T.C. WILLIAMS HIGH SCHOOL

ALEXANDRIA, VA

CHRISTOPHER B. DEKER

STRUCTURAL OPTION

FINAL REPORT

09 APRIL 2008

FACULTY CONSULTANT: PROF PARFITT

T.C. WILLIAMS HIGH SCHOOL

ALEXANDRIA, VA

GENERAL INFORMATION

- PROJECT COST: $87,000,000
- SIZE: 3 STORIES~461,000 SQ FT
- COMPLETED: SUMMER ‘07
- ARCHITECT: MOSELEY ARCHITECTS
- ENGINEERS: MOSELEY ARCHITECTS
- CONSTRUCTION MANAGEMENT: HENSEL PHELPS
- PROJECT DELIVERY METHOD: DESIGN BUILD~GMP

STRUCTURAL

- STRIP AND SPREAD CONCRETE FOOTINGS
- BUILDING FOUNDATIONS CONSTRUCTED ON SUB GRADE SOIL IMPROVED BY THE INSTALLATION OF A GEOPIER RAMMED AGGREGATE PIER SOIL REINFORCEMENT SYSTEM
- COMPOSITE FLOOR SYSTEM W/ 3” CONCRETE SLAB ON 1½” STEEL DECK SUPPORTED BY STEEL BEAMS
- ROOF SUPPORTED BY 3” STEEL DECK ON K SERIES STEEL JOISTS

ARCHITECTURAL FEATURES

- GREEN ROOF
- 70% OF ROOMS CONTAIN AN OUTSIDE VIEW
- EXPOSED STRUCTURAL STEEL
- OUTDOOR PLAZA

LEED DESIGN

- ACHIEVED SILVER RATING
- 450,000 GALLON CISTERN, PROVIDES WATER FOR CHILLERS, AIR CONDI-TIONING, AND TOILETS
- GREEN ROOF - COLLECTS WATER FOR CISTERN

MECHANICAL

- (2) 600 TON 975 GPM CHILLERS
- (2) 9,000,000 BTUH 1,200 GPM COOLING TOWERS
- 17 ROOF TOP AIR HANDLING UNITS W/ COMBINED 229,100 CFM
- 4 INDOOR AIR HANDLING UNITS W/ COMBINED 40,355 CFM

LIGHTING | ELECTRICAL

- CLASSROOMS -54W T5 HO 277V PENDANT FIXTURE
- CORRIDORS - 32W T8 277V RECESSED FIXTURE
- (24) 270V PANEL BOARDS
- (67) 120V PANEL BOARDS

CHRISTOPHER B DEKER

STRUCTURAL OPTION

http://www.engr.psu.edu/ae/thesis/portfolios/2008/cbd127/

ACKNOWLEDGEMENTS

I would like to thank the following people for all their help and support:

My Parents

Gail Shaffer

Bruce Deker

Moseley Architects

Steve Jones

Paul Gagnon

The Pennsylvania State University

Kevin Parfitt

Robert Holland

Dr. Linda Hanagan

Most importantly I'd like to thank the entire Architectural Engineering faculty and staff for all their help and support over the past five years.

TABLE OF CONTENTS

TABLE OF FIGURES

EXECUTIVE SUMMARY

T.C. Williams is a 3 Story 461,000 SF high school in Alexandria, VA, designed to accommodate 2,500 students. This report deals with the two classroom wings, and attempts to create a more economical design.

Due to poor soil conditions, a Geopier 'Rammed Aggregate Pier' Soil Reinforcement system was installed to create a soil bearing capacity of 6,000 PSF. The total bid price for this system was $780,000. It was decided to reduce the size of the school's footprint, while adding two additional stories. The existing square footage of each classroom wing will not change from the original 108,000 SF. Along with decreasing the cost of the existing structure, changing the shape of the wings will add other benefits as well. It was calculated with the new layout of the classroom wings, that 91% of the rooms in these buildings will receive natural lighting, an approximate increase of 24%. The existing building as a whole took pride in the fact 70% of rooms in the entire building had an outside view, and this new layout greatly increases this number to around 82%. Additionally, with the new layout of the classroom wings, less corridor area is needed for the same results. An expected savings of approximately 5,000 additional square feet of floor area will be added to classrooms in each wing.

After some inspection, it was noticed that decreasing the building footprint would actually increase the cost of the structure, due to the cost of the floor system being even larger than that of the foundations. To justify the advantages of the new layout, further cost cutting systems needed to be set in place. Most noticeably the floor system and lateral resisting systems were changed for more economical solutions.

The new floor system was designed using composite steel joists from Vulcraft. In order to decrease the number of joists, and thus save on the expensive costs of fireproofing, the joists were designed to be spaced a maximum of 8 feet on center. In order to still meet the vibration criteria of 0.5%g, only a quarter inch of concrete was able to be saved. If vibration wasn't a critical criterion a much more efficient floor system could have been used. However, it was decided that in a school setting, vibration issues would be critical to ensure the comfort of all students. After pricing the new floor system a total savings of $4.65 per square foot was saved on the floor system.

A new lateral system was also designed, and takes advantage of the masonry partitions already in place. The existing steel concentrically braced moment frames were replaced by fully grouted 8 inch masonry shear walls. The shear walls span 34 feet in length and are required to be fully reinforced at 8 inches on center. This is mostly due to the cause of high torsional forces created from the layout of the shear walls. This was due to the required stacking of the shear walls on the new architectural floor plan, and the layout of these walls cannot change without an additional time consuming redesign of the architectural floor plans. Additionally the story drift of these walls was calculated to be 0.55 inches, well below the maximum 2.25 inches (L / 400) allowed by code. A total savings of $1.19 per square foot of building floor area, or $128,000, was saved from the use of masonry shear walls over braced frames. Even though a savings was created from the use of these shear walls, a major downfall is the increase in construction time, which greatly affected the schedule of the redesign. An estimated 58 days of construction time is added to the project, which eliminates the original time savings from the reduction of excavation and Geopier reinforcing.

Some unforeseen difficulties were also realized during the redesign faze. The increase in height ended up adding much more square footage of wall surface area to the project, than was saved from the reduction in linear feet of the wall. Also additional reinforcement and grout was needed to stabilize the wall at its additional heights. The new exterior façade was priced $497,100 higher than the existing.

An additional unforeseen cost increase of the roof system was realized when problems arose with the mechanical roof systems. With the new building layout, the mechanical systems which once were hidden from site may now be seen from the surrounding residential areas. This created the need for a redesign of the roof system, which was able to fix this problem while adding $1.25 per square foot to the cost of the roof.

With all factors considered the total savings was found to be just $10,000 per classroom wing, which is a very negligible savings of a structural system originally costing 4.6 million per wing, and a total project cost of $87 million for the entire school. 17 Days were also added to the completion date, 11 which are work days, 6 of which are weekends. However, through further inspection this issue may also be negligible as the school was completed 2 months before the start of August classes in 2007.

With the future construction of a similar building, the owner would have many options. If the owner feels that the extra 5,000 SF per wing or 10,000 SF for the entire school, and a 24% increase of extra rooms with an outside view beneficial, then he may be willing to accept the slight increase in construction time, while also benefiting from a measly $10,000 in savings. If he still would feel this new design would be beneficial, but an increase in construction time would be damaging, then he could opt to replace the masonry shear walls with the concentrically steel braced frames, adding an estimated $100,000 to the total cost. This option would also add the decrease of 50 days of construction time, decreasing the total construction time by over a month. Furthermore a simple change in floor systems from composite steel beams to composite steel joists would save $162,750 without having any negative effect on the original design.

BUILDING INTRODUCTION

T.C. Williams is a 3 Story 461,000 SF high school in Alexandria, VA, designed to accommodate 2,500 students. The architects and engineers on the job were Moseley Architects. It was later constructed by Hensel Phelps. Construction was completed during the summer of 2007, and later opened in the fall of 2007.

The building utilizes a composite slab with decking on steel frame construction. Due to the large size of the school, it was separated into six different 'buildings' using expansion joints. All together these six buildings have 4 different lateral resisting systems, the most common being Steel Concentrically Braced Frames. The others include Steel Moment Resisting Frames, and both Ordinary and Intermediate Masonry Shear Walls.

Buildings separated by expansion joints are located on the next page. Buildings A and B are the ones under analysis. These buildings are the known as the classroom wings, and contain classrooms, labs, and offices. They were chosen for analysis since they are the only sections of the school where a change in height could be justified. Building C contains the cafeteria, library, and green roof. Building D contains many miscellaneous rooms, including some classrooms and mechanical systems. Building E contains the gymnasium and locker rooms. Finally, building F contains the auditorium and stage.

An original design of the school was done using ASD, while this technical report focuses on the design using LRFD. Due to both the difference in design methods, and the difference in building codes used, small discrepancies between my calculations and those of the engineer are expected. In no way does this report make the claim that any of the designer's approaches, assumptions, calculations, or resulting designs are incorrect or unsuitable.

