roof.

Mechanical System

The mechanical system for the Temecula Medical Center features standard equipment. 12 roof-top mounted Air Handling Units (AHU's) are on top of the two-story D&T while two larger AHU's are on the roof of the six-story bed tower.

On the first floor is a Mechanical Yard which consists of two cooling towers and two emergency generators (on grade). Also on grade is a mechanical room that houses two chillers, two boilers, 6 water pumps, and other miscellaneous equipment.

Connecting the mechanical equipment is piping and ductwork which had to be seismically braced according to the California Building Code.

Electrical System

The electrical system also features standard equipment which is controlled by a central electrical/telecomm room on each level of the building. These rooms serve as the distribution point for each floor.

Most rooms have either recessed compact fluorescent or recessed full-length fluorescent tube lighting (2'x4' fixtures – 2-F32TB/SP35/RS) with dimmable ballasts. The electrical system is powered by 277V standard.

A notable feature of the electrical system is the lighting present for the helipad on the roof (2-500w quartz floodlights & various traffic signal lamps) which can be activated if helicopter transport is required.

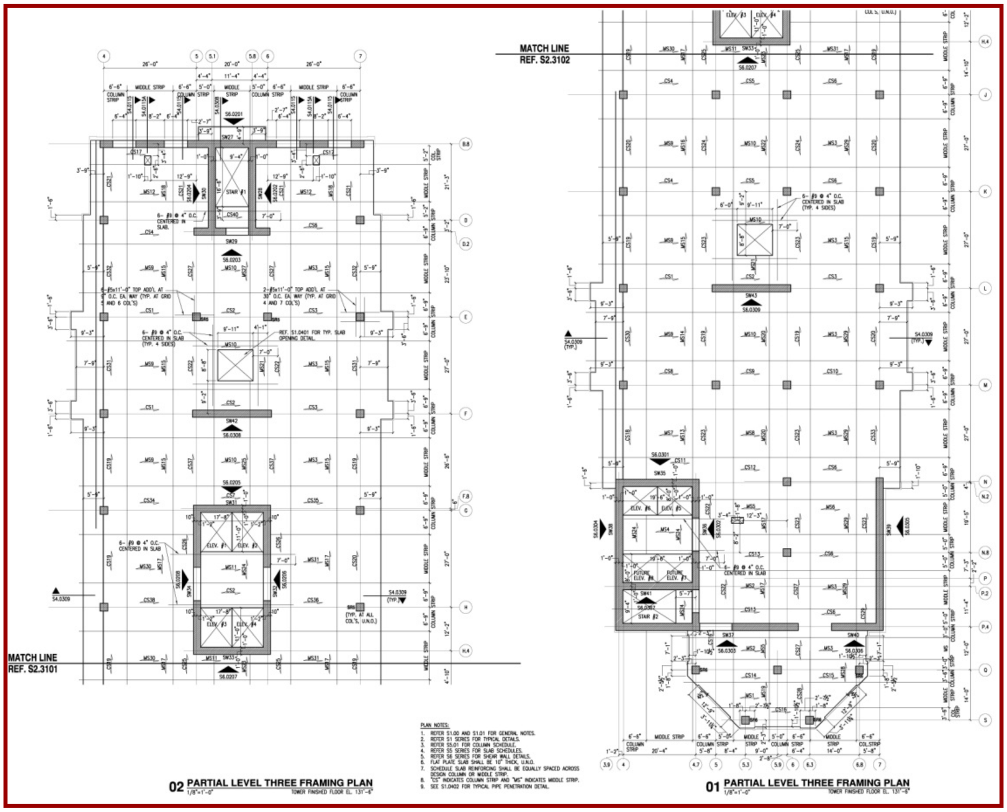
Existing Conditions

Lateral System

The lateral forces are resisted predominantly by concrete shear walls placed throughout the plan. The elevator shafts serve as the main component of the lateral resistance system. Shear walls are typically 27’-9” long, and 2’ thick with varying reinforcement sizing and spacing. Each wall is built with a minimum 28-day compressive strength of 7000 psi. Specifically labeled walls have a compressive strength of 9000 psi. The shear walls are anchored to the supporting soil by footings, typically 6’ deep and reinforced with #9 at 9” o.c. See Chart and Figure below for additional details on the existing system. The bold shapes represent the shear walls placed throughout the floor plan.

Concrete Strengths

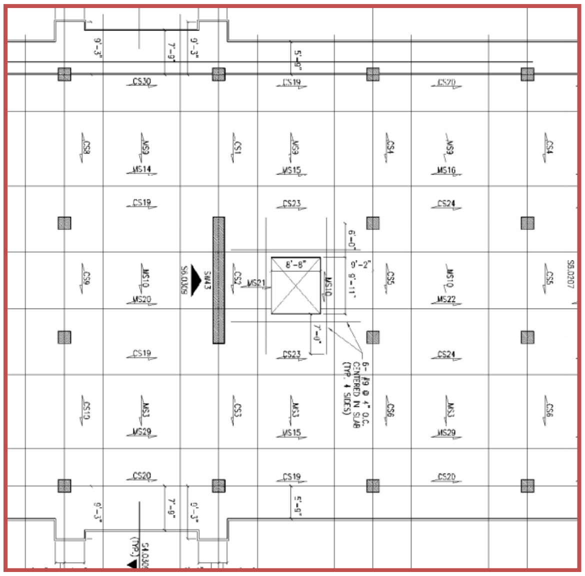
	F’c (psi)	Conc. Type	Max. Agg. Size
Typical Shear Walls	7000 (56-day)	N.W.C .	3/8”
Shear Walls (where noted)	9000 (90-day)	N.W.C.	3/8”



Floor System

The floor system of the first floor consists of a 5” slab-on-grade while the remaining floors of the Drug and Therapy Center (D&T) are supported by various sized precast, prestressed double-tees. The 6-story bed tower consists of two-way, 10” reinforced concrete flat slabs. Slab reinforcement ranges from #4 bars to #6 bars, spaced from 6” to 9” on center.

Topping slabs of the double tees in the D&T consists of 6” normal weight concrete, typically reinforced with #4 at 9” o.c. Typical spans between tee’s is 6’-0 but vary on location. Two-way flat slab reinforcement sizes for the 6-story bed tower vary but are placed equally across designed column and middle strips. A typical floor layout is shown below.



Roof System

The lower roof over the 6-story bed tower is composite slab with 4 ½” normal weight concrete over 2”, 16 gage composite metal deck (galvanized), reinforced with #3 at 9” o.c. each way. Supporting the 1 ½”, 20 gage metal deck on the high roof are rolled steel W-shapes, typically W10x17, 33, or 45. The roof system over the 2-story D&T is very similar and consists of a 1 ½”, 20 gage metal deck held up by rolled steel W-shapes, varying in size from W8 to W18.

Foundation

The foundation is a combination of spread footings and drilled piers with concrete pier caps. The spread footings vary in size from 5'x5' to 18'x18', depending on location, and are labeled F5-F18 accordingly. The reinforcement for these footings goes from 16 #5 each way in the F5 to 18 #9 each way in the F18.

Foundations for the shear walls feature footings anchored to the supporting soil by drilled piers, typically being 42" in diameter. Each pier is spirally reinforced, varying in size while the pier caps are typically reinforced with #9 - #11 at 9" o.c.

Columns

Vertical supports for the first level consist of 26" x 26" cast-in-place columns as well as 20" x 20" precast columns, however the upper floors (2-6) have only the 26" x 26" cast-in-place columns. A typical bay size is 54' x 27', although they vary depending on location and demand.

The cast-in-place columns typically run from spread footing through each floor while being reinforced with 12 #9's vertically and #4 at 6" o.c. horizontally. Pre-cast columns are reinforced with 4 #9's vertically and #4 at 5" o.c. horizontally. The compressive strength for the C.I.P. columns is 5000 psi and the strength of the PL columns is 6000 psi.

Problem Statement

While the proposed design of the Temecula Medical Center effectively uses the combination of a two-way flat-plate floor system and concrete shear walls, a redesign using a composite steel structure coupled with concentric diagonal bracing should prove to save time, money, and space. The new system will utilize the same areas for lateral bracing as well as adhere to similar floor thickness in an effort to provide a new look and performance for the medical center.

The budget of the building must also be taken into account. Any changes to the existing building structural design need to be similar or lower cost. Earlier technical reports concluded some parts of the concrete system appeared to be larger than required, more than likely to keep the design conservative. A predominantly steel system could be more efficient by reducing the amount of materials needed as well as requiring a lighter lateral system.

Proposed Solution

A composite steel structural floor system with steel columns is proposed, to be designed for gravity and lateral load criteria. The concrete shear walls will be replaced with steel braced frames. These changes can be done with very little effect on the current floor layout and architecture of the medical center.

Technical Report 2 showed composite beam sizes ranging from 16”-18”, with a slab thickness of 4”. This is considerably thicker than the existing 10” slab, but the Temecula Medical Center is well within height restrictions. The new steel system may prove to be more efficient than the existing concrete by providing added resistance with a lighter and possibly more cost-effective design.

To implement these changes, a computer model of the new gravity system will be constructed and tested in RAM Structural System. Due to the change in the structural systems weight, height, and lateral system, lateral loads will be recalculated and applied to a new lateral system model.

Breadth Topics

Building Envelope

An analysis and redesign of the building envelope will involve replacing the existing plaster exterior façade with predominantly glass. This will include additions that limit incoming light and heat which in turn will affect the buildings architecture. With the western motif evident in the surrounding buildings, this change will make the Temecula Medical Center very unique. Horizontal extensions above the windows will appear to lengthen the building while blocking the incoming summer heat. An example of these extensions is shown to the right which appears on the Life Sciences building on the Penn State University campus. An all glass façade will present many obstacles but in the end will produce a more enjoyable day time interior as well as a more pronounced exterior at night. Calculations will be performed to prove (or disprove) the significant interior environment changes resulting from the addition of glass and protrusions.

Cost and Schedule

The second breadth will involve the constructability, time, and cost savings regarding the structure system being designed with steel instead of concrete. The scheduling impact due to the structural changes will be analyzed in order to compare with the current critical path of the schedule. While the building has not been constructed yet, this study will entail the comparison of steel erection time compared with typical concrete construction times. Also included will be an analysis of cost comparisons between steel and concrete floor and lateral resistant systems. Included in this analysis by default is the constructability of the steel system in the heavy seismic zone.

Tasks and Tools

A list of tasks to be completed in the investigation of these proposals, as well as the tools required, is included below:

1. Gravity System
    a. ASCE 7-05 for dead, live, snow loads
    b. Determine preliminary slab and member sizes using hand calculations
    c. RAM structural model check of composite steel floor system

2. Lateral System
    a. ASCE 7-05 for wind and seismic loads
    b. Determine load distribution to steel braced frames
    c. Determine member sizes for steel braced frames
    d. Lateral system model – check strength and serviceability

3. Cost and Schedule
    a. R.S. Means for cost/crew information
    b. Spreadsheets with cost data

4. Building Envelope Study
    a. Determine changes to exterior façade
    b. Calculate incoming light vs. old system
    c. Sketch façade architectural changes

Project Goals

The goal of the depth study for this thesis is to determine the feasibility of changing the structure of the Temecula Medical Center from a two-way flat-plate concrete system with shear walls to a composite steel system with diagonal steel bracing. This new system will be checked according to gravity and lateral load requirements.

The Construction Management breadth will follow the depth study by examining the construction feasibility of a composite steel system. The breadth study will determine the impact on the cost and schedule in order to determine the financial feasibility.

Changing the current plaster façade to predominantly glass will detail an architectural breadth study which will feature changes in the mechanical and electrical requirements of the medical center. The goal of this study is to roughly estimate the planning that would need to go into such a facility.

Structural Depth Study

Overview

The Temecula Medical Center was built to make a statement in the city of Temecula, CA. The lower levels house many advanced laboratories and research centers while the 6-story bed tower must be designed to carry multiple I.C.U. and Patient rooms. While many other factors must go into the redesign of the structural system, vibration requirements are at a minimum due to the lack of motion sensitive equipment. Because budget is a very important factor in any construction project, finding the most economical solution while maintaining safety standards is the number one priority.

This depth study investigates a redesign of the Temecula Medical Center with a steel framing system, using composite floors and lightweight, 5 ksi concrete. The building was originally designed in concrete and while this proved to be a very effective approach, a steel structure will offer positives such as less required space and a lighter overall structure. The first and second level will maintain a precast double-tee floor system due to the large spans although all floors of the bed tower (1-6) will be redesigned for strength and deflection with vibration being checked for human comfort. While there are no established methods to determine vibration in concrete design, conservative approaches are assumed. For the redesign, no special methods will be used besides the needs for basic human comfort.

Due to the change of system from concrete to steel, the cast-in-place columns on the top three floors were changed to wide-flange steel shapes. The 24-inch-thick cast-in-place shear walls were replaced by concentric steel braced frames, with wide-flange columns and beams, and rectangular HSS shapes. Because the existing design calls for 26” x 26” square columns, only W10 and W12 shapes were used for the redesign so they would not affect the current layout and therefore no changes will need to be made. To avoid any changes to the layout, the braced frames were designed such that the bracing members do not interfere with openings that were present in the existing shear wall design. Also for simplicity, all members of the braced frames were designed within the thickness of the existing shear walls. This was simple due to the large two foot thick existing walls.

Design Procedure

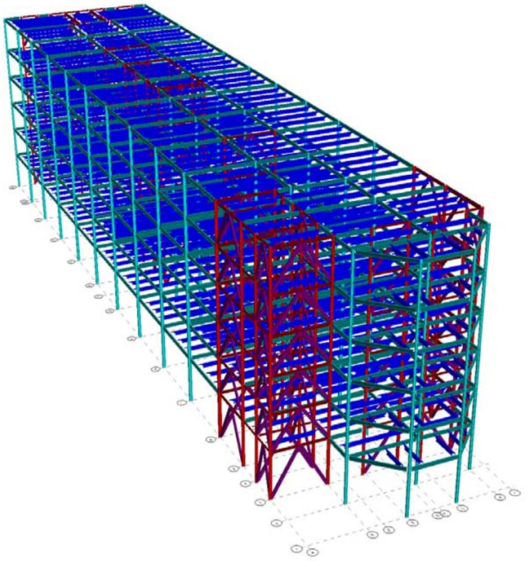
A preliminary framing plan layout was created to help assist in redesigning the floor framing systems of the building. This plan was used to determine the best and most efficient layout of girders, beam spans, and member spacing. Once the layout was determined, preliminary beam sizes were determined using LRFD design methods along with the Thirteenth Edition AISC Steel Construction Manual. Deflection limits were as follows:

Live Load:	*L/360*
Total Load:	*L/240*
Pre-Composite Construction Load:	*L/360*

The layout and preliminary member sizes were then entered into a RAM Structural model and design checks were performed. Beam sizes determined by RAM closely resembled those determined by hand calculations and very few changes needed to be made.

While there were no specific requirements for vibration control, checks were performed on the upper floor's typical bays for basic human comfort. Many columns were pre-designed by hand but RAM was used to verify the results. Sizes selected in the computer model were similar to the hand calculated results and any differences were due to personal decision.

The final part of the structural system to be designed was the lateral system. This had to be looked at in great detail due to the strong lateral forces resulting from the building's west coast location. The lateral structure is composed of ordinary concentric braced frames which were added to the RAM Structural System model and designed in RAM Frame. According to ASCE 7-05, The Temecula Medical Center is considered as Seismic Design Category B, which allows for equivalent lateral force analysis. The lateral forces were applied to the center of mass of the floor diaphragms, with an accidental eccentricity of 5%.