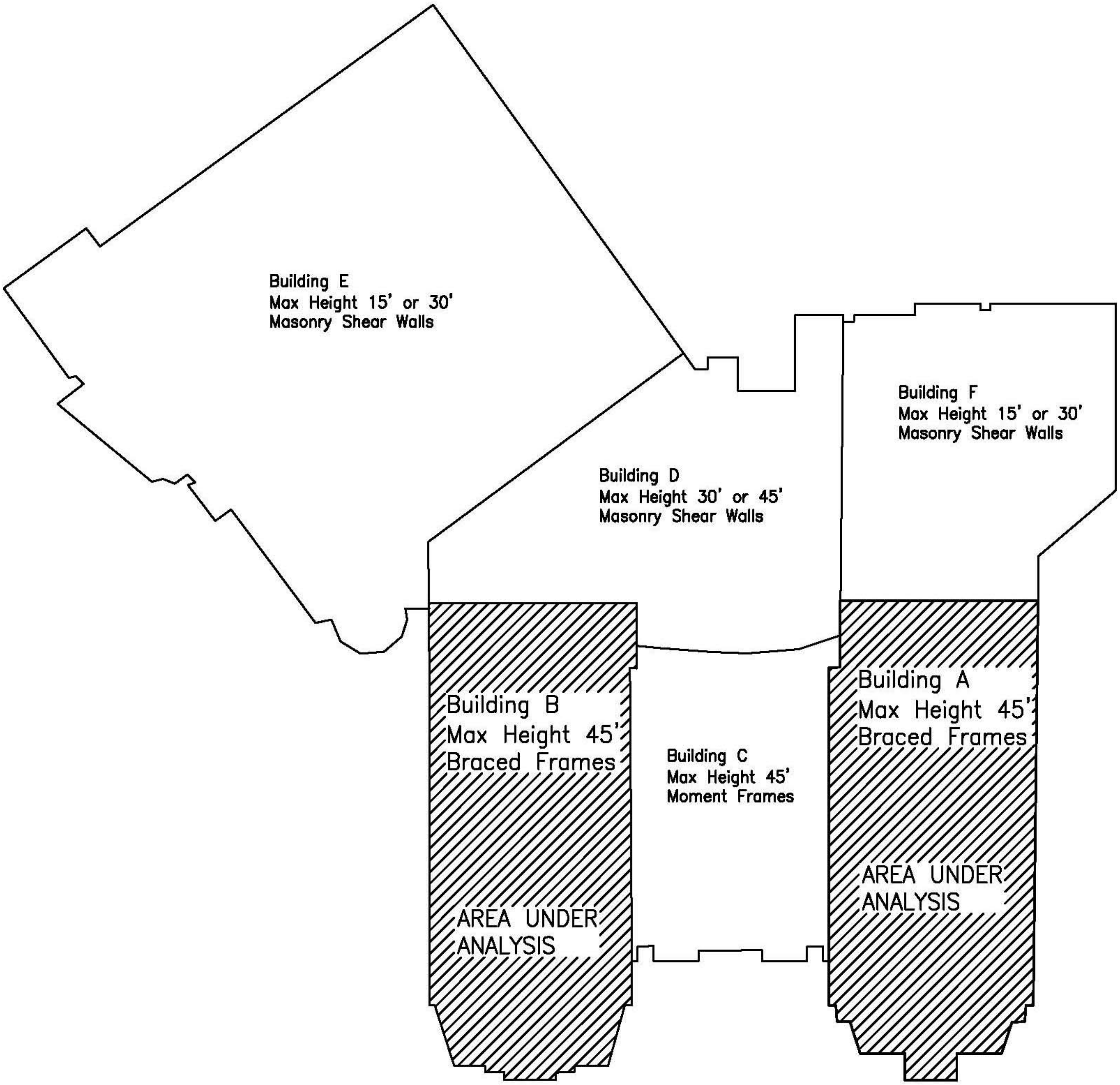


Figure 1 - Overal Building Plan

BUILDING BACKGROUND

GENERAL BUILDING DATA

- **Building name**: TC Williams High School
- **Location and site**: 3330 King St Alexandria, Virginia
- **Building Occupant Name**: TC Williams High School
- **Occupancy or function types**: High School ~ 2,500 Students
- **Size**: 461,000 SF
- **Number of stories**: 3
- **Primary project team**
    - **Owner**: City of Alexandria, VA
    - **General Contractor and CM**: Hensel Phelps
    - **Architects**: Moseley Architects
    - **Engineers**: Moseley Architects
- **Dates of construction**: July 02 2004 – June 21 2007
- **Overall Project Cost**: $87,000,000
- **Project delivery method**: Design Build – GMP
- **Zoning** : Commercial

ARCHITECTURE

Architecture Concepts:

- TC Williams High School was originally designed with a very modern feel, but the owner decided a more traditional look was desired. The TC Williams High school was then redesigned with a traditional look that took various designs from other buildings in the general area. Natural light was also a major factor in the design, and 70% of the rooms have an outside view.
- The other architecture concept the building was designed around was a Green Design. The building achieved a LEED rating of silver. Some of the main LEED designs included a 450,000 gallon Cistern, and a small green roof. The cistern will be used to provide water for the chillers, air conditioning, and toilets. The Green Roof will be used as a learning tool, as well as to collect additional rain water for the cistern.

Figure 2 - Green Roof

STRUCTURAL

The foundation of the building consists of both strip and spread NWC (145 PCF) footings with a compressive strength f'c = 3,000 psi. The foundations are constructed on sub grade soils improved by the installation of a 'Geopier Rammed Aggregate Pier Soil Reinforcement' system and are designed to bear on strata capable of sustaining a minimum bearing pressure of 6,000 PSF.

The typical floor is a composite system consisting of a 3" concrete slab on 1½" 18 gage steel composite deck, supported by Steel Beams typically spaced 8' O.C that vary in size. The 3 story classroom sections of the building consist of a steel braced frame construction, while other lateral force resisting systems range from Masonry Shear Walls to Steel Moment Frames. The typical roof consists of 1½" 22 gage steel roof deck, supported by K-Series Steel Joists which are typically spaced 5' O.C.

LIGHTING / ELECTRICAL

The classrooms are lit with 54W T5 HO 277V Pendant fixtures, while the corridors are lit with 32W T8 277V Recessed fixtures.

A 480 Y / 277, 3 phase, 4 wire primary feed services the building. Two main 4000 ampere, 3 phase switchboards distribute the required power to the electrical loads throughout the building. The building contains a total of (24) 270V panel boards, and (67) 120V panel boards. The life safety system is backed up by two 800kW, 480V, 3 phase 60 Hz, diesel fueled generators.

MECHANICAL

There are a total of 17 roof top air handling units with a combined capacity of 229,100 CFM supply conditioned air to the majority of spaces. An additional 4 indoor air handling units combine for 40,355 CFM supply of air to the auxiliary gymnasium, east and west commons areas and the remaining spaces in the Eastern Classroom wing. These units employ the use of enthalpy wheels to recover total energy. Four natural gas-fired condensing boilers, with capacities of 1.68 million BTUH, heat water from 120˚F to 160˚F. Water is cooled to 38˚F by two, 600 ton water cooled, electrical chillers. Two 750 ton cooling towers condense the R-123 refrigerant so that it can be re-circulated through the chillers which will accept the heat from the systems chilled water lines. An additional water unit heater and an electric heater service the mechanical and equipment rooms respectively.

A five zone, wet pipe sprinkler system services T.C. Williams High School. Each zone covers approximately 50,000 sq. ft. A 100 hp vertical in-line fire pump produces a flow rate of 1,000 GPM with a total head pressure of 120 psi. A mixture of sidewall and pendant sprinkler heads will service the spaces while concealed heads are required in all the stairwells.

CONSTRUCTION

Hensel Phelps is the CM on the job, and had working under a design build guaranteed maximum price contract. Construction started in July of 2004, and construction was completed in June of 2007. The old school which currently resides next to the new school is still currently under deconstruction.

FIRE PROTECTION

The steel in the building is protected with spray on fireproofing rated for 1 hour for floor, and column members, and 1 hour for roof members. The floor slab has a required 1 hour minimum fire rating. A fire alarm system with automatic sprinklers is in place throughout the school.

TRANSPORTATION

There are three main elevators located in the 3 story classroom sections. They are all for public use. There is one service elevator located in the classroom section for private use.

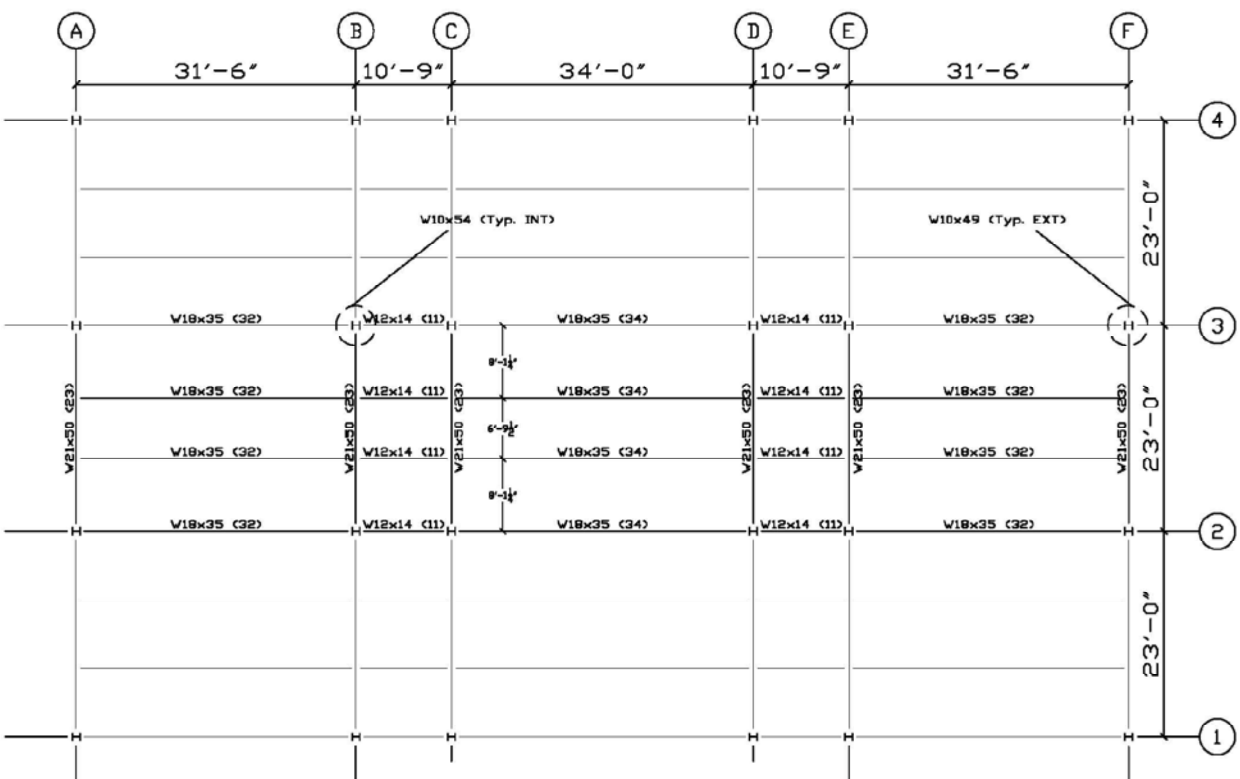


Figure 3 - Existing Structure Typical Bay Strip

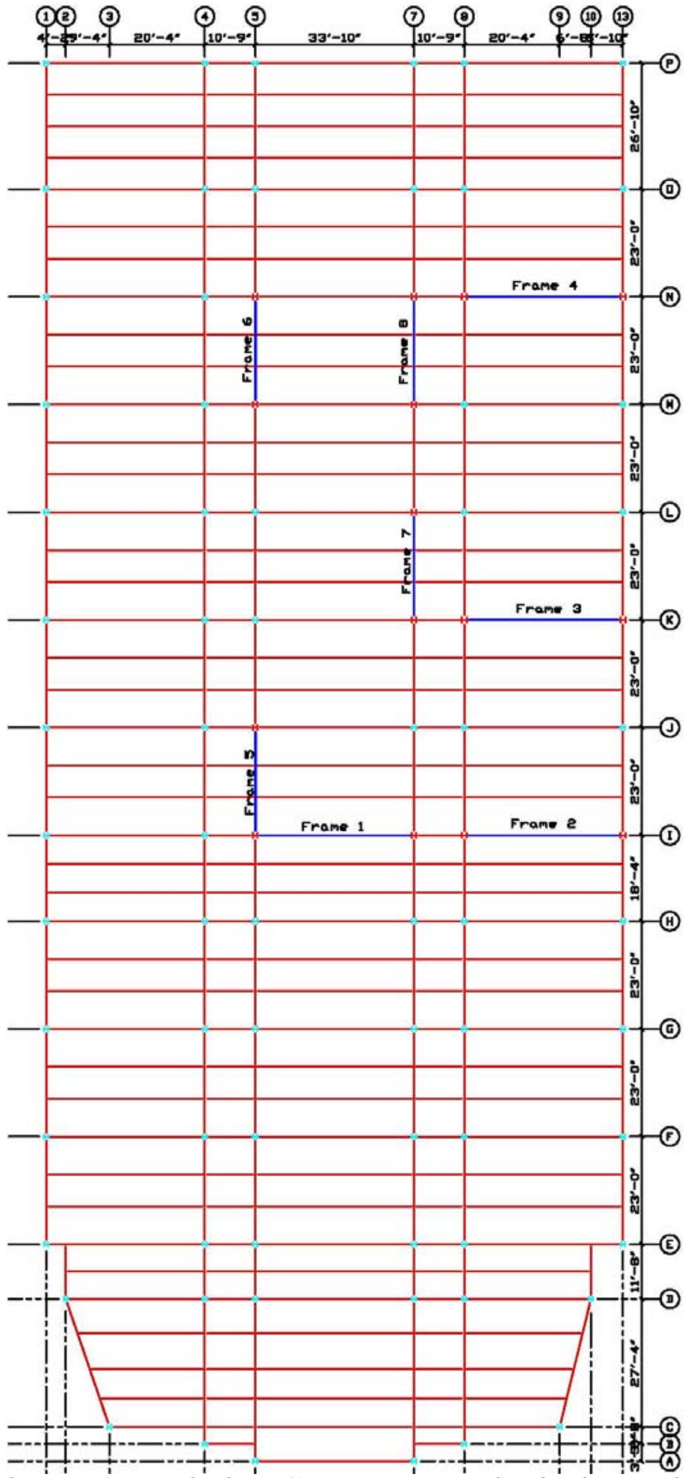


Figure 4 - Existing Structure Typical Floor Plan

STRUCTURAL SYSTEM OVERVIEW

ROOF SYSTEM

Typical flat roof systems on T.C. Williams High School consists primarily of a Thermoplastic Polyolefin (TPO) Membrane system with 6 inch rigid insulation on 1½" 22 gage steel roof deck, supported by K-Series Steel Joists which are typically spaced 5' O.C. Typical sloped roofing systems are similar to the flat roofing systems except instead of the TPO Membrane system there is a standing seam metal roof.

Typical roofing systems over larger span areas such as the gymnasium and the auditorium consist of 3" 20 gauge steel roof deck, supported by DLH Steel Joists typically spaced 12' O.C.

FLOOR SYSTEM

Typical floor systems consist of a steel composite deck and beam system with a 3" concrete slab topping on 1½" 18 gauge steel composite deck, supported by Steel Beams typically spaced 8' O.C. The concrete slab is made of Normal Weight Concrete (145 PCF) and has a minimum 28 day compressive strength (F'c) of 4000 PSI. Most typical Steel Beams are W18x35 spanning a maximum of 34' with steel studs spaced at 12" O.C. The range of steel beams varies greatly depending on specific room requirements; generally ranging anywhere from a W16x26 to a W21x44. Steel studs creating the composite action are ¾" in diameter and 3½" long.

FOUNDATION

All main building foundations are constructed on sub grade soils improved by the installation of a 'Geopier Rammed Aggregate Pier Soil Reinforcement' system and are designed to bear on strata capable of sustaining a minimum bearing pressure of 6,000 PSF. The slab on grade consists of Normal Weight Concrete (145 PCF) and has a minimum 28 day compressive strength (F'c) of 3,500 PSI. Typical slabs are 4" thick and are reinforced with 6x6-W1.4xW1.4 WWF at mid depth. All spread and strip footings consist of Normal Weight Concrete (145 PCF) and have a minimum 28 day compressive strength (F'c) of 3,000 PSI.

LATERAL SYSTEM

T.C. Williams is separated into 6 different "buildings" through the use of 'Fire Walls'. Both classroom towers are laterally supported with ordinary steel concentrically braced frames in both the N-S and E-W directions. The 3 story area connecting the 2 three story classroom towers is laterally supported with ordinary steel moment frames in both the N-S and E-W directions. Gymnasium and auditorium areas are supported by intermediate reinforced masonry shear walls, in all directions. The rest of the building, which includes the area between the gymnasium and auditorium sections, is laterally supported by ordinary reinforced masonry shear walls, in all directions.

COLUMNS

Steel columns are the primary gravity load resisting members of the building. They consist of Grade 50 ASTM A992 wide flange shapes, grade 46 ASTM A500 rectangular HSS shapes, and grade 42 ASTM A500 round HSS shapes. The wide flange shapes generally range from a W10x49 to a W10x68, and are the primary support for most of the building. The Round HSS shapes found connecting the two classroom wings and under the green roof, and generally range from HSS12.750x.375 to HSS16x.500.