Gravity Loads

The gravity loads used in the analysis of the structural system were determined according to ASCE 7-05, and are as follows:

DEAD LOADS (psf)	
Slab + Deck	48
Superimposed M/E/P/L	12
TOTAL	60

LIVE LOADS (psf)	
Laboratories / O.R.	60
Offices	50
Partitions	20
Corridors	80
Patient Rooms	40
TYPICAL FLOORS	80

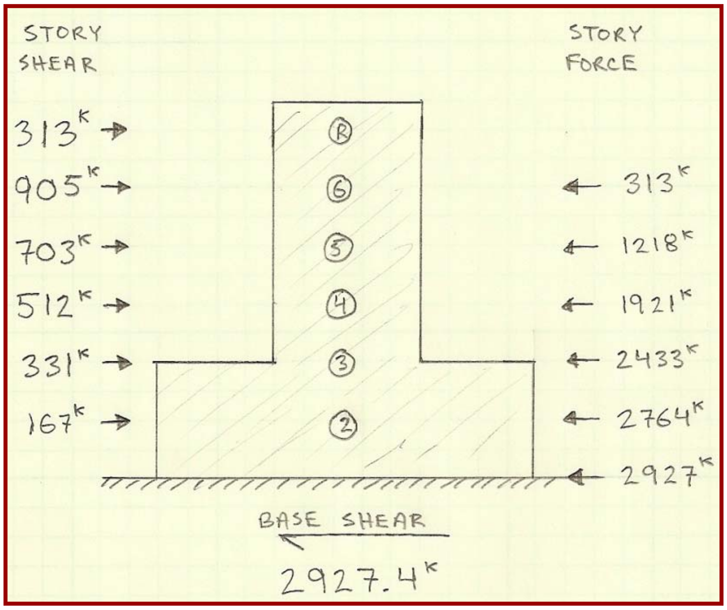
ROOF LOADS (psf)	
Live	30
Snow	21

Dead Loads above include the self-weight of the concrete slab, the deck, and any other permanent building systems attached to the structure. The steel beam weight was not included in the preliminary hand calculations, but was accounted for in the RAM model. Live load reduction was taken into account as prescribed in ASCE 7, Section 1607.

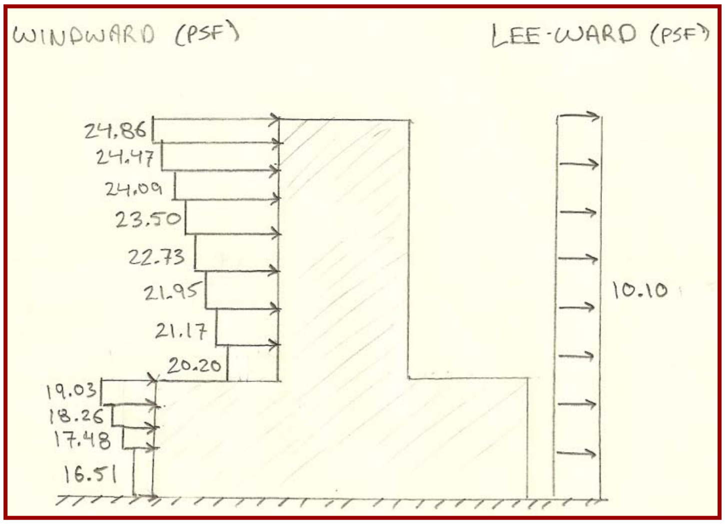
Lateral Loads

ASCE 7-05 was used to determine the lateral loads on the building including wind and seismic forces. Since the new steel system is lighter than the previous concrete structure, the seismic loads were expected to decrease. The change from concrete shear walls to concentric bracing, however, causes a decrease in R-fact from 4.0 to 3.25. These two changes along with the structural changes result in a reduction of the seismic base shear, from 4248^K to 2927^K. The building's height increase, due to the new steel structure, did not result in a significant change in the calculated wind loads primarily because the values found in previous reports were conservative.

Due to the large length to width ratio of the building, as well as the region in which the building is located, the seismic loads generally control the design of the system. The lateral load calculations are shown in Appendix A at the end of this report. A summary of the loads is shown below.



Seismic Story Forces and Shears



North-South Wind Pressures

Deck, Beam, and Girder Design Details

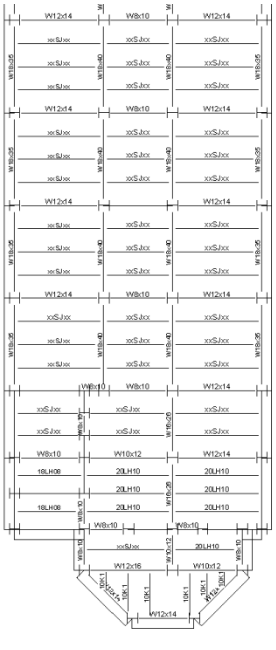
The layout developed features metal deck spanning perpendicular to the infill beams, a maximum of nine feet. The chosen deck and slab would be required to carry the 80 psf live load as mentioned above. United Steel Deck design manual was used to select the metal deck that would meet this requirement. A 2” LOK-Floor composite steel deck was selected, along with light-weight concrete. A 6” (4” above the deck) slab was chosen to help contribute to vibration control, as well as to ensure a 2-hour fire rating without requiring the use of fireproofing.

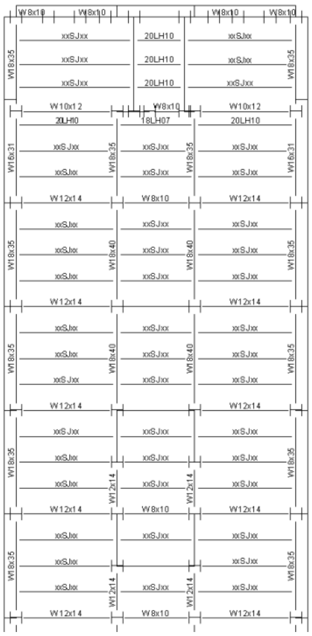
The Thirteenth Edition AISC LRFD was used to select typical beam sizes and the amount of shear studs required to support the gravity loads. The load case that controlled in all of the gravity load cases was 1.2D + 1.6L. Pre-composite construction load deflection controlled the design in many cases after beam sizes were chosen for strength. This deflection must be limited during construction, as too much deflection could lead to the addition of extra concrete to the slab, which would increase the deflection even more. Without control of the deflection, shoring would be required which drives up construction costs and scheduled time.

The design resulted in light W18 sizes for girders and light W12 sizes as the infill beams. In some locations it would have been cheaper to design using a non-composite floor system since one shear stud is roughly equivalent to 10 pounds of steel, but composite was used for regularity.

A disadvantage of the steel structural system is the added depth caused by the steel shapes and composite design. This makes for a larger floor-to-floor height which results in a building that is slightly taller than the original. In order to avoid interference with mechanical systems and other ductwork, the floor-to-floor heights were increased by 12” in most cases.

An efficient steel design is characterized by repetition of steel shapes. Using fewer numbers of





different sizes cuts down on coordination time in the field; material costs for the structure, and also reduces the chance of mistake during construction. Because of this, member sizes were coordinated such that beams and girders were similar throughout the building in typical bays or locations. This helped reduce the number of different shapes and created typical layout details throughout the building. The calculations can be found in Appendix B, and the resulting designs are shown in Appendix C at the end of this report.

Column Design

The gravity loads of the building are carried by the slab and deck, to the beams. The beams then carry this load to the girders and finally it is transferred to the ground by the frame and columns. Loads are dispersed through the ground by thick foundation pilings which are driven deep into the soil. The columns of the Temecula Medical Center were designed for axial loads as well as gravity-induced moments according to Thirteenth Edition AISC LRFD criteria. Total axial load was determined by finding the tributary area for each column on every floor. Finally, these results were compared with the ones found through the RAM Structural System model.

Since the original design resulted in 26” x 26” columns, no architectural changes needed to be made. Column sizes were designed as W10 sizes where possible, although any conventional steel shape would result in an increase in floor area.

Similar to the beam selection process, the column sizes were adjusted to increase repetition and cut down on the number of different sections. The gravity loading resulted in a total of six different column sizes throughout the building. These sizes ranged from W10x33 to W12x79. The calculations for these sizes can be found in the Appendix B, along with the resulting designs in Appendix C.

Lateral System Design

The lateral forces applied to the building are resisted by braced frames placed throughout the building where shear walls were originally designed. The frames containing the braces also include moment connections between the vertical and horizontal members to provide additional lateral load resistance. An attempt was made to place braces where they would not interfere with doorways that existed in the original system.

In order to make the center of mass close to the actual center of the building, braces were placed semi-symmetrically. This puts the center of rigidity close to the center of the building which reduces the inherent torsion in the building when lateral loads are applied.

RAM Frame was used to design the lateral system. The lateral loads were determined according to ASCE 7 and applied to the structure at the center of mass, with an accidental eccentricity of 5%. The following load cases were analyzed:

1.4D
1.2D + 1.6W
1.2D + 1.0E
1.2D + 1.6L
0.9D + 1.6W
0.9D + 1.0E
1.2D + 0.5L + 1.6W
1.2D + 0.5L + 1.0E

Since the original shear walls were each 24” thick, member sizes for the lateral system were chosen to fit within the same parameters. Vertical elements of the frames were all selected to be either W10 or W12 shapes. Diagonal bracing members are all rectangular hollow structural steel sections and were limited to 5” in width. Elevations of the frames as well as sizes of each of the members can be found in Appendix D at the end of this report.

Seismic Drift

RAM Structural System analysis was used to determine the seismic drift in the redesign of the Temecula Medical Center. Allowable seismic drift was calculated using ASCE Chapter 12. Story drift for each floor is taken from the RAM Structural model and allowable story drift is per Eq. (12.12-1) below:

$$\Delta_a = 0.015h_{sx}$$

		X-Direction		Y-Direction			
		Controlled by Seismic		Controlled by Seismic			
Story	h_{sx}(ft)	Story Drift	Displacement	Story Drift	Displacement	Δ_a	Result
6	14.5	0.68	3.12	0.51	2.79	2.61	OK
5	14.5	0.64	2.51	0.48	2.23	2.61	OK
4	14.5	0.64	1.95	0.48	1.71	2.61	OK
3	14.5	0.61	1.39	0.45	1.19	2.61	OK
2	19	0.52	0.86	0.37	0.71	3.42	OK
1	19	0.49	0.41	0.31	0.32	3.42	OK

Construction Management Breadth Study

Overview

Cost and schedule are crucial to any building project. Before a redesign of a structural system is performed, the impact it will have on construction needs to be analyzed to determine what changes should be made. For the construction management breadth study, the schedule and cost implications of the structural system changes made in the structural depth study were analyzed for difference in direct costs, such as material, labor, and time. Other differences that exist such as overhead, profit, and earlier rent payments, are not part of the scope of this study.

For this study, material take-offs, from the RAM Structural model, were compared with typical concrete take-offs of the original design. Cost data for materials and labor crews, as well as the daily output of the crews were taken from R.S. Means Building Construction Cost Data 2008. Data gathered from the analysis was entered into a spreadsheet to calculate the differences in cost between the two systems, as well as the construction time required for each item.

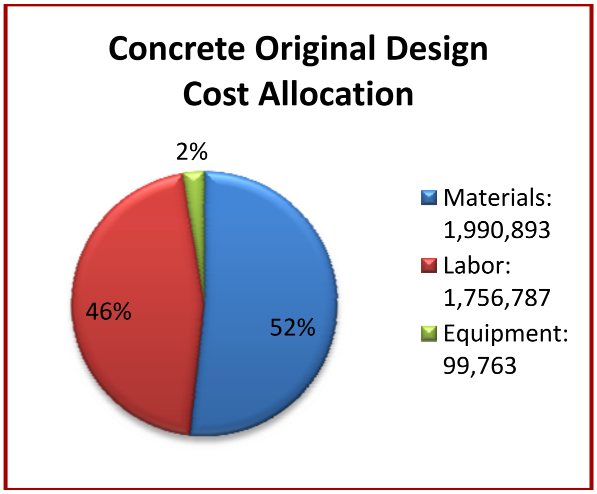
Material Takeoffs

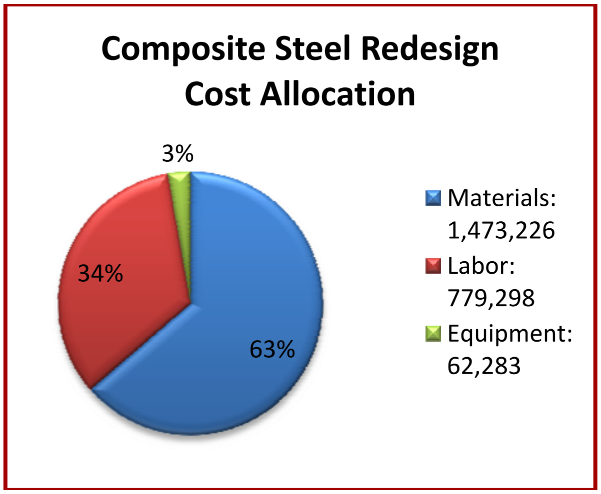
Due to the lack of takeoff records for the original concrete structural, typical numbers were used according to R.S. Means. The takeoff values were combined into three categories: Columns, Shear walls, and Slabs. Each of these categories includes values for formwork, reinforcement, placement, and finishing concrete. The "Takeoff" feature in RAM Structural System provided the weight of the steel in the composite redesign, which is broken down into Columns, Braced Frames, and Floors. For more details on the takeoffs, refer to Appendix E at the end of this report.

Results

Using this estimation method on both the existing system and the proposed redesign yielded consistent results for comparison between the two structural systems. The existing concrete system was estimated at approximately $3.8 million, while the redesign with steel was estimated at $2.3 million, a total savings of $1.5 million.

After analyzing the scheduling impact, it was found that the concrete system would take 261 days while the steel structural system would take 208 days. This equals a total savings of approximately 2.7 months, assuming there are four five-day work weeks in a month. Using a contractor supplied figure of about $1.4 million dollars for 24 months on the jobsite, the cost per month comes to $60,000. With this figured into the total time savings, the redesign saves an additional $162,000 in direct jobsite costs. Shown below are simple illustrations to point out where the funds for each design were allocated.


Concrete Original Design Cost Allocation


Composite Steel Redesign Cost Allocation

CONCRETE EXISTING CONDITIONS	
COLUMNS	COST
Formwork	255,893
Concrete	357,108
Reinforcement	122,006
SLABS	COST
Formwork	825,210
Concrete	633,330
Slab Finish	262,668
Reinforcement	861,218
SHEARWALLS	COST
Formwork	118,017
Concrete	190,176
Reinforcement	143,536
CRANE	78,280
	$3,847,443 261 Days

COMPOSITE STEEL SYSTEM RE-DESIGN	
COLUMNS	COST
Steel	124,792
Baseplates	4,675
Fireproofing	48,000
FLOORS	COST
Framing	239,387
Steel Deck	442,942
Shear Studs	18,752
Fireproofing	254,400
Concrete	628,423
WWF	54,481
Slab Finish	262,668
BRACES	COST
HSS Steel	169,204
Fireproofing	4,800
CRANE	62,283
	$2,314,807 208 Days

CONCRETE	
Materials:	1,990,893
Labor:	1,756,787
Equipment:	99,763
TOTAL:	3,847,443

STEEL	
Materials:	1,473,226
Labor:	779,298
Equipment:	62,283
TOTAL:	2,314,807

STEEL SAVINGS:	1,532,636	
	53	Days
	2.7	Months
Jobsite Direct Costs:	$60,000	/Month
Time Savings:	$162,000	
TOTAL SAVINGS	$1,694,636	

Conclusions

As shown in this breadth study was the considerable savings that could be attained with a switch from a concrete structure to composite steel. A total savings of $1.7 million and 2.7 months was the result which is a considerable amount on any size project. While the savings were large, there are many advantages and disadvantages to the change from concrete to steel that were not covered in the scope of this study.

The most significant advantage that was not covered in this breadth, is the changes that would need to be made to the existing foundation system. According to the original design drawings, 42-inch diameter drilled piers were used to anchor the building. Comparing the weight of the concrete structure and the steel redesign, it is found that the new structure weighs roughly half that of the concrete structure. With the large reduction in dead load, it may be possible to reduce the size of the drilled piers or even look into cheaper spread footings, although the latter would be hard to accomplish with such heavy seismic loads. These changes could result in an even cheaper system.

A fairly significant disadvantage of the change from concrete to steel is the long lead time required to obtain all of the steel members. The steel needs to be design and fabricated before it is shipped to the site which could result in significant changes to the construction schedule. This also decreases the ability to make slight changes to the design once on the jobsite.

Another significant disadvantage to the structural change is the increase in flooring system thickness. This can only be dealt with by either shortening the floor-to-floor heights or by increasing the overall building height. The total redesigned height of the Temecula Medical Center increased from 107’ to 113’. Estimating a value of $20,000 per extra foot of façade, the added six feet would come out to cost $120,000, which would be subtracted from the total savings due to the change to steel.

The engineer for this project would need to take into account all of these advantages and disadvantages. Without studying this breadth from every angle, it can still be concluded that a change from concrete to composite steel with diagonal bracing is a viable option for the redesign of the Temecula Medical Center. It is the recommendation of this thesis that further investigation into this system be considered.

Architectural Breadth Study

Overview

The original design of the Temecula Medical Center includes windows covering approximately half of the façade with plaster as the exterior wall covering. While this matches the typical architecture of the southern California region, a predominantly glass façade would provide more light to the perimeter patient rooms as well as give the medical center a modern feel.

Temecula, CA features a very warm climate with average temperatures ranging in the upper 70's. This is an obstacle when redesigning the façade due to strong sun rays entering the building. After analyzing various building designs and façade types, many options exist for ways to cut down on the amount of sun that enters the building.

The main component of the new façade is cantilevered sun-shades that are prevalent on the Life Science Building, located in State College, PA on the Pennsylvania State University campus. These shades are approximately three feet wide and provide enough cover to block out a large portion of the mid-afternoon summer sun. With rays coming in at approximately 79° during the hottest summer months, the sun shades will need to stop most of those rays from entering the 8' high windows.

This breadth study briefly investigates what changes need to be made to the architectural façade of the medical center in order to add more glass while still limiting the amount of incoming sunlight. In addition, the mechanical, lighting, and electrical upgrades that would be needed to accommodate the changes will be explored.

Architecture

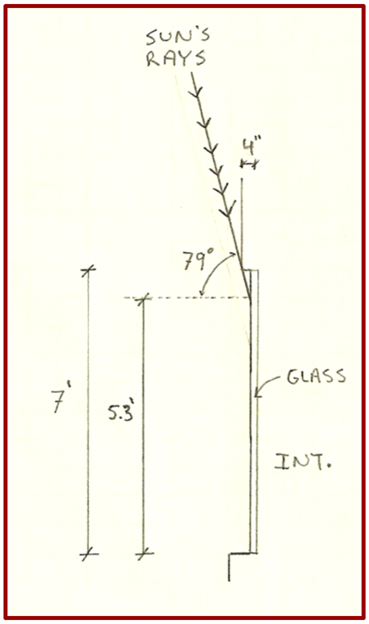
In the southern region of California, most of the buildings feature a common western motif of plastered façades, aluminum roofing, and limited window openings. Since the Temecula Medical Center was designed to make a statement in the city of Temecula, this breadth study still explore the possibility of a, architecturally different, glass façade.

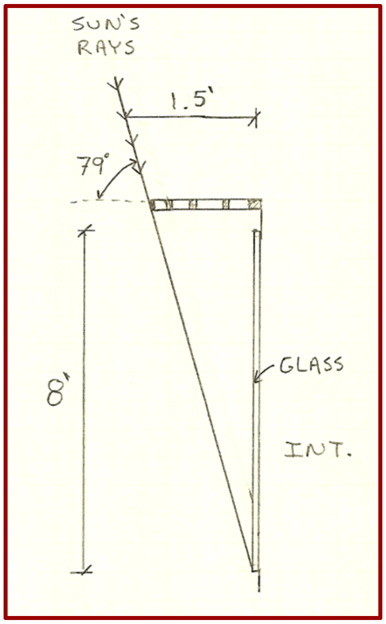
By studying buildings that feature glass façades, different appearances have been noted. Present in many buildings is glass panels separated by 3”-6” thick mullions. These systems allow for maximum glass coverage but often make the building’s structure viewable from the exterior. This layout is especially present in the design of the Penn State Health Services Building. Protrusions are added at each level interface to the large amounts of glass to aide in blocking the incoming rays of sunlight.

Other options include variations of keeping the plastered window surroundings but making it so glass area is greater than that of the plaster. This is a viable option but for this breadth study, the method listed above will be analyzed in order to fully change the architecture of the current medical center design.

Regional Study

Using the ‘Sustainable By Design’ website, sun angles were determined for Temecula, CA in the peak summer season. The sun’s rays hit the building at a max altitude angle of 79° on June 15th at 3 p.m. While the sun gets as low as 35° in the winter, they lose much of their intensity and do not transmit as much heat into the interior of the building. Protrusions between each floor will have to be at least 1.5’ to block all incoming sunlight to the eight foot windows during the summer season. While the original design blocked approximately 1.7’ of light, much of the sun’s rays entered the patient rooms and caused overheating or overuse of the air conditioning.

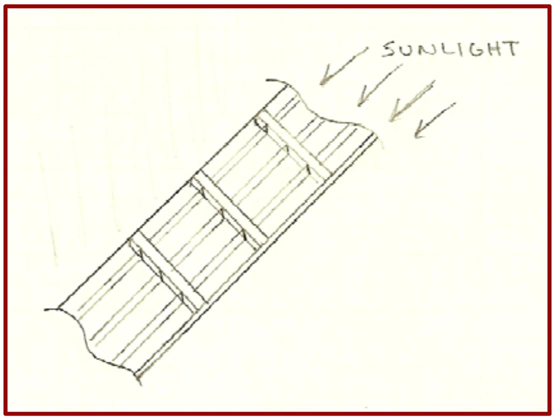




In the new design, 8’ windows are assumed which is only a foot larger than the previous design but will still allow a significant increase of incoming light. This will decrease the electrical needs of the exterior patient rooms during the day hours by providing more natural light.

Design

While architecture in the southern California region consisted of primarily red roofs, and off-white plastered façades, the new design will incorporate a modern feel into the city of Temecula. The large panes of glass will attract the most visual attention but what will help bring out the true character of the building are protrusions between each floor. These will block a significant amount of light while still providing enough to help reduce the lighting needs in the perimeter patient rooms. The protrusions are 1.5' wide with supports anchored to the structure every 3 feet. Shown in the figure to the right is a detail of the design which would span the entire perimeter of the medical center.



Conclusions

The new glass façade with 18" protrusions between floors will contradict the surrounding architecture but will serve as a new landmark for the city of Temecula. Various examples are present on the Pennsylvania State University campus such as the new health center that shows excellent usage of an all glass façade.

With strong summer sun rays coming down at 79°, protrusions were needed between floors to block most of the direct light. While they are not completely solid, they will offer a distinct look as well as efficient shading. Along with providing shade, the protrusions are architecturally designed to work with the glass façade and provide a modern look. Design calculations yielded a width of 1.5' in order to provide adequate shade and structurally anchored members every 3' to provide enough support. The new design gives the region a new look and will add to the original vision for a new, prominent medical center.

Summary

Structural Depth

The goal of this depth study was to determine the efficiency of redesigning the Temecula Medical Center's structural system using steel versus the original concrete flat-plate system. While the gravity system was changed to composite steel, the lateral system replaced the shear walls with concentric diagonal bracing along with moment frames. All of this was to be done with little effects on the original architectural layout or the building systems already in place.

Without having a large impact on the original design, it was made evident by the study that the structure system could be changed to steel while still carrying the loads prescribed by the codes. While many assumptions went into the original concrete system, many of them were kept the same to ensure an effective redesign. Vibration and deflection played a large role in determining the required steel member sizes, while requiring a large increase in the floor thickness from the original 10".

Construction Management Breadth

After redesigning the structural system from concrete to steel, the goal of the construction management breadth study was to analyze the cost of the materials and labor. This included a comparison of the old system with the new and determined the financial feasibility of such a redesign.

This study yielded results that showed the redesign not only being a possibility, but could yield substantial savings over the original concrete system. In addition to the construction costs, the steel system construction was found to be several months shorter, meaning an earlier move-in date, and earlier ability to start building operations.

Architectural Breadth

The original design of the Temecula Medical Center included a minimum amount of windows surrounded by a plastered façade. This breadth was a study to determine the feasibility of making the exterior of the medical center predominantly glass with overhangs to block incoming sunlight.

After analysis, results showed an increase in sunlight, decreasing the lighting and winter heating demand. Changes to the building's architecture gave the building a more modern feel but stuck out in the surrounding California motif.

While this study showed various ways to shade summer sunlight as well as utilize glass façades, it was determined that this is not the most efficient design for the area. With hot temperatures year around, the windows would offer lower insulation than the original plastered façade and result in a higher air conditioning demand with higher prices throughout the year.

Elevation of Original Minimal Window Coverage

Conclusions

The Temecula Medical Center was designed to be a trademark medical facility for the city of Temecula, California. With this in mind, along with specific criteria for hospital design, a redesign was performed using a composite steel structure versus the original concrete system. While seismic showed to be a big contributor in the deciding member sizes, criteria such as vibration, deflection, and load combinations had to be taken into account.

This thesis study investigated the use of AISC Design Guide in the design of the composite steel structure for the building. While there were no project-specific vibration or deflection guidelines, this design provided an industry-standard to design the steel structure. The result is a lighter and effective building design.

There are several advantages to using a steel system versus concrete. The structure is much lighter than the existing design, leading to smaller foundation sizes, and possibly (seismic permitting) a change from drilled piers to less expensive spread footings. Smaller columns were also used in the new design, W10's and W12's instead of the large 26"x26" concrete columns. Also shown in the construction management breadth study, the steel system would be less expensive to build than the concrete, saving several months in construction time.

As with any structural system, there are disadvantages as well. The new steel system causes an increase in floor height, 12" in most cases, which in turn results in a taller building. This leads to a larger surface area of the building's exterior, meaning higher façade material costs. Steel members also require longer lead times which could impact the schedule of the building if construction were to begin soon. Due to the extended prefabrication time, the shipping time could be a problem as well as lack of flexibility considering each member is specifically built to fit. Lastly, steel construction requires a large staging area on the site to store members not yet erected. This would pose a problem in an urban setting where site space is critical.

Weighing all the advantages and disadvantages, it is the conclusion of this thesis study that the composite steel system is a viable alternative to the existing concrete design. It is recommended that this system be further investigated.

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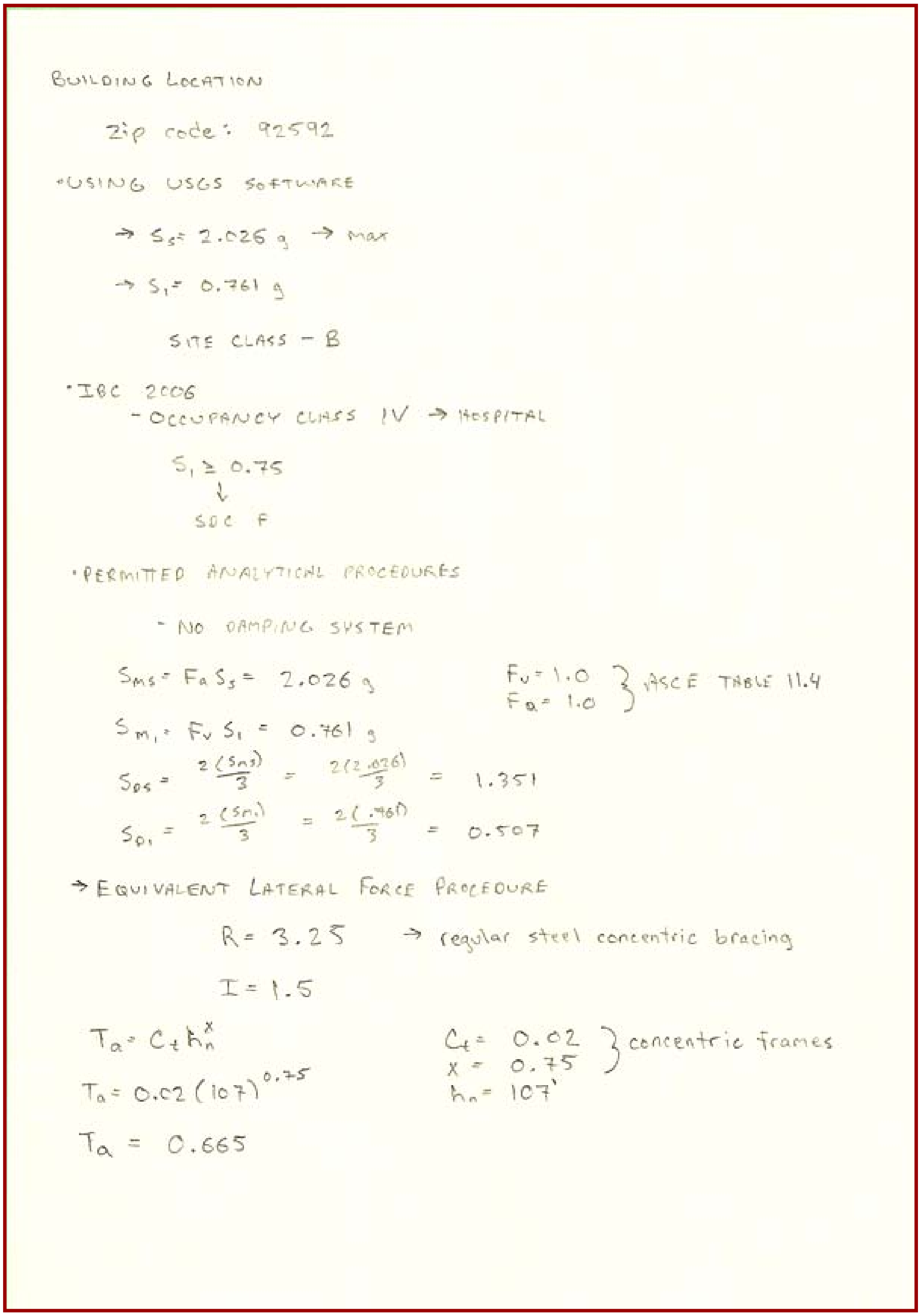
Penn State Architectural Engineering Class of 2009

Appendix A

Seismic Calculations



BUILDING LOCATION

Zip code: 92592

*USING USGS SOFTWARE

→ $S_s = 2.026\ g$ → max

→ $S_1 = 0.761\ g$

SITE CLASS – B

·IBC 2006

- OCCUPANCY CLASS IV → HOSPITAL

$S_1 \geq 0.75$

$\downarrow$

SDC F

·PERMITTED ANALYTICAL PROCEDURES

- NO DAMPING SYSTEM

$S_{MS} = F_a S_s = 2.026\ g$

$S_{M1} = F_v S_1 = 0.761\ g$

$\left.\begin{matrix} F_v = 1.0 \\ F_a = 1.0 \end{matrix}\right\}$ ASCE TABLE 11.4