CODES

ORIGINAL DESIGN CODES:

Virginia State Building Code (VUSBC), 2000 Edition

International Building Code (IBC), 2000 Edition

American Society of Civil Engineers (ASCE-7), 1999 Edition

Building Code Requirements for Structural Concrete (ACI 318-95)

Standard Specifications for Structural Concrete (ACI 301-96)

AISC Code of Standard Practice for Steel Buildings, 2000 Edition

AISC Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design, 1989 Edition

THESIS DESIGN CODES:

International Building Code (IBC), 2006 Edition

American Society of Civil Engineers (ASCE-7), 2005 Edition

AISC Steel Construction Manual, LRFD, 13th Edition

THESIS DEFLECTION CRITERIA:

TOTAL = L / 240

LIVE = L / 360

CONSTRUCTION = L / 360

STRUCTURAL MEMBER SUPPORTING MASONRY WALLS = L / 600

Drift = L / 400

LOADS

SUPERIMPOSED ROOF DEAD LOAD	THESIS DESIGN
TPO Membrane / S.S. metal Roof	3 PSF
4"-6" Rigid Insulation	2.5 PSF
Ceiling Finishes	5 PSF
Mechanical / Electrical	6.5 PSF
Sprinklers	2.5 PSF
TOTAL	19.5 PSF

SUPERIMPOSED FLOOR DEAD LOAD	THESIS DESIGN
Ceiling Finishes	5 PSF
Mechanical / Electrical	7.5 PSF
Sprinklers	2.5 PSF
TOTAL	15 PSF

TYPICAL ROOF LIVE LOAD	THESIS DESIGN	CODE REFERENCE
Minimum Roof LL	20 PSF	ASCE 7-05 Section 4.9.1
Ground Snow Load (Pg)	25 PSF	IBC Figure 1608.2
Importance Category III	Is = 1.10	IBC Section 1604.5
Exposure Factor	Ce = 1.0	IBC Table 1608.3.1
Thermal Factor	Ct = 1.0	IBC Table 1608.3.2
Flat Roof Snow Load	19.25 PSF + Drift	IBC Section 1608.3
Drift	Varies	ASCE 7-05 Section 7.7

FLOOR LIVE LOADS	THESIS DESIGN	ORIGINAL DESIGN	ASCE 7-05 MIN VALUE
Classroom	50 PSF	50 PSF	40 PSF
First Floor Corridor	100 PSF	100 PSF	100 PSF
Above First Floor Corridor	80 PSF	80 PSF	80 PSF
Offices	50 PSF	50 PSF	50 PSF
Light' Storage	125 PSF	125 PSF	125 PSF
Mechanical	150 PSF	150 PSF	n/a
Green Roof	100 PSF	100 PSF	n/a
Library Stacks	150 PSF	150 PSF	150 PSF

STRUCTURAL DEPTH

PROBLEM STATEMENT

Due to the large budget, the structural system was designed using fairly conservative sizes, and a simple design. Had the owner felt the need for a more valued engineering approach, the structural system would most likely need to be optimized. A major problem with the building site was its poor soil quality, which led to complicated foundations. If two more stories were added to the top of the classroom wings, and the overall square footage of the wings remained the same, then there may be some savings in the overall cost of the structure. With an addition to a reduction in just foundation costs, it will also be beneficial to examine the possibility of a more economical building design. Had the owner felt a need for additional stories at the time more solutions may have been explored by the design engineer. I intend to propose a value engineered solution that will decrease construction costs, project duration, and material usage, while accounting for two additional stories in exchange for a smaller building footprint. The overall building square footage will remain approximately the same (108,000 SF / Classroom Wing). To accomplish this I will use code requirements from IBC 2006, and ASCE 7-05.

STRUCTURAL REDESIGN ELEMENTS

- REDESIGN OF ROOFING SYSTEM
- REDESIGN OF FLOOR SYSTEM
- REDESIGN OF COLUMNS
- REDESIGN OF LATERAL FORCE RESISTING SYSTEM
  - WIND
  - SEISMIC
  - DISTRIBUTION
- REDESIGN OF EXTERIOR WALLS
- REDESIGN OF FOUNDATIONS

REDESIGN OF ROOFING SYSTEM

Originally there was nothing wrong with the roofing system. It was both economically efficient, and aesthetically pleasing. However with the adding of two additional stories, and the thinning of the building, the mechanical systems on the roof which were once hidden from sight may now be seen.

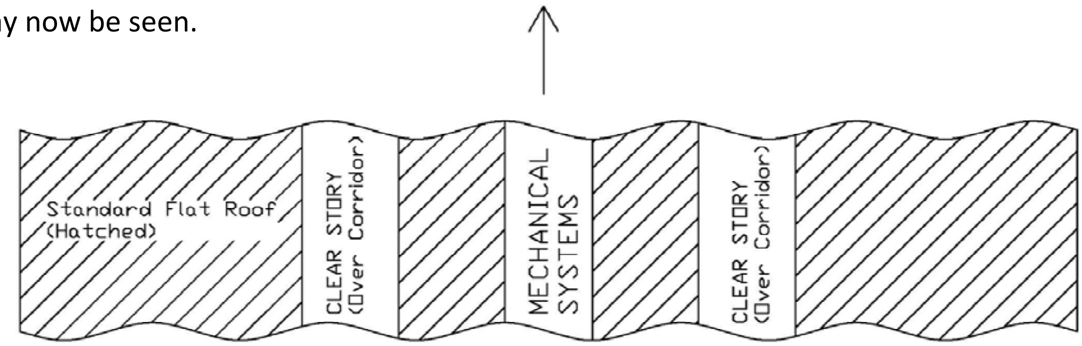


Figure 5 - Existing Roof Plan Strip

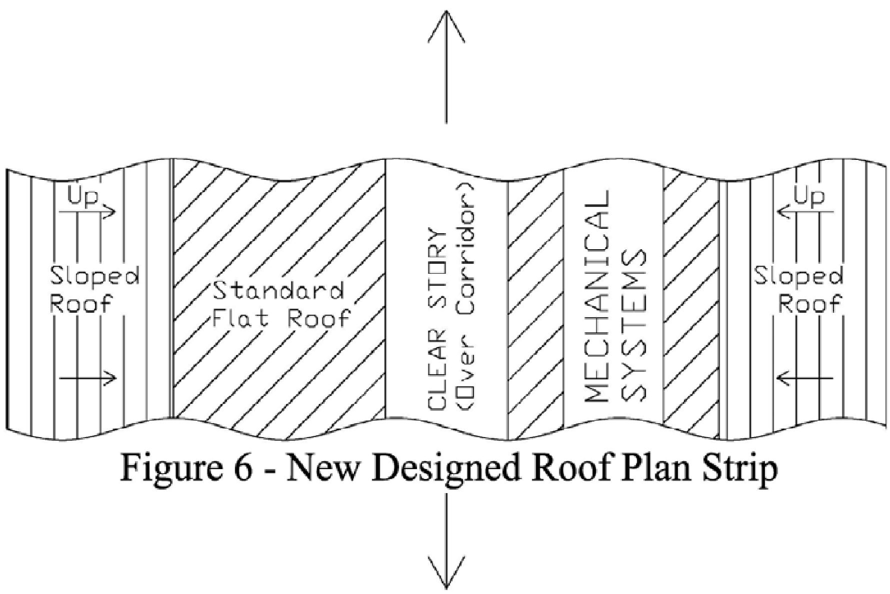


Figure 6 - New Designed Roof Plan Strip

The existing roof was made up of 24K6 open web steel joists spanning a maximum 34 feet and spaced no more than 5 feet on center. Supporting the two clearstories are large trusses, used additionally as an architectural feature, and are spaced 23 feet on center. 24KCS5 steel joists are found under the mechanical systems, because they are able to better resist an unbalanced load, where a k-series steel joist is more suitable for resisting an evenly distributed load. The KCS joists are typically spaced no more than 3-4 feet apart. W21x44 girders were used to transfer the loads from the joists to the columns.

In the redesign of the roof a more complicated system was needed. 24KCS3 joists and 1.5" 18GA decking support the mechanical system. These joists are spaced no more than 3 feet on center, and span 24.5 feet. 18K3 joists spaced 5 feet on center support the same area as the KCS joists, but only when mechanical systems are not present. Where the roof slopes, 10K1 joists on 1.5" 22GA deck are used to resist the 11.5 foot span. W18x35 girders were designed to transfer the loads from the joists to the columns. The steel truss supporting the clearstory remained the same. All roof joists are subject to meet an L/240 total load deflection, and an L/360 life load deflection.

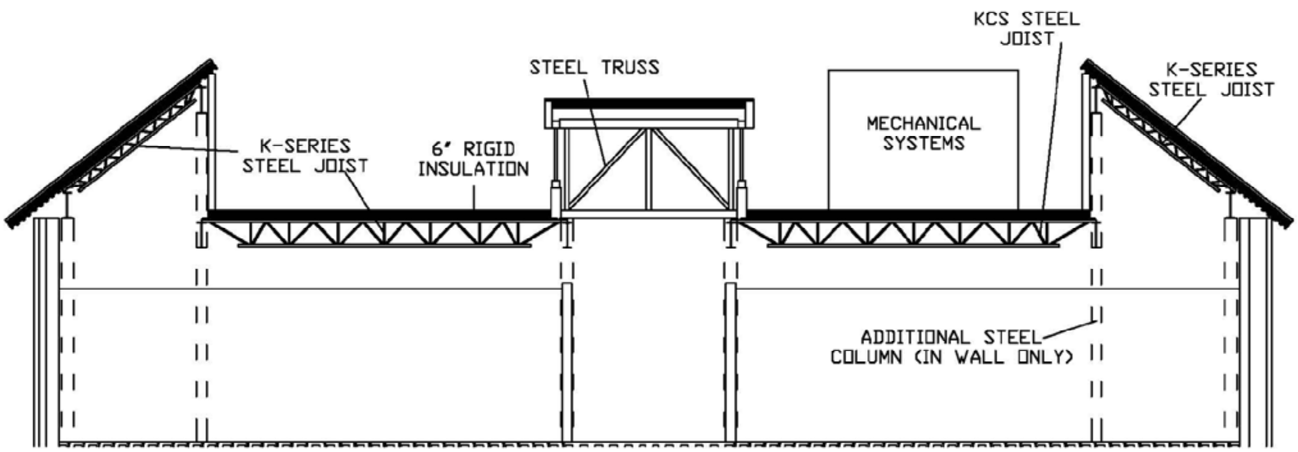


Figure 7 - New Designed Roof Section Cut

As seen in the figure above, a column comes up from the floor below and supports the two girders at mid span. This column starts at the 5th floor and ends at the roof. It is supported by a steel beam on the floor below, and braced at the top, in two positions by steel girders. This column is only located inside masonry partitions, and are therefore typically spaced 23 feet on center.