$S_{DS} = \frac{2(S_{MS})}{3} = \frac{2(2.026)}{3} = 1.351$

$S_{D1} = \frac{2(S_{M1})}{3} = \frac{2(.761)}{3} = 0.507$

→ EQUIVALENT LATERAL FORCE PROCEDURE

$R = 3.25$ → regular steel concentric bracing

$I = 1.5$

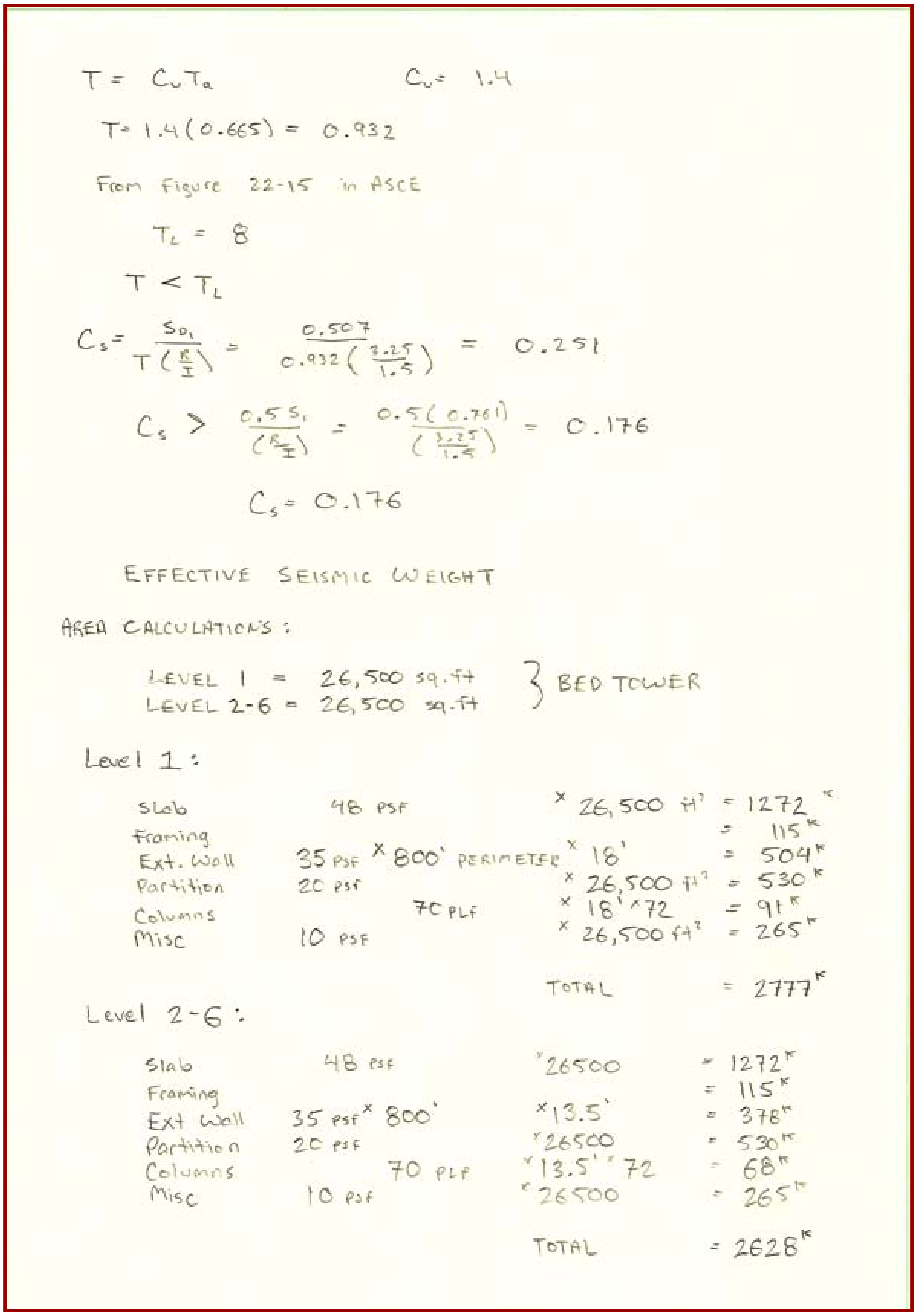
$T_a = C_t h_n^x$

$T_a = 0.02(107)^{0.75}$

$T_a = 0.665$

$\left.\begin{matrix} C_t = 0.02 \\ x = 0.75 \end{matrix}\right\}$ concentric frames

$h_n = 107'$



$T = C_u T_a$ $C_u = 1.4$

$T = 1.4(0.665) = 0.932$

From Figure 22-15 in ASCE

$T_L = 8$

$T < T_L$

$$C_s = \frac{S_{D1}}{T\left(\frac{R}{I}\right)} = \frac{0.507}{0.932\left(\frac{3.25}{1.5}\right)} = 0.251$$

$$C_s > \frac{0.5 S_1}{\left(\frac{R}{I}\right)} = \frac{0.5(0.761)}{\left(\frac{3.25}{1.5}\right)} = 0.176$$

$$C_s = 0.176$$

EFFECTIVE SEISMIC WEIGHT

AREA CALCULATIONS :

LEVEL 1 = 26,500 sq.ft
LEVEL 2-6 = 26,500 sq.ft } BED TOWER

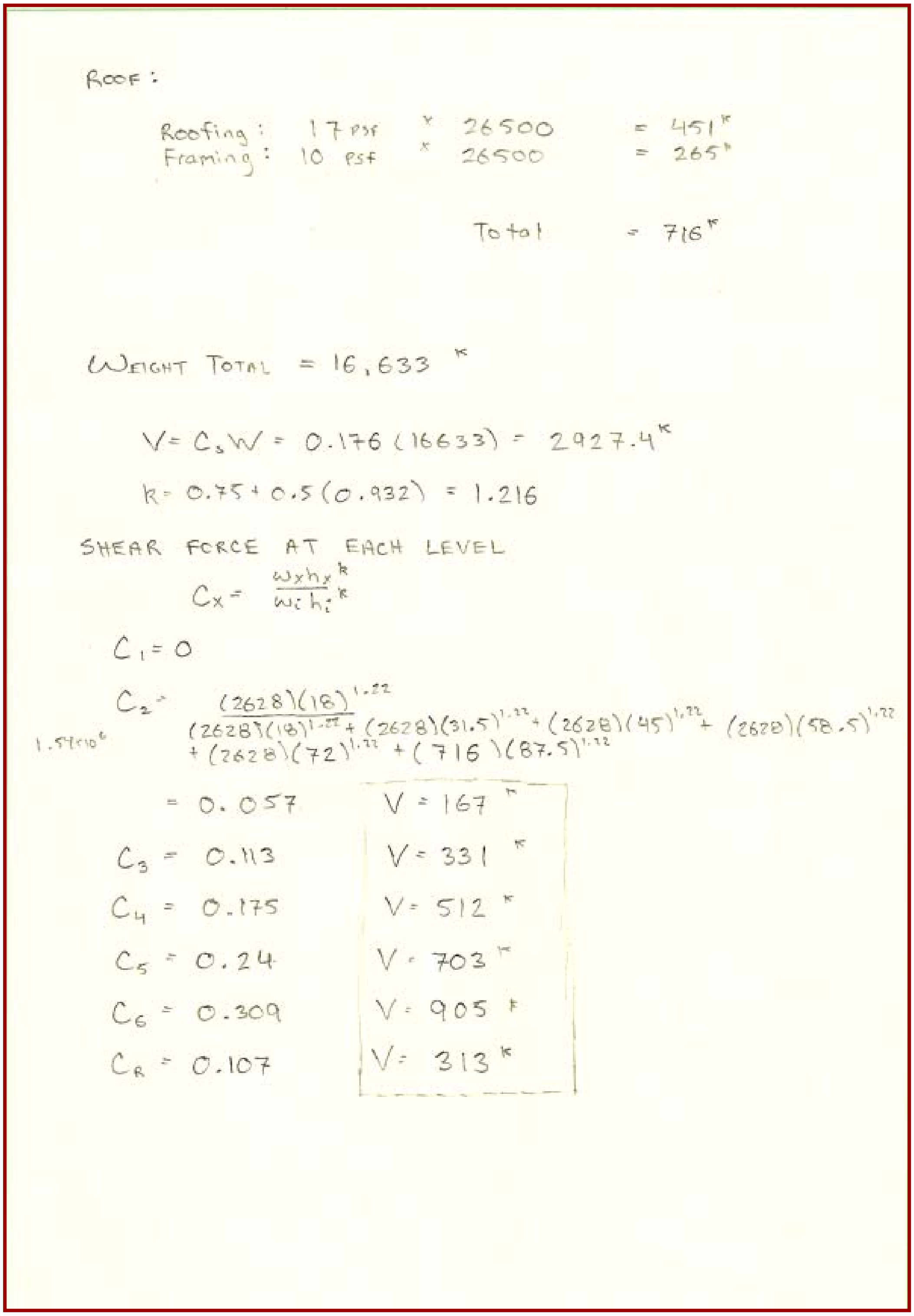
Level 1 :

Slab	48 PSF		× 26,500 ft²	= 1272^k
Framing				= 115^k
Ext. Wall	35 PSF	× 800' PERIMETER	× 18'	= 504^k
Partition	20 PSF		× 26,500 ft²	= 530^k
Columns		70 PLF	× 18' × 72	= 91^k
Misc	10 PSF		× 26,500 ft²	= 265^k
			TOTAL	= 2777^k

Level 2-6 :

Slab	48 PSF		× 26500	= 1272^k
Framing				= 115^k
Ext Wall	35 PSF	× 800'	× 13.5'	= 378^k
Partition	20 PSF		× 26500	= 530^k
Columns		70 PLF	× 13.5' × 72	= 68^k
Misc	10 PSF		× 26500	= 265^k
			TOTAL	= 2628^k

]



ROOF:

Roofing: 17 psf × 26500 = 451^k
Framing: 10 psf × 26500 = 265^k

Total = 716^k

WEIGHT TOTAL = $16,633^k$

$V = C_s W = 0.176(16633) = 2927.4^k$

$k = 0.75 + 0.5(0.932) = 1.216$

SHEAR FORCE AT EACH LEVEL

$$C_x = \frac{w_x h_x^k}{w_i h_i^k}$$

$C_1 = 0$

$$C_2 = \frac{(2628)(18)^{1.22}}{(2628)(18)^{1.22} + (2628)(31.5)^{1.22} + (2628)(45)^{1.22} + (2628)(58.5)^{1.22} + (2628)(72)^{1.22} + (716)(87.5)^{1.22}}$$

1.57×10^6

$= 0.057$ $V = 167^k$

$C_3 = 0.113$ $V = 331^k$

$C_4 = 0.175$ $V = 512^k$

$C_5 = 0.24$ $V = 703^k$

$C_6 = 0.309$ $V = 905^k$

$C_R = 0.107$ $V = 313^k$

Wind Load Calculations

Gust Effect Coefficients										
Rigid Building										
IZ	QN-S	QE-W	BN-S (ft)	BE-W (ft)	gQ	h(ft)	c	Є bar	z(ft)	gV
0.179	0.769	0.805	564	353	3.4	97	0.2	1/5.0	64.2	3.4

N-S Wind Forces					
Floor	Height	Tributary Height	Story Force	Story Shear	Overturning Moment
	(ft)	(ft)	(kips)	(kips)	(ft-kips)
1	0.0	0.0	0.0	504.3	0.0
2	18.0	18.0	279.0	504.3	2511.3
3	31.5	13.5	30.6	225.3	757.4
4	45.0	13.5	32.3	194.7	1235.5
5	58.5	13.5	33.6	162.4	1738.8
6	72.0	13.5	34.5	128.7	2251.1
roof	87.3	15.3	40.8	94.3	3249.7
ridge	107.0	19.7	53.5	53.5	5197.5
		Total	504.3		16941.3

E-W Wind Forces					
Floor	Height	Tributary Height	Story Force	Story Shear	Overturning Moment
	(ft)	(ft)	(kips)	(kips)	(ft-kips)
1	0.0	0.0	0.0	1213.5	0.0
2	18.0	18.0	177.1	1213.5	1593.9
3	31.5	13.5	140.3	1036.4	3472.4
4	45.0	13.5	150.7	896.1	5764.3
5	58.5	13.5	154.5	745.4	7995.4
6	72.0	13.5	158.2	591.0	10322.6
roof	87.3	15.3	187.1	432.7	14902.5
ridge	107.0	19.7	245.6	245.6	23860.0
		Total	1213.5		67911.1

Pressure: $p = q\,GC_p - q_i(GC_{pi})$

Windward

$p_z = q_z G_f C_p - q_h(GC_{pi})$

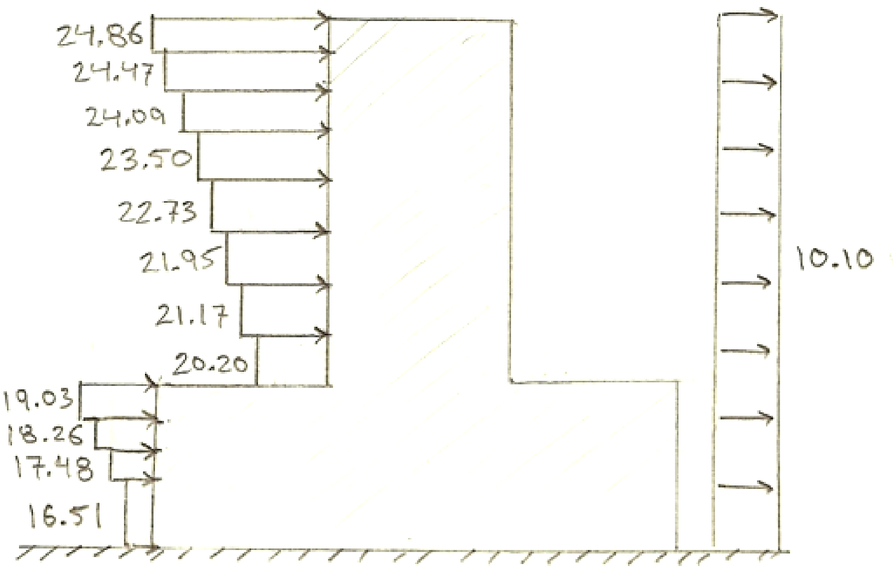
Leeward

$p_h = q_h GC_p - q_h(GC_{pi})$

WIND FROM N-S

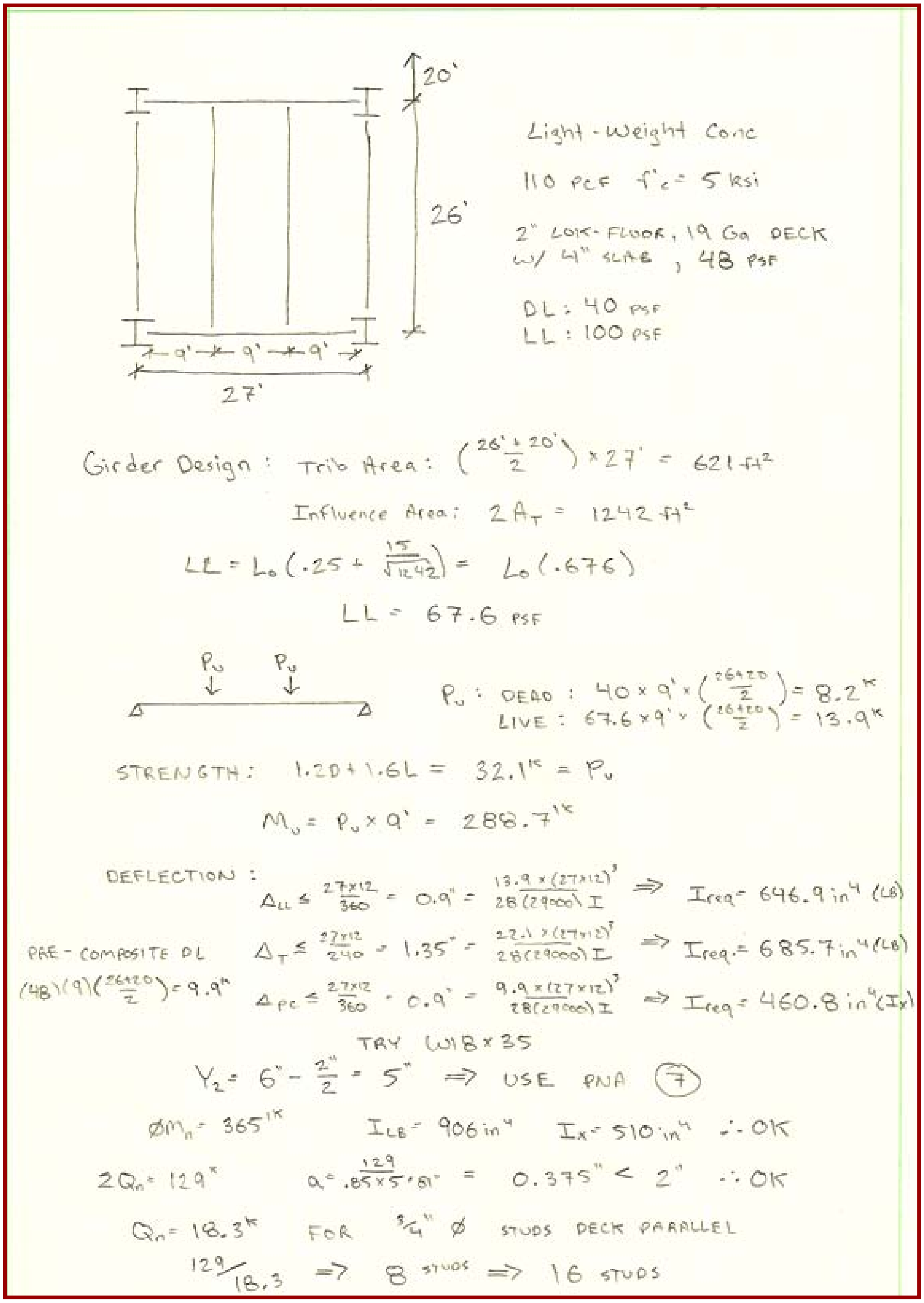
WIND LOAD

WINDWARD (PSF) LEE-WARD (PSF)