REDESIGN OF FLOOR SYSTEM

Originally the floor system was composed of W18x35 composite steel beams on 1.5" 18GA composite deck. ¾" thick 3.5" long shear studs with a 3" NWC slab, resulting in an effective slab depth of 3.75", and a total slab depth of 4.5" were used to transfer the composite action. The beams span a maximum of 34 feet and are staggered spaced in a 23 foot bay at 8'-

1¼”, 6’-9½”, and 8’1 ¼”. The W21x50 girders supporting the beams are also composite, and typically span 23 feet. In all instances the steel studs are spaced 1 foot on center. In addition, none of the beams are cambered.

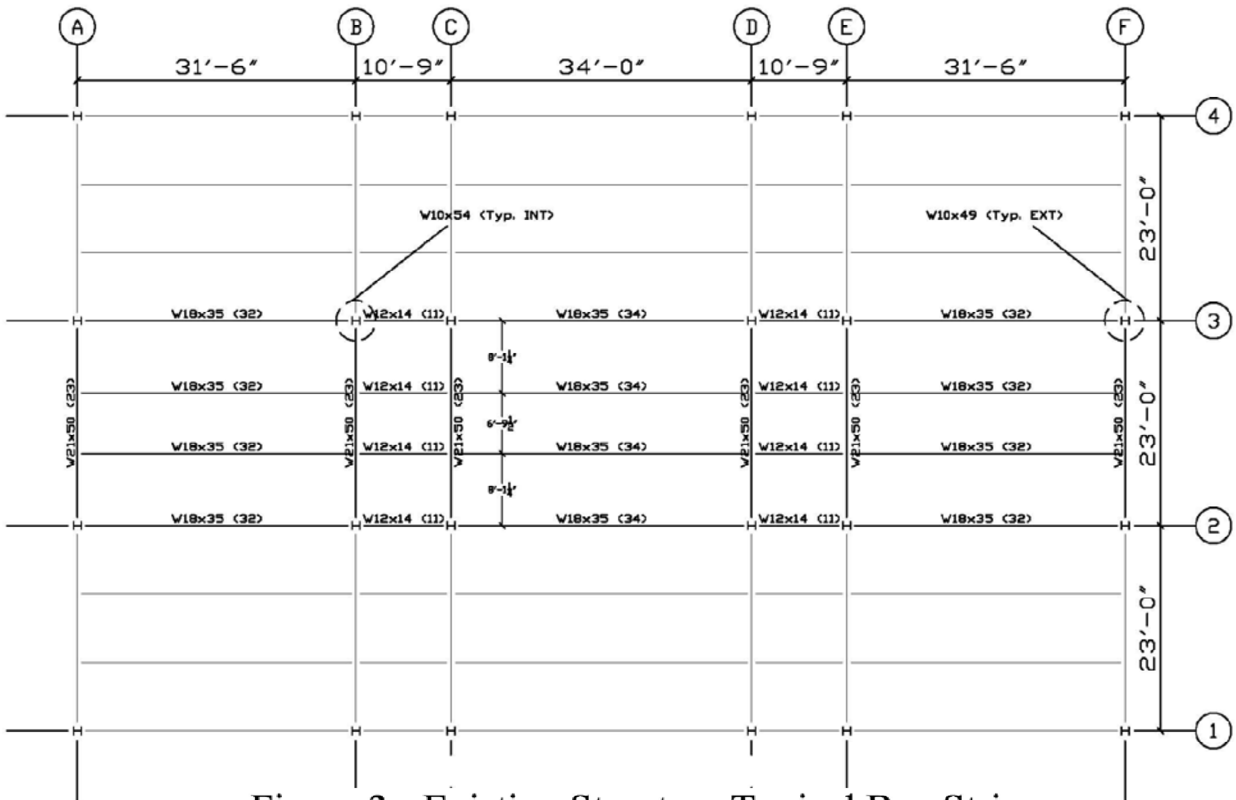


Figure 3 - Existing Structure Typical Bay Strip

STRENGTH DESIGN

EVALUATION CRITERIA

- DL = 50 PSF
- LL (reduced) = 46 PSF
- Δ = L / 600 (Live for Masonry Walls)
- Span = 34’
- Spacing = 7.67’

In the floor redesign an attempt was made to reduce the slab thickness by switching to a steel joist system. In addition to a thinner slab, consideration was also made to keep the cost of fireproofing of joists down. By reducing the number of joists and increasing their spacing to that of the composite system, it significantly reduces the cost of fireproofing. Normal K-Series steel joists normally will only be efficient when spaced 24”-30” on center. Therefore a composite joist system was designed to meet the required criteria. Using the Vulcraft catalog for composite steel joists, for strength and deflection design the minimum required size was found to be a 20VC1200 (weighing 21 PLF). To meet the required spans a 2 inch deck with 2.5 inch topping is required. It would also be most efficient to place the shear studs as shown, in the strong position. This will slightly increase the strength capacity of the composite joist. Additionally a worst case design was used to design the joist that would place a joist under a masonry wall partition, and limit its live load deflection to L/600. An L/600 deflection is chosen to prevent the masonry wall from cracking.

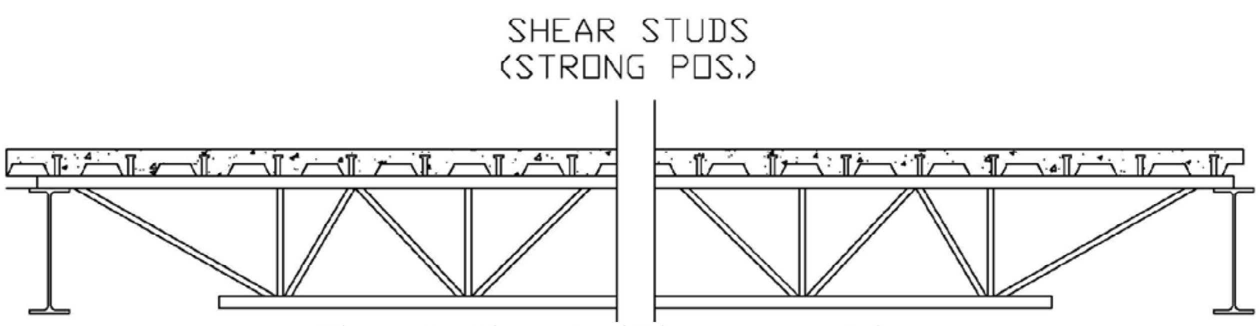


Figure 8 - Shear Stud Placement on Joist

CORRIDOR

Supporting the corridor is a 10k1 K-series steel joist. Normally a form deck would be the most appropriate for the non composite joist system, but since most of the floor is using composite decking it would make more sense to just stay consistent than to change the decking in the middle of the floor.

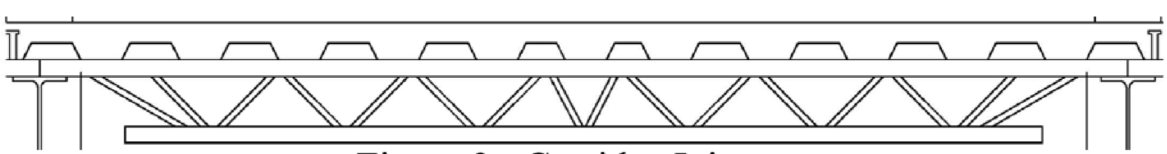


Figure 9 - Corridor Joist

VIBRATION

EVALUATION CRITERIA

- P_o = 65lb
- $\beta = 0.03$
- $\alpha_o / g = 0.5\%g = 0.005g$
- $a_p / g = P_o \, e^{(-0.35fn)} / \beta W$
- f_n = 4.9 Hz
- W = 78 kips

When vibration analysis was calculated using Design Guide 11, both the joist and girder sizes had to be bumped up to meet criteria for an office building design. While an office building definitely is not the same as a school building, the assumption this building is an office building should be fairly conservative. A live load of 11 PSF, and a dead load of 4 PSF was assumed in the calculations, because these are the design loads for a paper office building. A β value of 0.03 was chosen since masonry walls surround the exterior of the bay. If a masonry wall is inside the bay a β value may be used of 0.04, but to be conservative all bays were designed using β = 0.03. The joist was sized up to a 22VC1600 (weighing 24 PFL). This joist is able to support an additional 400 pounds per foot, and needed to be 2 inches deeper than the joist designed just for strength and deflection purposes. The deck and slab remained the same as the strength design. The final slab properties are 2" decking with a 2.5" topping equating to an effective slab depth of 3.5", and a total slab depth of 4.5".

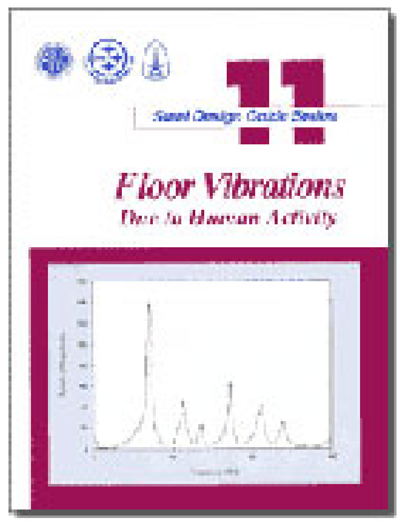


Figure 10 - DG 11 Floor Vibrations

FINAL COMPOSITE JOIST DESIGN

A more efficient composite joist could have been chosen, but it would have had to have been a deeper joist, and more coordination with the mechanical engineer would need to have been taken into account. With all things considered it most likely would be less economical to increase the depth of the joist any further, as it would cause a change to the mechanical system. As it is now the joist is almost even with the 21 inch girders. Considering the joist seat is 2 inches deep, the bottom of the joist will still be able to increase one inch in depth before it reaches even with the girder.

The Vulcraft design guide of composite steel joists requires a 22VC1600 joist to contain 24 ¾" thick shear studs, for the size required by the vibration analysis. However for strength only 18 ¾" thick shear studs are required. Since shear studs do not effect vibration at all, since all members assume composite action with vibration analysis, it will be sufficient to only use 18 ¾" thick shear studs as required by the strength and deflection design. This is approximately 1 stud every 2 feet.

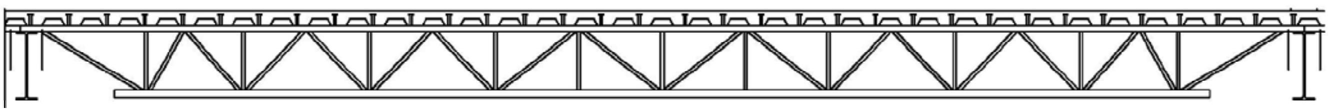


Figure 11 - Typical Composite Joist

Without driving the cost of fireproofing up, the slab was only able to be ¼" thinner than originally designed, which is very minimal savings, and will only result in about a $10,000 savings for each classroom wing. However, approximately 50% less shear studs will be required with this design, which should add up to more sufficient savings. But, considering joists cost more to make than a beam it will be interesting to see if this system is actually cheaper than the composite steel beam system.

REDESIGN OF COLUMNS

The columns used to support the previous floor system of the classroom wings were all steel and ranged from a W10x49 to W10x54 Grade 50 ASTM A 992 members. None of the columns needed to be spliced in the previous design, as they all spanned the full 45 feet or 3 stories.

With the building increasing in size, to 75 feet in height and 5 stories tall, it is now necessary to splice the columns. Typically columns are spliced at either every 2nd or every 4th floor because it is the most economical. However the reasoning behind this is for construction purposes with the different trades as you go up the building. Since a splice is also equivalent to 500 pounds of steel, it will be necessary to reduce the number of splices. For this building of 5 stories it will be most economical to splice the column after 3 stories. This will keep the size of the columns to a manageable size, and the effect of a 4:1 splice, or a 3:2 splice would be the same when considering construction trades. The splice will be taken a couple feet above floor level where it will be most manageable.

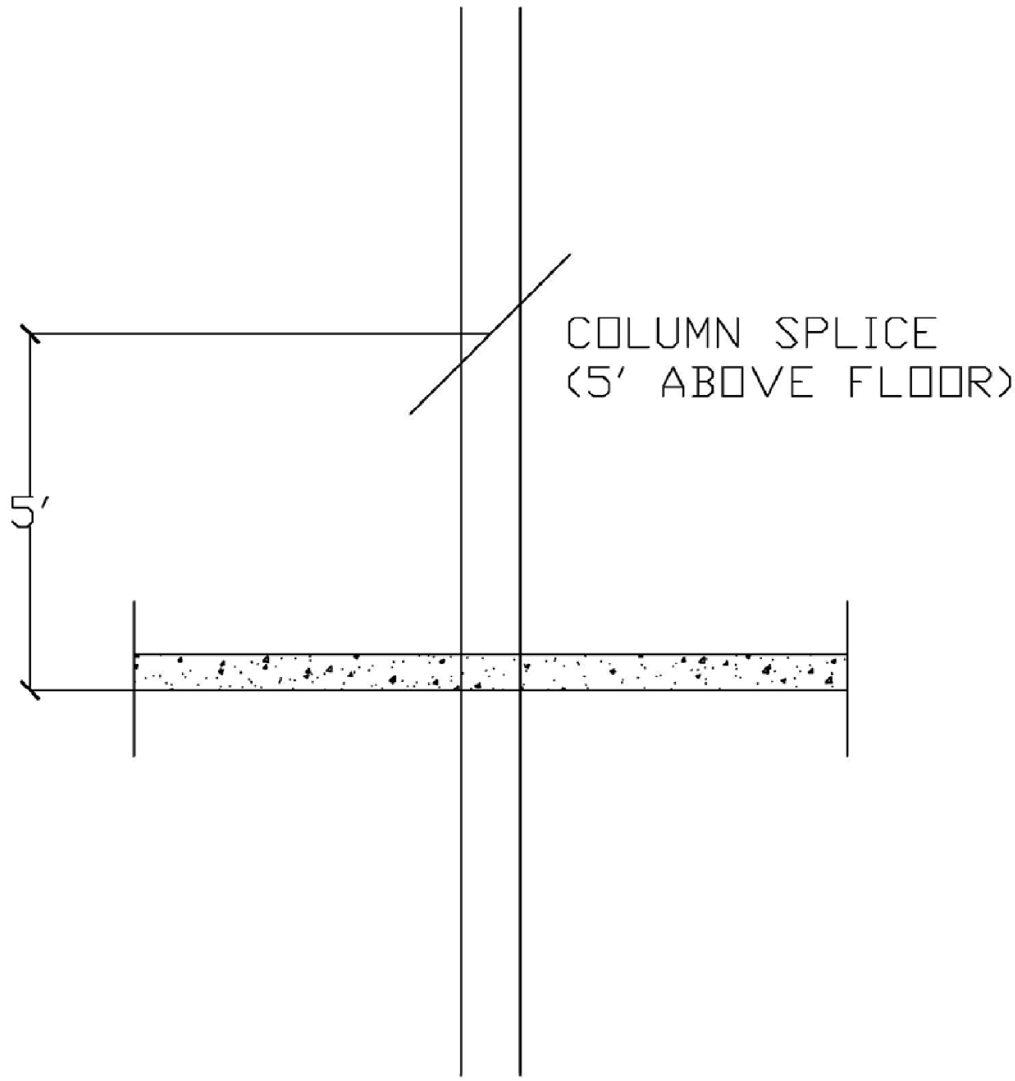


Figure 12 - Column Splice

The typical column with the new design will be a W10x54, similar to the worst case design of the original building. This may be due to the fact of a lighter floor system and a change in codes from ASD to LRFD. Some of the columns actually turned out to be slightly smaller, but it was decided to standardize them at W10x54 to lower the overall costs.

REDESIGN OF LATERAL SYSTEM

WIND

Wind originally wasn't the controlling load case with the existing building. Due to the buildings short and wide shape, along with poor soil conditions, seismic controlled in each direction. When the building gained height and reduced in thickness, the original controlling cases had to be rechecked. Wind was originally designed to give a base shear of 332 kips in for wind acting towards the long direction and 120 kips for wind acting towards the short direction, both of which turned out to be less than the seismic base shear. With the change in shape of the building, the loads where recalculated. The new wind forces were calculated to be 410 kips for wind acting in the long direction, and 157 kips for wind acting towards the short direction. The differences in these numbers are related to the amount of square footage of building façade the wind has to act on.

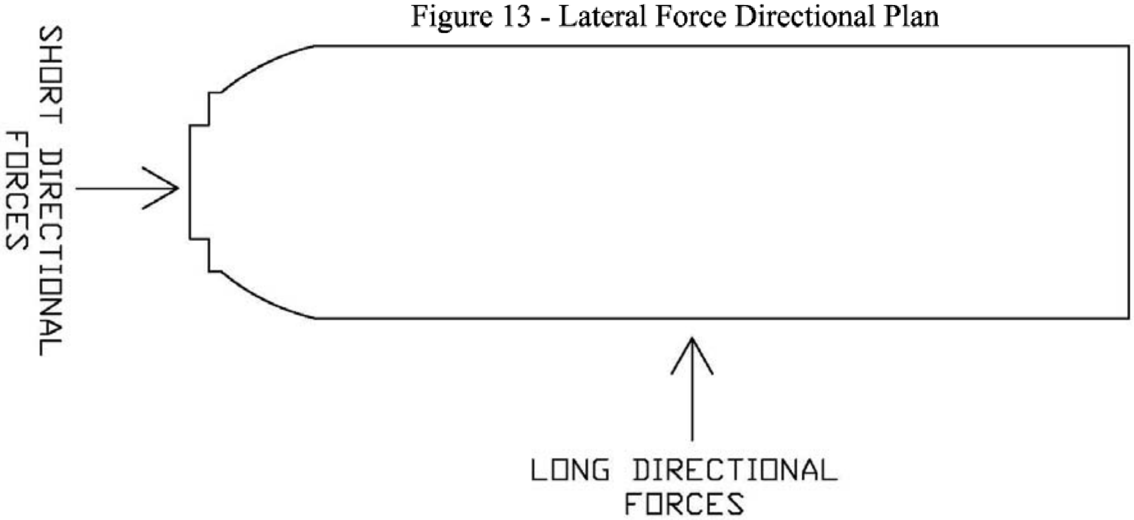
SEISMIC

EVALUATION CRITERIA

- Site Class D
- S_{DS} = 0.1632, S_{D1} = 0.080
- Seismic Design Cat: B
- R = 4.0
- T = 0.867 seconds
- C_S = 0.029
- W_F = 2200 kips / Floor
- W_{RF} = 1620 kips / Roof
- V = 302 kips

Seismic originally easily controlled in both directions with a base shear of 488 kips. With the buildings change in size to a thinner and taller building, along with the slight reduction in floor weight, and change in lateral resisting system, the new calculated base shear was 302 kips. This is significantly smaller than the previous shear force. With the new building design seismic no longer controls for forces acting in the long direction, but instead only controls the forces acting toward the short direction.