Appendix B

Floor Framing and Column Calculations



Light-Weight Conc

110 PCF $f'_c = 5$ ksi

2" LOK-FLOOR, 19 Ga DECK
w/ 4" SLAB, 48 PSF

DL : 40 PSF
LL : 100 PSF

Girder Design : Trib Area : $\left(\frac{26' + 20'}{2}\right) \times 27' = 621\ ft^2$

Influence Area : $2A_T = 1242\ ft^2$

$LL = L_o\left(.25 + \frac{15}{\sqrt{1242}}\right) = L_o(.676)$

$LL = 67.6$ PSF

P_u : DEAD : $40 \times 9' \times \left(\frac{26+20}{2}\right) = 8.2^k$
LIVE : $67.6 \times 9' \times \left(\frac{26+20}{2}\right) = 13.9^k$

STRENGTH : $1.2D + 1.6L = 32.1^k = P_u$

$M_u = P_u \times 9' = 288.7^{1k}$

DEFLECTION :

$\Delta_{LL} \le \frac{27 \times 12}{360} = 0.9" = \frac{13.9 \times (27 \times 12)^3}{28(29000)I} \Rightarrow I_{req} = 646.9\ in^4$ (LB)

PRE-COMPOSITE DL $\Delta_T \le \frac{27 \times 12}{240} = 1.35" = \frac{22.1 \times (27 \times 12)^3}{28(29000)I} \Rightarrow I_{req.} = 685.7\ in^4$ (LB)

$(48)(9)\left(\frac{26+20}{2}\right) = 9.9^k$ $\Delta_{pc} \le \frac{27 \times 12}{360} = 0.9" = \frac{9.9 \times (27 \times 12)^3}{28(29000)I} \Rightarrow I_{req} = 460.8\ in^4$ (I_x)

TRY W18 × 35

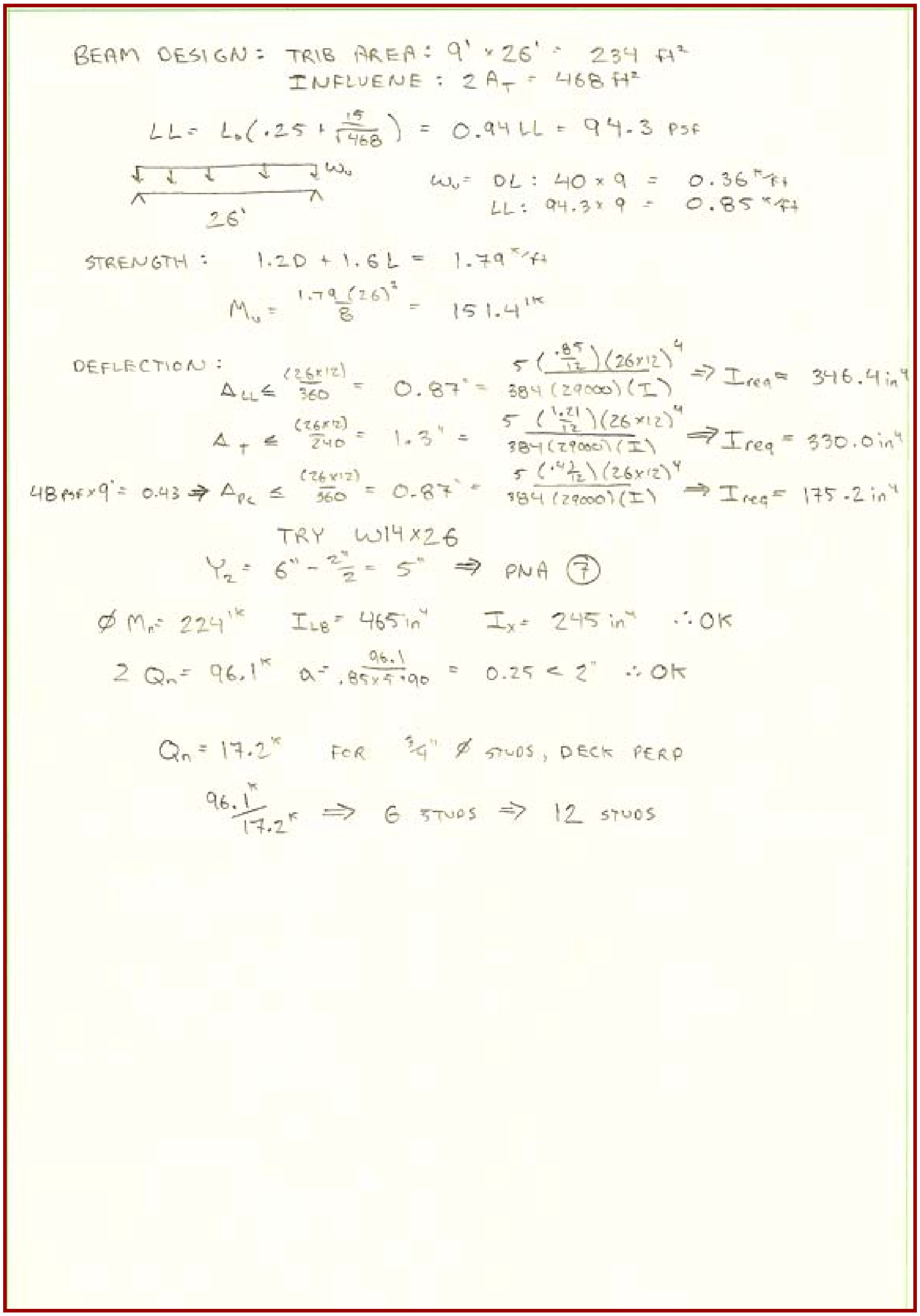
$Y_2 = 6" - \frac{2"}{2} = 5" \Rightarrow$ USE PNA ⑦

$\phi M_n = 365^{1k}$ $I_{LB} = 906\ in^4$ $I_x = 510\ in^4$ ∴ OK

$2Q_n = 129^k$ $a = \frac{129}{.85 \times 5 \times 81"} = 0.375" < 2"$ ∴ OK

$Q_n = 18.3^k$ FOR $\frac{3}{4}"$ ⌀ STUDS DECK PARALLEL

$129/18.3 \Rightarrow 8$ STUDS $\Rightarrow 16$ STUDS



BEAM DESIGN: TRIB AREA: $9' \times 26' = 234\ ft^2$

INFLUENE: $2A_T = 468\ ft^2$

$$LL = L_0\left(.25 + \frac{15}{\sqrt{468}}\right) = 0.94LL = 94.3\ psf$$

$w_u =$ DL: $40 \times 9 = 0.36^{k}/ft$

LL: $94.3 \times 9 = 0.85^{k}/ft$

STRENGTH: $1.2D + 1.6L = 1.79^{k}/ft$

$$M_u = \frac{1.79(26)^2}{8} = 151.4^{1k}$$

DEFLECTION:

$$\Delta_{LL} \leq \frac{(26 \times 12)}{360} = 0.87'' = \frac{5\left(\frac{.85}{12}\right)(26 \times 12)^4}{384(29000)(I)} \Rightarrow I_{req} = 346.4\ in^4$$

$$\Delta_T \leq \frac{(26 \times 12)}{240} = 1.3'' = \frac{5\left(\frac{1.21}{12}\right)(26 \times 12)^4}{384(29000)(I)} \Rightarrow I_{req} = 330.0\ in^4$$

$$48\ psf \times 9' = 0.43 \Rightarrow \Delta_{pc} \leq \frac{(26 \times 12)}{360} = 0.87'' = \frac{5\left(\frac{.43}{12}\right)(26 \times 12)^4}{384(29000)(I)} \Rightarrow I_{req} = 175.2\ in^4$$

TRY W14X26

$Y_2 = 6'' - \frac{2''}{2} = 5'' \Rightarrow$ PNA ⑦

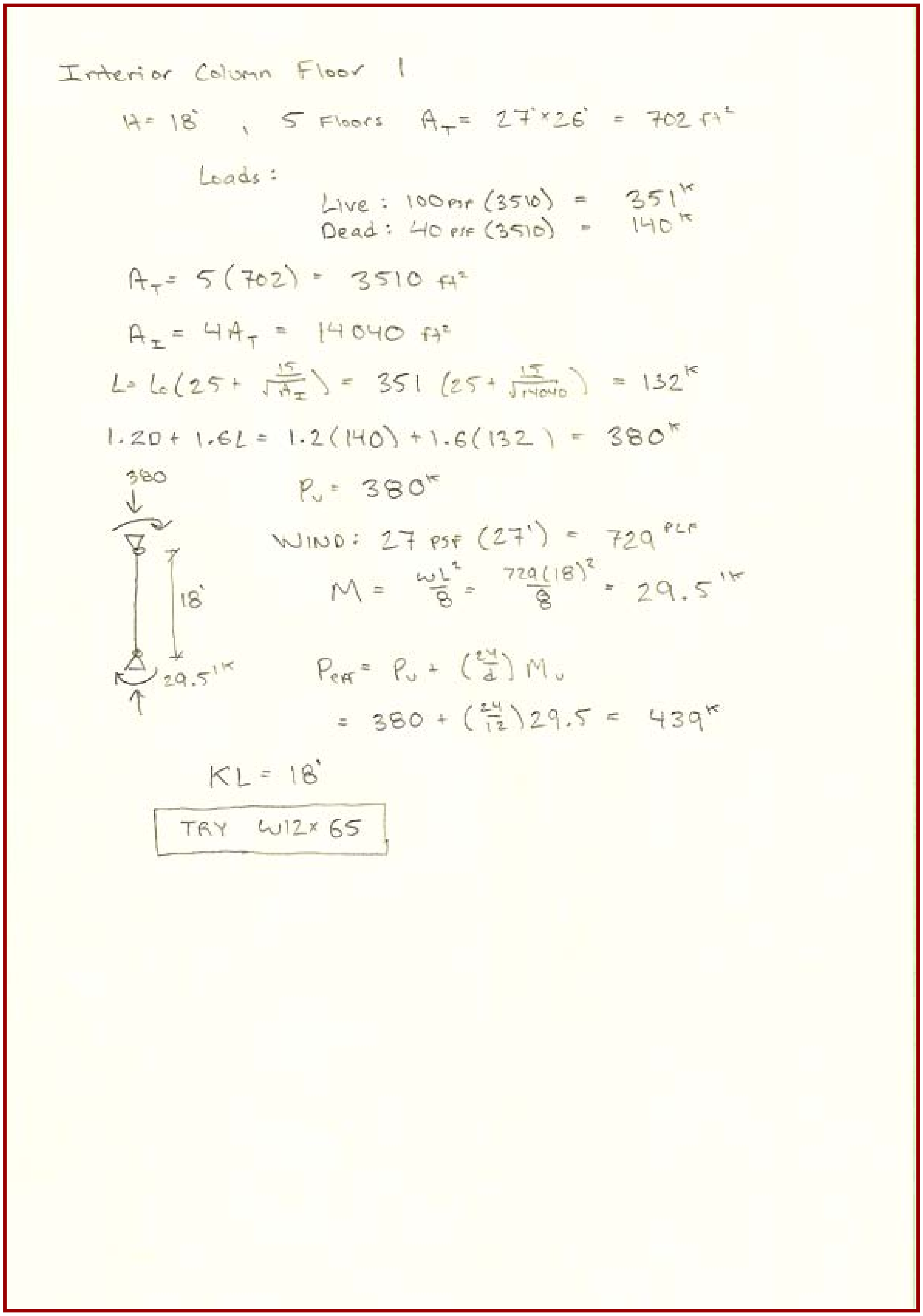
$\phi M_n = 224^{1k}$ $I_{LB} = 465\ in^4$ $I_x = 245\ in^4$ $\therefore$ OK

$2 Q_n = 96.1^{k}$ $a = \frac{96.1}{.85 \times 5 \times 90} = 0.25 < 2''$ $\therefore$ OK

$Q_n = 17.2^{k}$ FOR $\frac{3}{4}''\ \phi$ STUDS, DECK PERP

$\frac{96.1^{k}}{17.2^{k}} \Rightarrow$ 6 STUDS $\Rightarrow$ 12 STUDS

Interior Column Calculation



Interior Column Floor 1

$H = 18'$, 5 Floors $A_T = 27' \times 26' = 702\ \text{ft}^2$

Loads:

Live : 100 psf (3510) = 351^k

Dead : 40 psf (3510) = 140^k

$A_T = 5(702) = 3510\ \text{ft}^2$

$A_I = 4A_T = 14040\ \text{ft}^2$

$L = L_0\left(25 + \frac{15}{\sqrt{A_I}}\right) = 351\left(25 + \frac{15}{\sqrt{14040}}\right) = 132^k$

$1.2D + 1.6L = 1.2(140) + 1.6(132) = 380^k$

$P_u = 380^k$

WIND: 27 psf (27') = 729^{PLF}

$M = \frac{wL^2}{8} = \frac{729(18)^2}{8} = 29.5^{'k}$

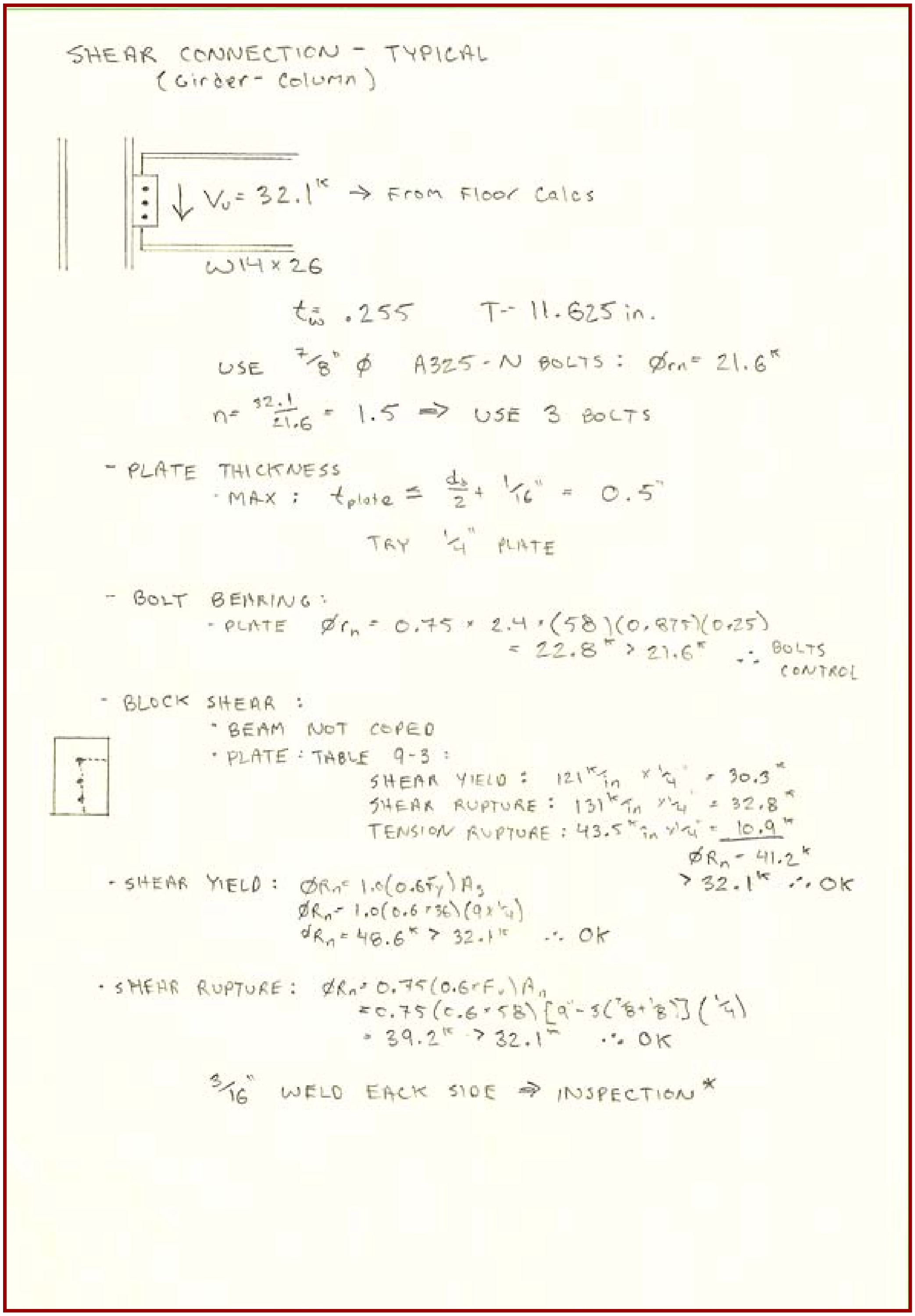
$P_{eff} = P_u + \left(\frac{24}{d}\right)M_u$

$= 380 + \left(\frac{24}{12}\right)29.5 = 439^k$

KL = 18'

$\boxed{\text{TRY W12×65}}$

Shear Connection Calculation



SHEAR CONNECTION – TYPICAL
(Girder – Column)

$\downarrow V_u = 32.1^k$ → From Floor Calcs

W14×26

$t_w = .255$ T – 11.625 in.

USE 7/8" ϕ A325-N BOLTS : $\phi r_n = 21.6^k$

$n = \frac{32.1}{21.6} = 1.5 \Rightarrow$ USE 3 BOLTS

- PLATE THICKNESS
  - MAX : $t_{plate} \leq \frac{d_b}{2} + \frac{1}{16}" = 0.5"$

TRY 1/4" PLATE

- BOLT BEARING :
  - PLATE $\phi r_n = 0.75 \times 2.4 \cdot (58)(0.875)(0.25)$
    $= 22.8^k > 21.6^k$ ∴ BOLTS CONTROL

- BLOCK SHEAR :
  - BEAM NOT COPED
  - PLATE : TABLE 9-3 :

SHEAR YIELD : $121^k/in \times 1/4" = 30.3^k$
SHEAR RUPTURE : $131^k/in \times 1/4" = 32.8^k$
TENSION RUPTURE : $43.5^k/in \times 1/4" = \underline{10.9^k}$
$\phi R_n = 41.2^k$
$> 32.1^k$ ∴ OK

- SHEAR YIELD : $\phi R_n = 1.0(0.6 F_y) A_g$
  $\phi R_n = 1.0(0.6 \times 36)(9 \times 1/4)$
  $\phi R_n = 48.6^k > 32.1^k$ ∴ OK

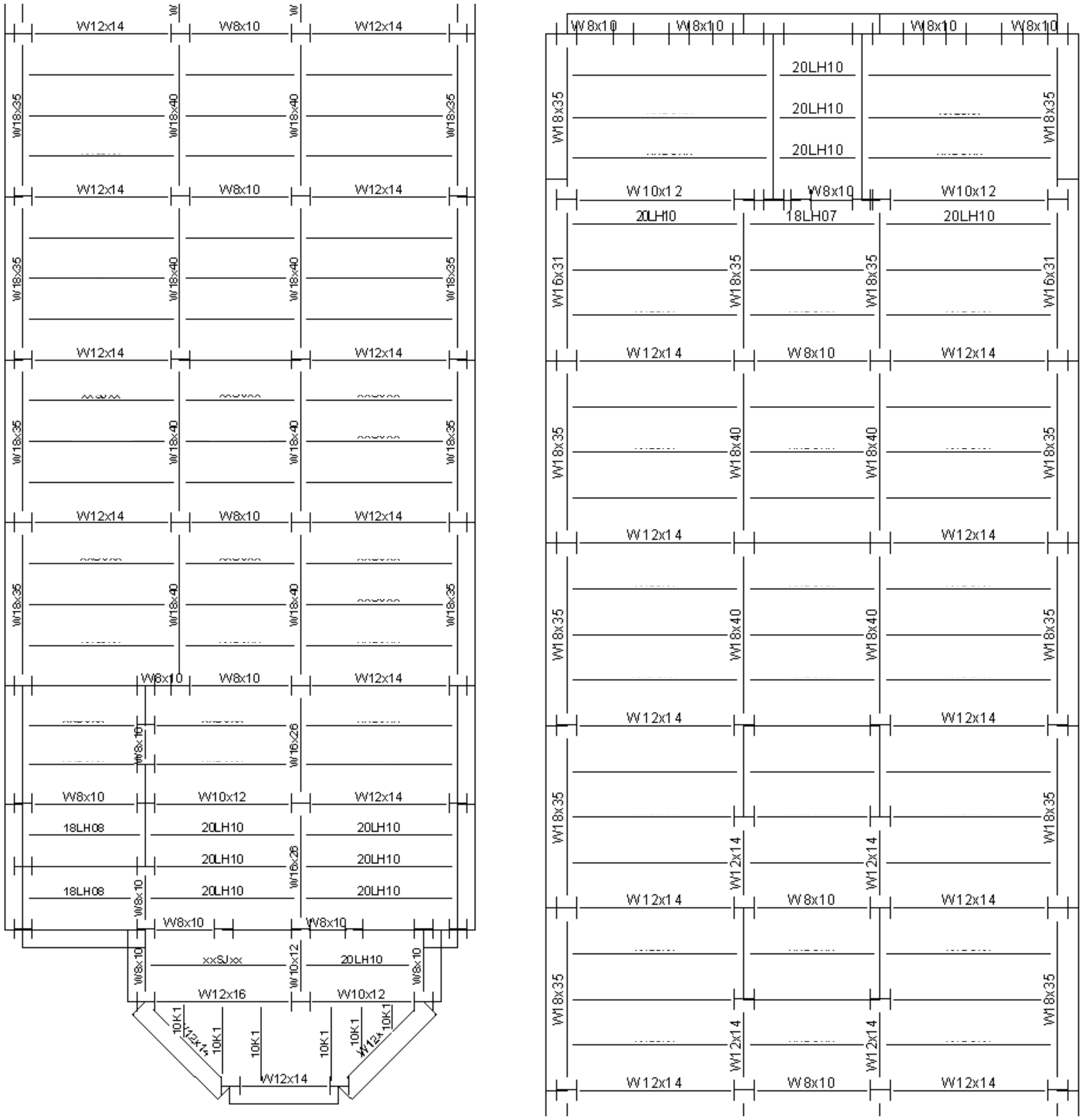
- SHEAR RUPTURE : $\phi R_n = 0.75(0.6 \times F_u) A_n$
  $= 0.75(0.6 \times 58)[9" - 3(7/8 + 1/8)](1/4)$
  $= 39.2^k > 32.1^k$ ∴ OK

3/16" WELD EACH SIDE ⇒ INSPECTION*

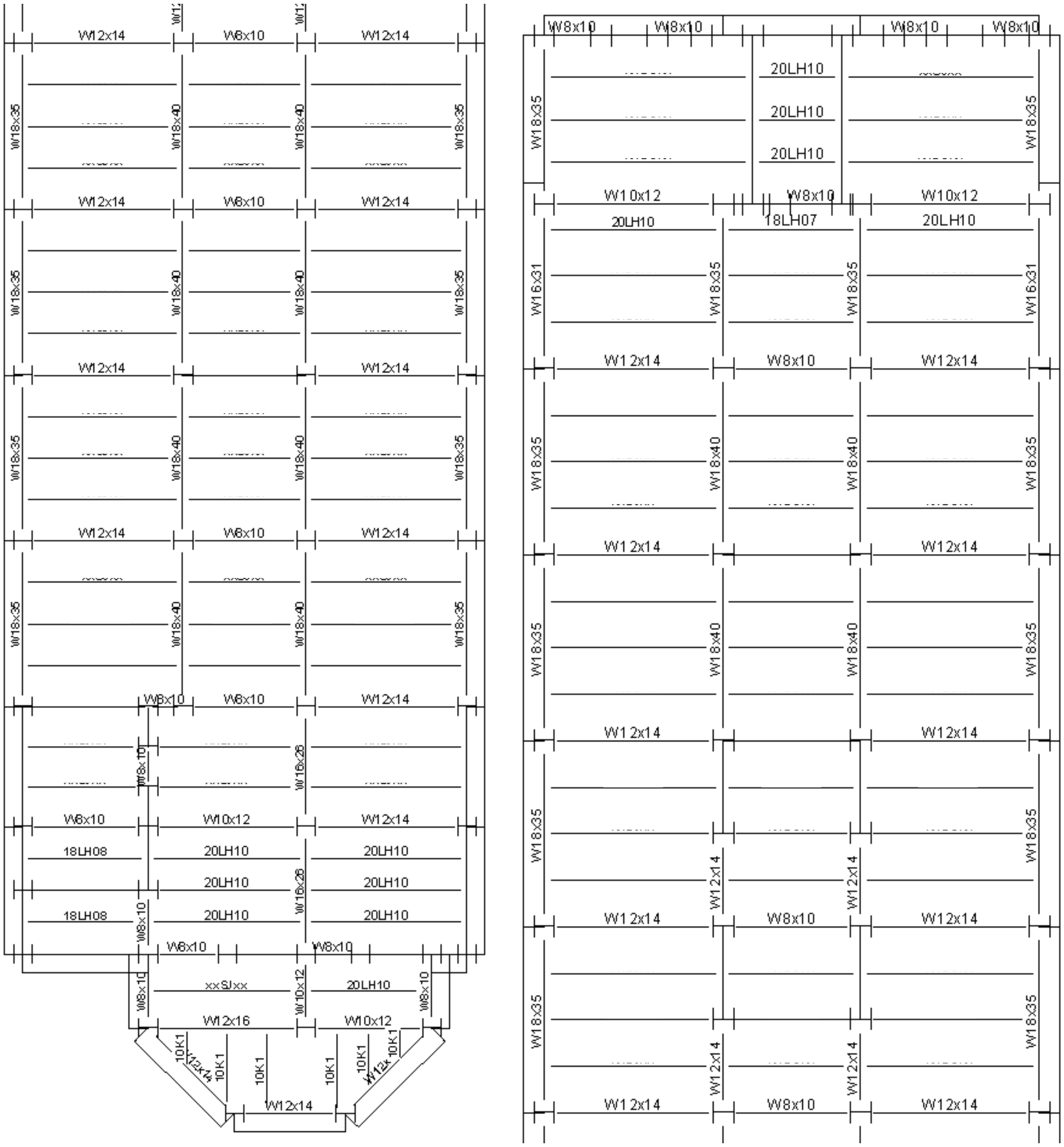
Appendix C

Floor Framing Results

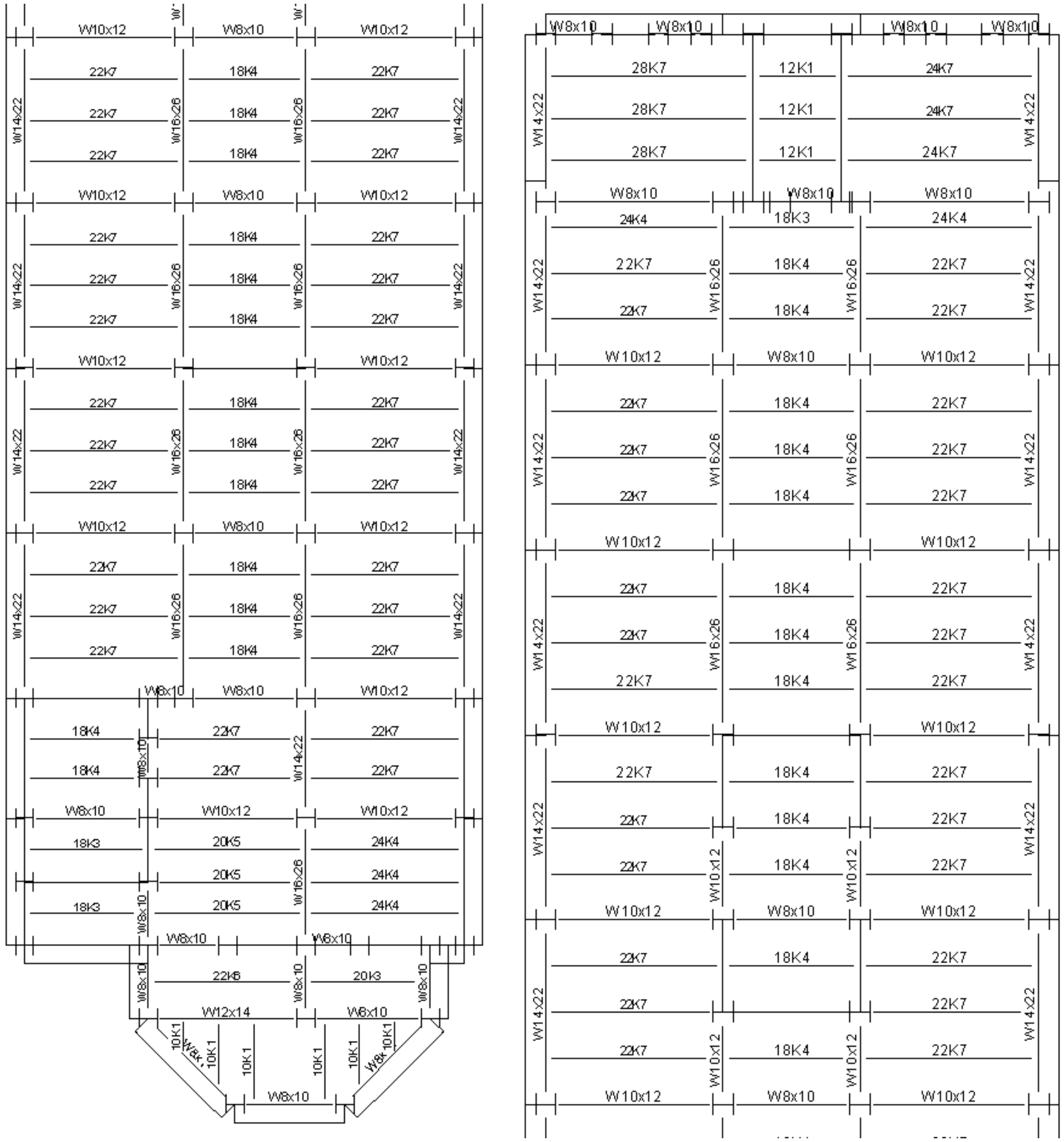
Floor 1 Layout (Typical)