Figure 13 - Lateral Force Directional Plan



LATERAL FORCE COMPARISON

Both wind and seismic will have an effect on the buildings lateral system. Wind will be the controlling long directional force, and seismic will be the controlling short directional force. The reasoning for this can be related to the amount of square footage the wind force has to act on. The short direction is only 80 feet in width, compared to the long direction which is 270 feet in length. The total seismic base shear will ignore the dimensions of the building, and is strictly related to the buildings weight, which allows seismic forces to govern the design of the lateral resisting system resisting loads from the short directional forces. The difference in the pound per square foot wind forces is from the difference in effects from leeward wind forces. The leeward wind force grows with the length of the building in the respective directions.

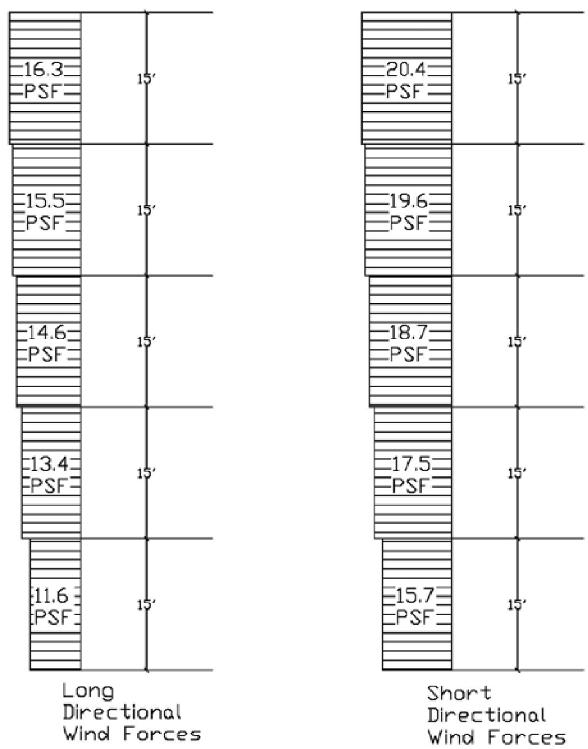


Figure 14 - Wind Force Diagram

LATERAL FORCE DISTRIBUTION

For wind design, the forces distributed to each floor are a combination of the force on the wall below and above the floor level. These are taken from the midpoint of the wall. For seismic the forces are taken from a combination of floor height about ground level, and the weight of the floor. After these loads are distributed to the floor level, they are then distributed to the ordinary reinforced masonry sheer walls based on stiffness of the respective walls. This is due to the concrete slab which lets the floor act like a rigid diaphragm. At the roof level the forces are distributed through tributary area, because it is assumed to act as a flexible diaphragm, since it is just steel decking. Along with direct shear forces, walls also receive a torsional shear force that can either raise or lower the total shear force in the wall, depending on the location of the sheer walls with respect to each other and the center of mass.

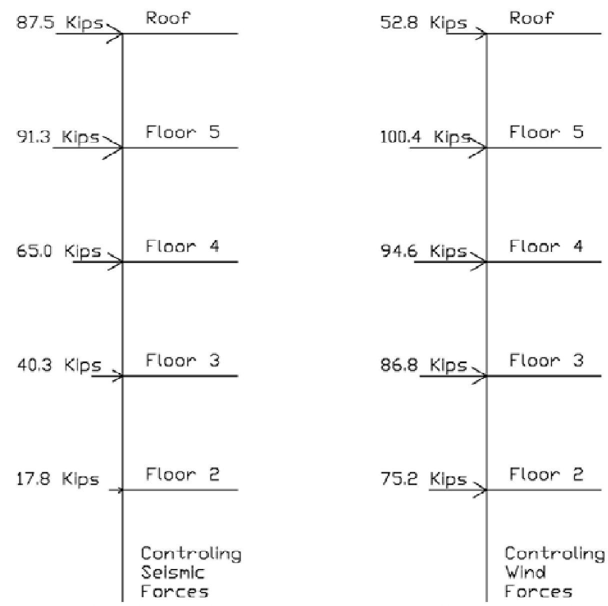


Figure 15 - Controling Lateral Force Floor Distributions

LATERAL RESISTING SYSTEM REDESIGN

The existing lateral force resisting system in the classroom wings was ordinary braced frames. The braced frames had a response modification coefficient, also known as an R-Value of 3.25. A switch to ordinary reinforced masonry shear walls will result in an R-Value of 4.0, which in turn will allow the seismic force taken on the building to be reduced. An ordinary reinforced masonry shear wall requires a minimum reinforcement spacing of 48 inches.

Main reasoning between the switch to masonry shear walls was an attempt to save money by using materials already present in the building. 8 inch CMU partitions are already found in the classroom wings, and it would be cost effective to take advantage of that. However, existing partitions are not full height, and generally stop approximately 4.5 feet below the next floor. Therefore, the only extra materials that will be needed are a few extra courses of CMU blocks, grout, and reinforcing steel. By extending the wall the full height, it also creates the ability to provide additional gravity load on the wall, which will in turn help resist the applied lateral forces.

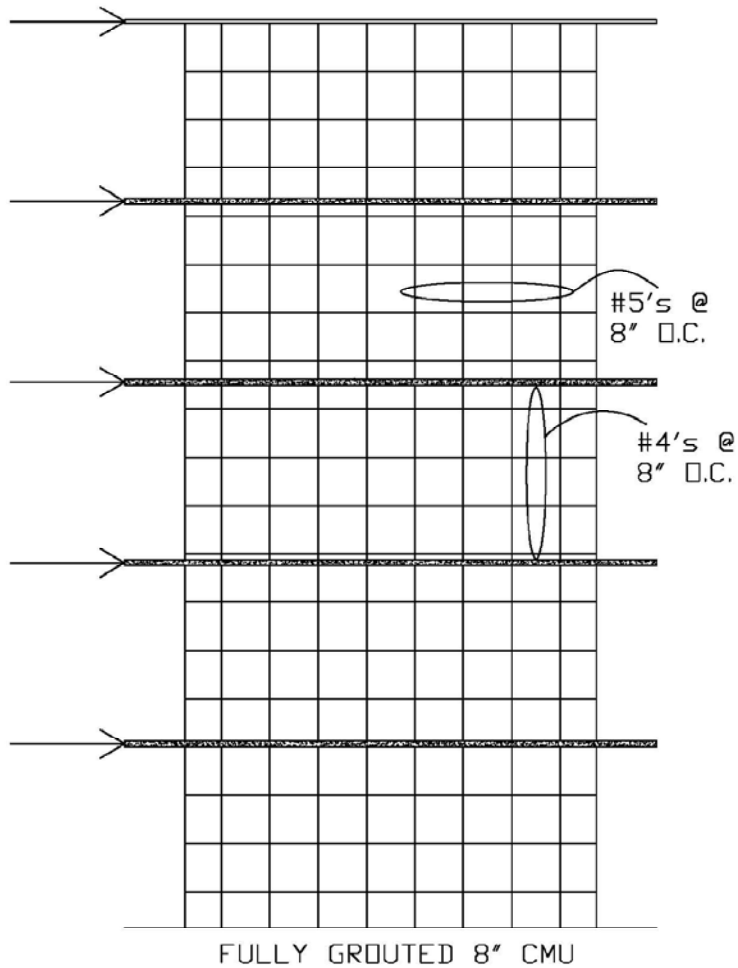


Figure 16 - Masonry Shear Wall

A spread sheet was created to make it possible to find the amount of reinforcing steel, and the resulting moment capacity of the 34 foot long shear wall. It was determined that when distributing the lateral load over 2 shear walls, while accounting for torsion, a fully grouted and reinforced shear wall would be required. Number 5 reinforcing bars where chosen to allow sufficient room to splice. Anything larger would cause problems for the contractor. The depth of the neutral axis, 'c', was calculated to be 73.024 inches. With (#5) vertical reinforcement, spaced 8 inches on center, the resulting moment capacity, ϕMn was calculated to be 121,120 inch kips. This was greater than the calculated moment load Mu of 107,838 inch kips. A calculated factored base shear of 205 kips was also calculated from the applied loading. To resist the base shear, (#4) reinforcing bars where chosen. When calculating the minimum required spacing, the effect of gravity was ignored. This is a conservative approach, and should generally be used when designing with masonry shear walls, as they have the tendency to crack. Minimum spacing was calculated to be 11.83 inches. However, since actual spacing of reinforcement in masonry walls must be in multiples of 8 inches, it was decided that #4 reinforcing bars spaced at 8 inches on center was acceptable to resist the shear loads.