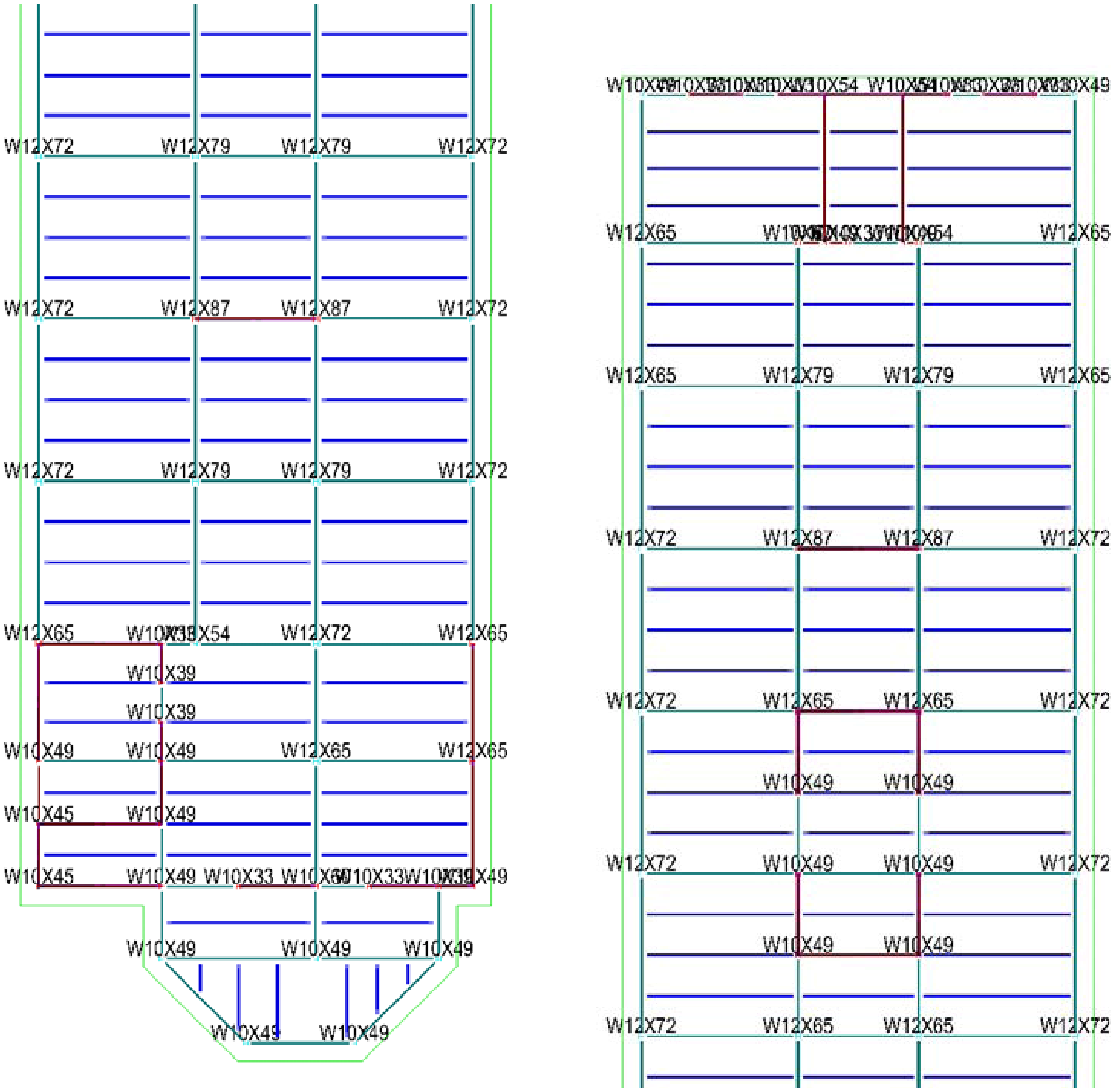
Level 5 Layout (Typical)



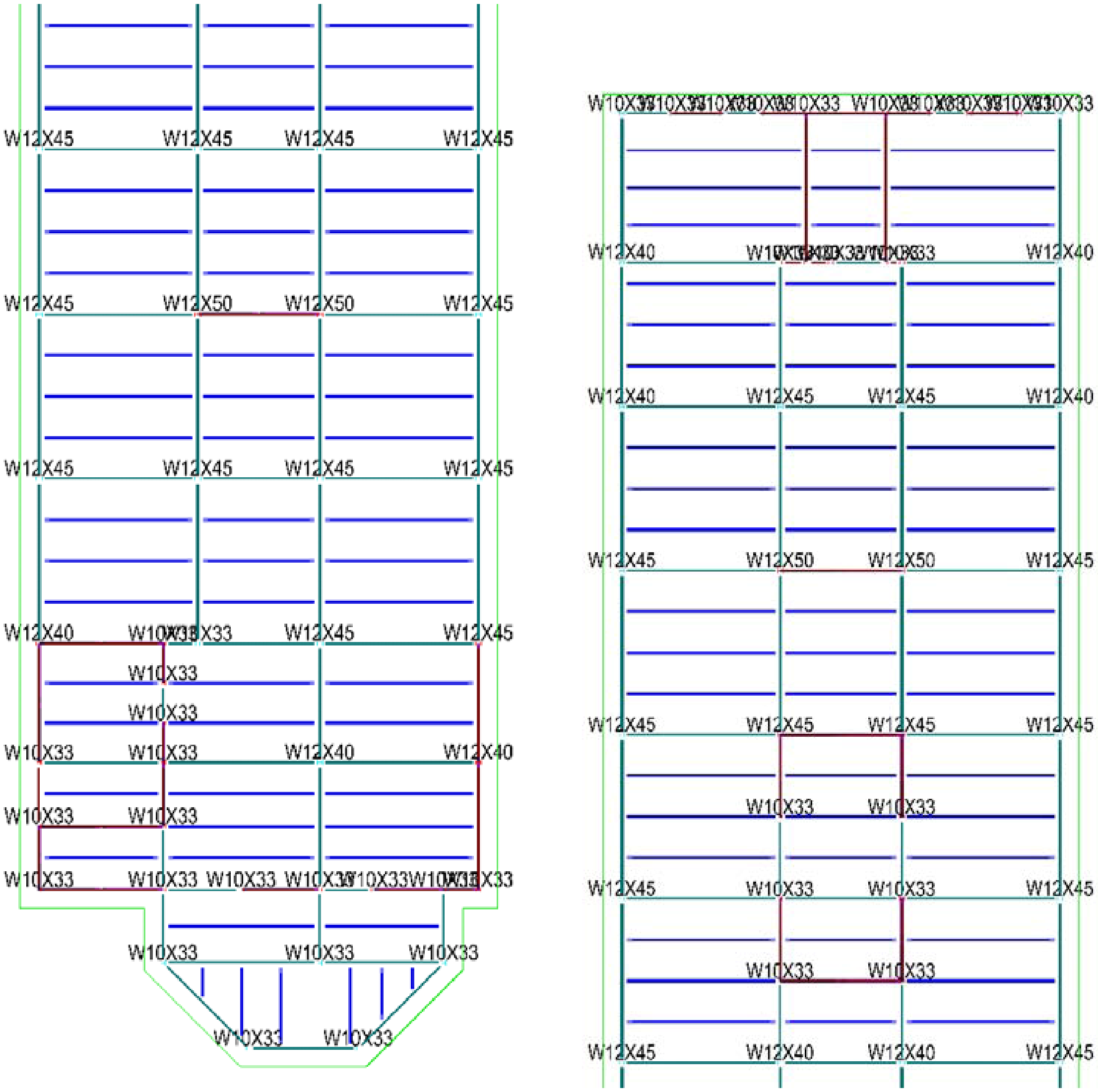
Roof Layout


W10x12
W8x10
W10x12
22K7
18K4
22K7
W14x22
W16x26
W16x26
W14x22
22K7
18K4
22K7
22K7
18K4
22K7
W10x12
W8x10
W10x12
22K7
18K4
22K7
W10x12
W10x12
W8x10
W10x12
W8x10
W8x10
W10x12
18K4
22K7
22K7
W8x10
W14x22
W8x10
W10x12
W10x12
18K3
20K5
24K4
W8x10
22K6
20K3
W12x14
W6x10
10K1
W8x
W8x10
W8x10
28K7
12K1
24K7
W8x10
18K3
24K4
22K7
W16x26
W10x12
W14x22

1st-2nd Story Column Plan



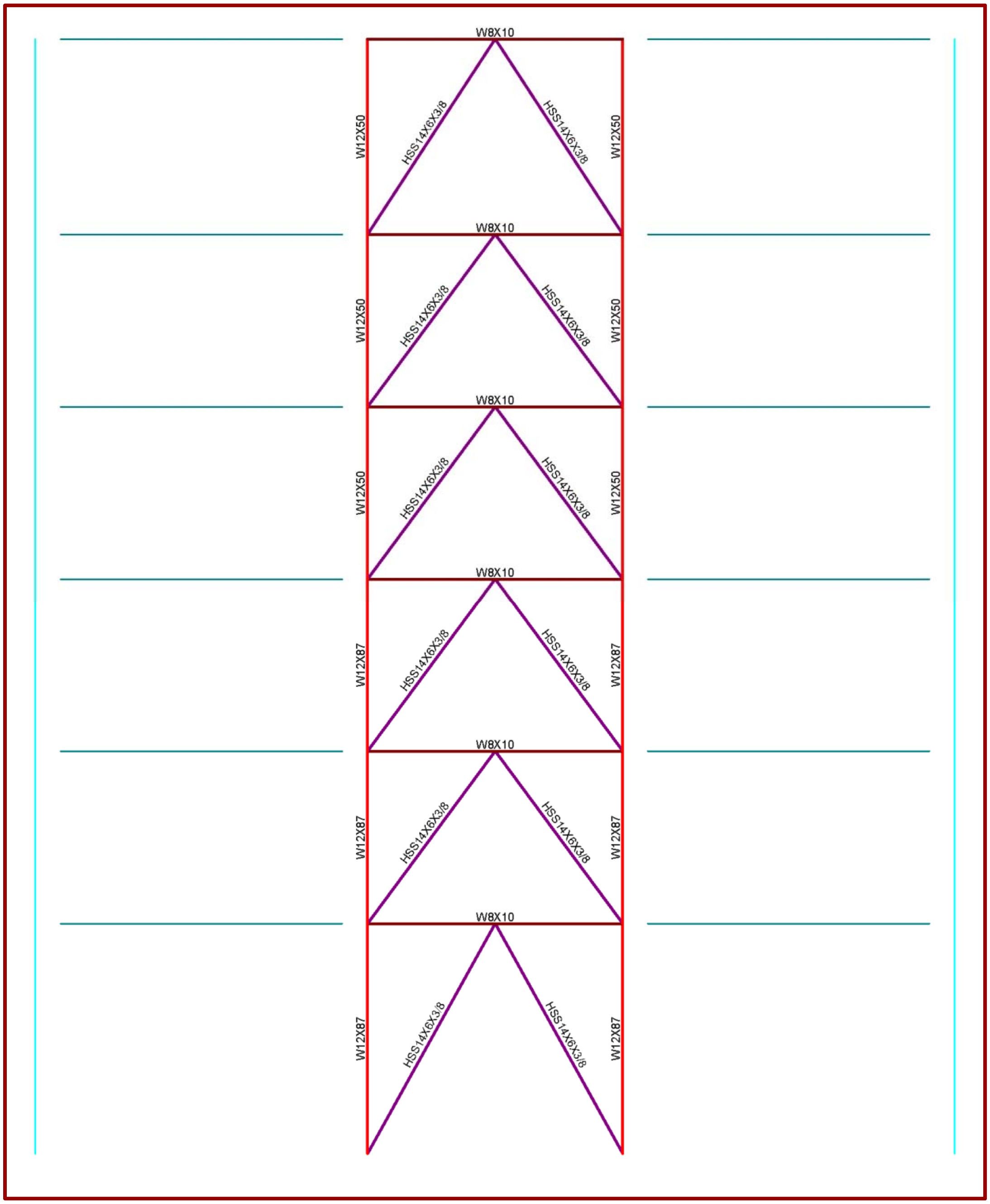
5th-6th Story Column Plan



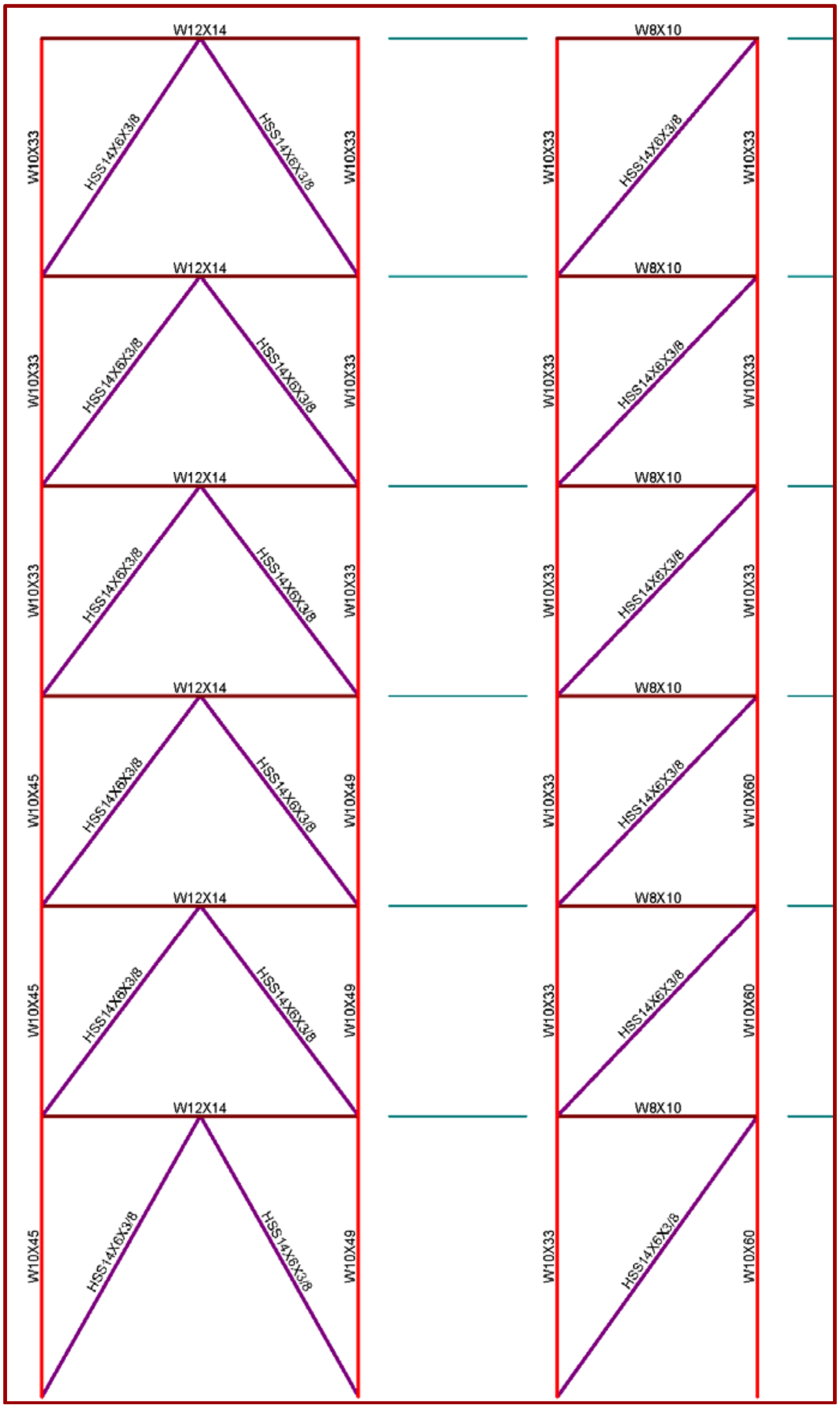
Appendix D

Braced Frame Elevations

Typical Braced Frame Configuration



Typical Braced Frame Configuration



Appendix E

Construction Management Breadth Study

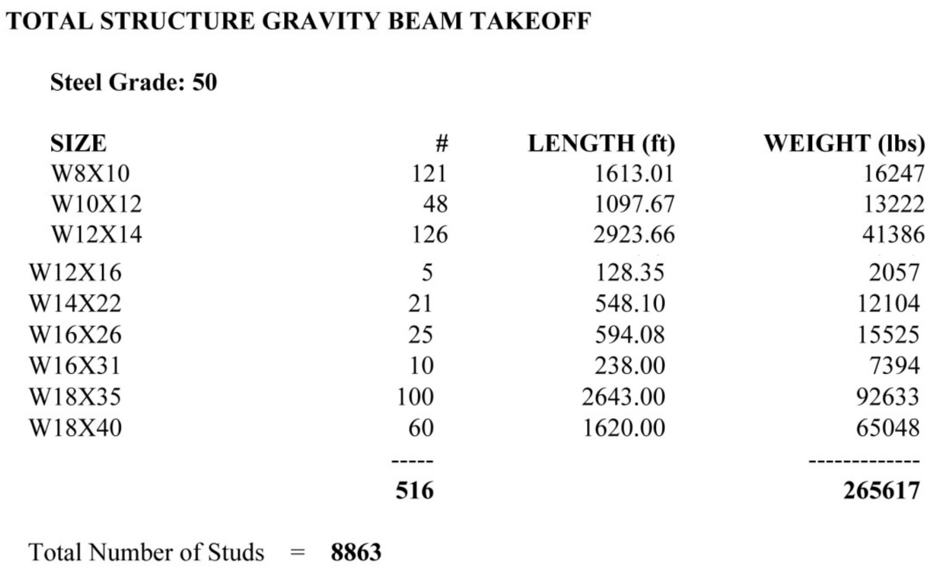
CAST-IN-PLACE CONCRETE SYSTEM - EXISTING CONDITION

COLUMNS	Amount	Unit	Crew	# Crews	Units/Day	Days	Labor Cost/Day	Labor	Mat'l Cost/Unit	Mat'l	Equip. Cost/Day	Equip.	TOTAL COST
Formwork	36504	SFCA	C-1	4	800	46	4624	210993	1.23	44899.92			255893
Concrete	2704	CY	C-20	1	150	18	2860	51556	109	294736	600	10816	357108
Reinf.	85	Ton	4 Rodm	4	11	8	5504	42531	935	79475			122006
SLABS	Amount	Unit	Crew	# Crews	Units/Day	Days	Labor Cost/Day	Labor	Mat'l Cost/Unit	Mat'l	Equip. Cost/Day	Equip.	TOTAL COST
Formwork	159000	SFCA	C-20	7	3150	50	12474	629640	1.23	195570			825210
Concrete	4907	CY	C-20	4	600	8	11440	93560	109	534863	600	4907	633330
Slab Finish	159000	SF	CeFl	8	4000	40	6608	262668					262668
Reinf.	600	Ton	4 Rodm	6	16.5	36	8256	300218	935	561000			861218
SHEARWALLS	Amount	Unit	Crew	# Crews	Units/Day	Days	Labor Cost/Day	Labor	Mat'l Cost/Unit	Mat'l	Equip. Cost/Day	Equip.	TOTAL COST
Formwork	24300	SFCA	C-2	2	900	27	3264	88128	1.23	29889			118017
Concrete	1440	CY	C-20	1	150	10	2860	27456	109	156960	600	5760	190176
Reinf.	100	Ton	4 Rodm	2	5.5	18	2752	50036	935	93500			143536
CRANE					Days:	261					300	78280	78280
											COST OF SYSTEM:		$3,847,443
											TIME TO CONSTRUCT:		261 Days

COMPOSITE STEEL SYSTEM - REDESIGN

COLUMNS	Amount	Unit	Crew	# Crews	Units/Day	Days	Labor Cost/Day	Labor	Mat'l Cost/Unit	Mat'l	Equip. Cost/Day	Equip.	TOTAL COST
Steel	1701	CWt	E-6	1	250	7	5091	34639	53	90153			124792
Baseplates	36		E-6	1	60	1	5091	3055	45	1620			4675
Fireproofing	30000	SF	G-2	1	1500	20	900	18000	1	30000			48000
FLOORS	Amount	Unit	Crew	# Crews	Units/Day	Days	Labor Cost/Day	Labor	Mat'l Cost/Unit	Mat'l	Equip. Cost/Day	Equip.	TOTAL COST
Framing	3263	CWt	E-6	1	250	13	5091	66448	53	172939			239387
Steel Deck	159000	SF	E-4	3	10140	16	7968	124942	2	318000			442942
Shear Studs	8863	Studs	E-10	1	950	9	1060	9889	1	8863			18752
Fireproofing	159000	SF	G-2	2	3000	53	1800	95400	1	159000			254400
Concrete	4907	CY	C-20	2	300	16	5720	93560	109	534863			628423
WWF	1000	CSF	2 Rodmn	4	108	9	2752	25481	29	29000			54481
Slab Finish	159000	SF	CeFl	6	3000	53	4956	262668					262668
BRACES	Amount	Unit	Crew	# Crews	Units/Day	Days	Labor Cost/Day	Labor	Mat'l Cost/Unit	Mat'l	Equip. Cost/Day	Equip.	TOTAL COST
HSS Steel	2132	CWt	E-6	1	250	9	5091	43416	59	125788			169204
Fireproofing	3000	SF	G-2	1	1500	2	900	1800	1	3000			4800
CRANE					Days:	208					300	62283	62283
											COST OF SYSTEM:		$2,314,807
											TIME TO CONSTRUCT:		208 Days

Floor Framing Takeoffs

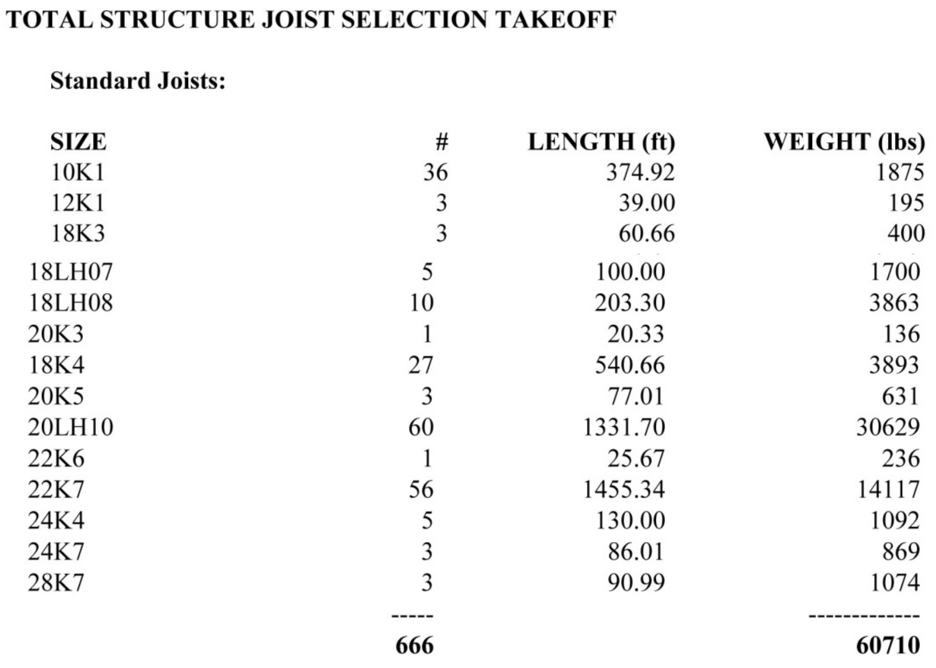


```
TOTAL STRUCTURE GRAVITY BEAM TAKEOFF

    Steel Grade: 50

    SIZE                  #     LENGTH (ft)    WEIGHT (lbs)
    W8X10               121         1613.01           16247
    W10X12               48         1097.67           13222
    W12X14              126         2923.66           41386
  W12X16                 5          128.35            2057
  W14X22                21          548.10           12104
  W16X26                25          594.08           15525
  W16X31                10          238.00            7394
  W18X35               100         2643.00           92633
  W18X40                60         1620.00           65048
                     -----                    -------------
                       516                           265617

  Total Number of Studs   =   8863
```

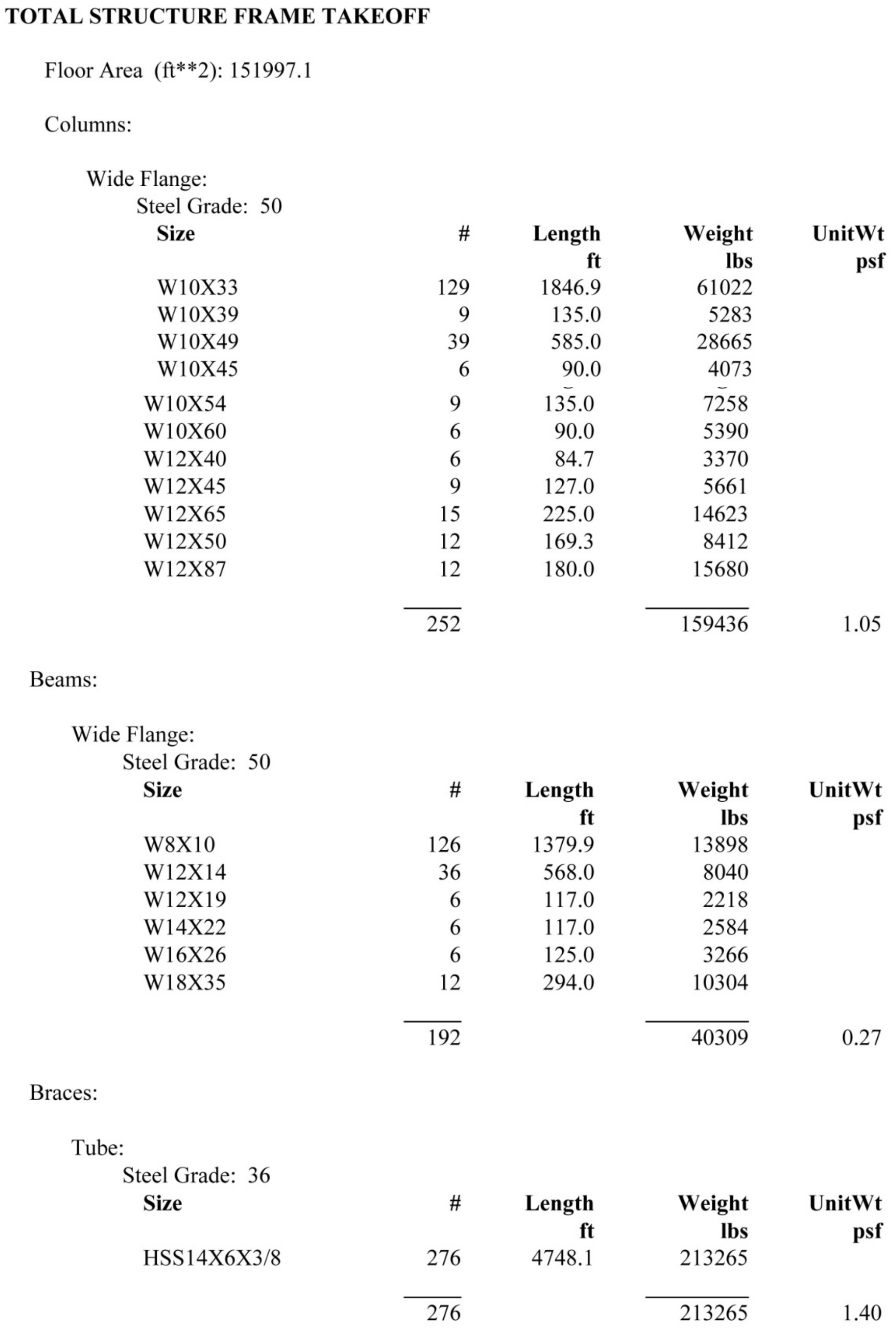


```
TOTAL STRUCTURE JOIST SELECTION TAKEOFF

    Standard Joists:

    SIZE                  #     LENGTH (ft)    WEIGHT (lbs)
    10K1                 36          374.92            1875
    12K1                  3           39.00             195
    18K3                  3           60.66             400
  18LH07                 5          100.00            1700
  18LH08                10          203.30            3863
  20K3                   1           20.33             136
  18K4                  27          540.66            3893
  20K5                   3           77.01             631
  20LH10                60         1331.70           30629
  22K6                   1           25.67             236
  22K7                  56         1455.34           14117
  24K4                   5          130.00            1092
  24K7                   3           86.01             869
  28K7                   3           90.99            1074
                     -----                    -------------
                       666                            60710
```

Lateral Bracing System Takeoffs



TOTAL STRUCTURE FRAME TAKEOFF

Floor Area (ft**2): 151997.1

Columns:

Wide Flange:

Steel Grade: 50

Size	**#**	**Length** ft	**Weight** lbs	**UnitWt** psf
W10X33	129	1846.9	61022	
W10X39	9	135.0	5283	
W10X49	39	585.0	28665	
W10X45	6	90.0	4073	
W10X54	9	135.0	7258	
W10X60	6	90.0	5390	
W12X40	6	84.7	3370	
W12X45	9	127.0	5661	
W12X65	15	225.0	14623	
W12X50	12	169.3	8412	
W12X87	12	180.0	15680	
	252		159436	1.05

Beams:

Wide Flange:

Steel Grade: 50

Size	**#**	**Length** ft	**Weight** lbs	**UnitWt** psf
W8X10	126	1379.9	13898	
W12X14	36	568.0	8040	
W12X19	6	117.0	2218	
W14X22	6	117.0	2584	
W16X26	6	125.0	3266	
W18X35	12	294.0	10304	
	192		40309	0.27

Braces:

Tube:

Steel Grade: 36

Size	**#**	**Length** ft	**Weight** lbs	**UnitWt** psf
HSS14X6X3/8	276	4748.1	213265	
	276		213265	1.40

Column Takeoffs

Size	#	Length (ft)	Weight (lbs)
W10X33	8	338.6	11189
W12X40	7	296.3	11797
W12X45	21	888.9	39625
W10X49	7	315.0	15435
W10X54	1	45.0	2419
W12X65	7	315.0	20473
W12X72	15	675.0	48464
W12X79	6	270.0	21315
	72		170717

Baseplate Takeoffs

Column Line	Column Size	(ksi)	N (in)	B (in)	tp (in)
A - 7	W12X72	36	14.50	14.00	1.375
A - 8	W12X72	36	14.50	14.00	1.375
A - 9	W12X72	36	14.50	14.00	1.375
A - 10	W12X72	36	14.50	14.00	1.375
A - 12	W12X72	36	14.50	14.00	1.375
A - 13	W12X72	36	14.50	14.00	1.375
A - 14	W12X72	36	14.50	14.00	1.375
A - 15	W12X65	36	14.25	14.00	1.250
A - 16	W12X65	36	14.25	14.00	1.250
A - 18	W10X49	36	12.00	12.00	1.000
B - 2	W10X49	36	12.00	12.00	0.875
C - 6	W10X54	36	12.25	12.00	1.000
C - 7	W12X79	36	15.00	14.25	1.375
C - 9	W12X79	36	15.00	14.25	1.375
C - 10	W12X65	36	14.25	14.00	1.250
C - 15	W12X79	36	14.50	14.25	1.375
D - 1	W10X49	36	12.00	12.00	0.875
F - 2	W10X49	36	12.00	12.00	1.000
F - 5	W12X65	36	14.25	14.00	1.250
F - 6	W12X72	36	14.50	14.00	1.375
F - 7	W12X79	36	15.00	14.25	1.375
F - 9	W12X79	36	15.00	14.25	1.375
F - 10	W12X65	36	14.25	14.00	1.250
F - 15	W12X79	36	14.50	14.25	1.375
G - 1	W10X49	36	12.00	12.00	0.875
H - 2	W10X49	36	12.00	12.00	0.750
I - 7	W12X72	36	14.50	14.00	1.375
I - 8	W12X72	36	14.50	14.00	1.375
I - 9	W12X72	36	14.50	14.00	1.375
I - 10	W12X72	36	14.50	14.00	1.375
I - 12	W12X72	36	14.50	14.00	1.375
I - 13	W12X72	36	14.50	14.00	1.375
I - 14	W12X72	36	14.50	14.00	1.375
I - 15	W12X65	36	14.25	14.00	1.250
I - 16	W12X65	36	14.25	14.00	1.250
I - 18	W10X49	36	12.00	12.00	0.875