The final shear wall design is fully grouted 8 inch CMU with #5 vertical reinforcement spaced at 8 inches on center, and #4 horizontal reinforcement spaced 8 inches on center. A total of two masonry shear walls in each direction are required to resist the lateral loads.

DRIFT CHECK

EVALUATION CRITERIA

- ΔShear = V*h / A*G
- ΔBending = $w*h^4 / 8E_mI_w$
- ΔTotal = ΔShear + ΔBending
- ΔAllowable = L / 400 = 2.25"

Drift was checked using a combination of shear and bending deflections. The total drift is the sum of the two. Each deflection was computed using fixed – fixed criteria. Area of the wall was taken as the walls length, multiplied by the walls width, because it is fully grouted. Moment of inertia of the wall, I_w was computed by taken by the equation $bh^3 / 12$, where b is the wall thickness and h is the wall length. The sum of the two deflections was 0.55 inches, which is far less than the required 2.25 inches.

REDESIGN OF EXTERIOR WALLS

The existing exterior curtain wall consisted oscillating 'window sections', and a 'column sections'. What are referred to as window sections, is a 14 foot span of exterior wall that contains the large windows. Above the windows are steel lintels that transfer the weight to the 'column sections'. The column sections consist of 8 inch CMU backing up 14 inch CMU, that then backs up the 4 inch face brick. Column sections are approximately 5 feet in length. A redesign was attempted to possibly make this exterior wall load bearing. Given the increase in height this would create a 75 foot high load bearing wall. As expected the wall fails to be able to resist any extra load bearing forces, and where just redesigned to resist components and cladding wind forces, and self weights.

The 14” CMU was able to remain un-grouted with the use of fully bedded masonry. However, the 8” CMU was required to be fully grouted with reinforcement spaced 16” on center. This is up from 8” CMU grouted and reinforced at 48” on center.

REDESIGN OF TYPICAL FOUNDATIONS

Since the change in height on the building related to a change in loads on the footings, they required a structural redesign. The Geopier system to increase the poor soil conditions was left unchanged, as it is the most efficient system for this job.

GEOPIER SOIL REINFORCEMENT

THE GEOPIER RAMMED AGGREGATE PIER SOIL REINFORCEMENT SYSTEM

- Drill a cavity to depths ranging from 7 to 30 feet deep.
- Place a 12-inch layer of open-graded aggregate at the bottom of the cavity.
- Compact the aggregate using a tamper that delivers a high-energy impact ramming action.
- The ramming action compacts the aggregate and pre-stresses the surrounding soil. Successive lifts of well-graded aggregate are then rammed in place.

Geopier ‘RAP’ Systems are intermediate foundation systems, constructed by densely compacting successive thin lifts of high quality crushed rock in a 2 to 3 foot cavity of varying depth using ramming equipment. The vertical ramming action increases the lateral stress and improves the soils surrounding the cavity, which results in foundation settlement control and greater bearing pressures for design.

RAP Systems can be installed using replacement or displacement methods, depending on site requirements. The installation process utilizes vertical impact ramming energy, resulting in extra strength and stiffness. RAP Systems are used to reinforce good to poor soils, including soft to stiff clay and silt, loose to dense sand, organic silt and peat, variable, uncontrolled fill and soils below the ground water table.

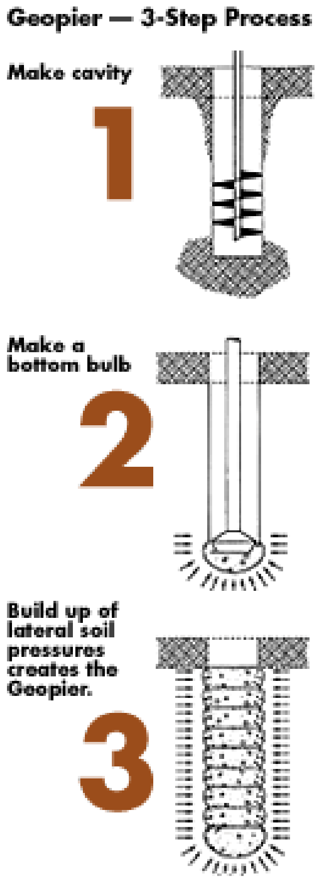


Figure 17 - Geopier Reinforcement

Geopier 'RAP' soil reinforcing is still the suggested form of reinforcement. The old TC Williams High school was still holding classes while the new school was under construction. The amount of noise and vibrations caused from installation would be critical to control. This Geopier process is excellent at creating minimal vibrations and noise, and therefore perfect for this environment. Additionally poor soil conditions, consisted of fill including clay, silt and gravel to depths ranging from 2 to 29 feet below the ground surface. The fill was underlain by native gravel, sand sandy silt, and clay. Groundwater was then encountered at 15 feet below the surface.

Deep foundations such as auger cast piles, pre-cast concrete piles and timber piles were initially considered, but the Geopier 'RAP' system was selected because it offered the most cost-efficient solution without compromising integrity. The savings were estimated at around 20%. More than 1,700 'RAP's were installed to reinforce the existing fill and support the shallow foundations.

FOOTINGS

Foundations were redesigned to account for the addition loads from the columns, exterior walls, and lateral resisting shear walls. Original spread footings for the columns were sized 6 feet by 6 feet and 7 feet by 7 feet by 1 foot 4 inches thick. They are reinforced by #6 and #7 bars respectively, at 12 inches on center. Typical strip footings were designed at 5 feet wide by 1 foot 4 inches deep. They are reinforced with #6 bars at 12 inches on center. All footings are 3,000 psi normal weight concrete.

The typical spread footing was redesigned to be 8 feet by 8 feet and 18 inches deep, with #5 reinforcing bars spaced 8 inches on center in each direction. An allowable soil bearing capacity of 6,000 PSF was used, along with 3,000 psi normal weight concrete. A 24 inch by 24 inch steel base plate was chosen to connect the column to the footing. The factored load from the column was calculated to be 406 kips. Wide beam shear was the controlling factor in the design of the spread footings.

The typical strip footing was redesigned to be 5 feet wide and 12 inches deep. The loads on the strip footings are just the self weight of the wall, which is approximately 14.325 KLF, factored. With an allowable soil bearing capacity of 6000 PSF, the minimum required width was 2.4 feet, but in order to keep the load of the oscillating wall in the kern, a width of 5 feet was chosen. Wide beam shear was found to control in the design, and the minimum reinforcement was found to be #5 bars spaced 12 inches on center. This also satisfies the minimum shrinkage and temperature reinforcement.

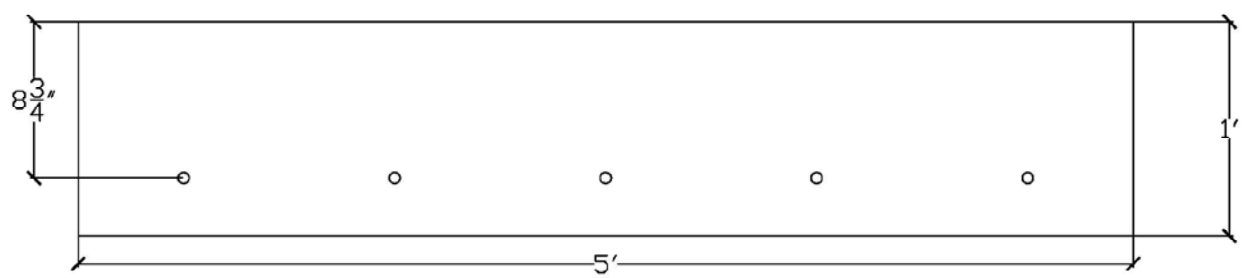


Figure 18 - Strip Footing

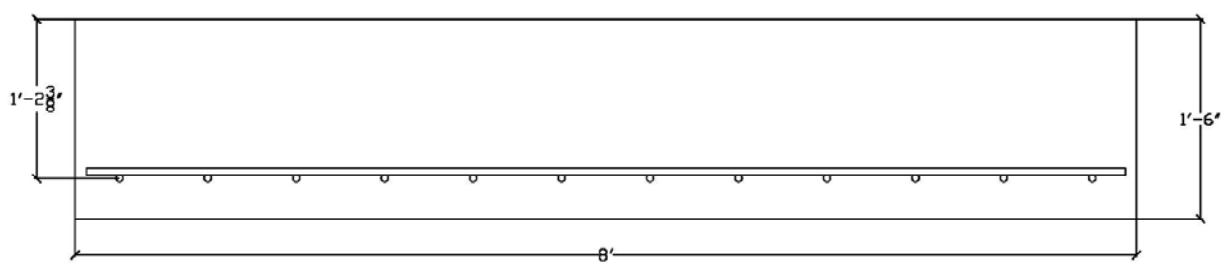


Figure 19 - Spread Footing

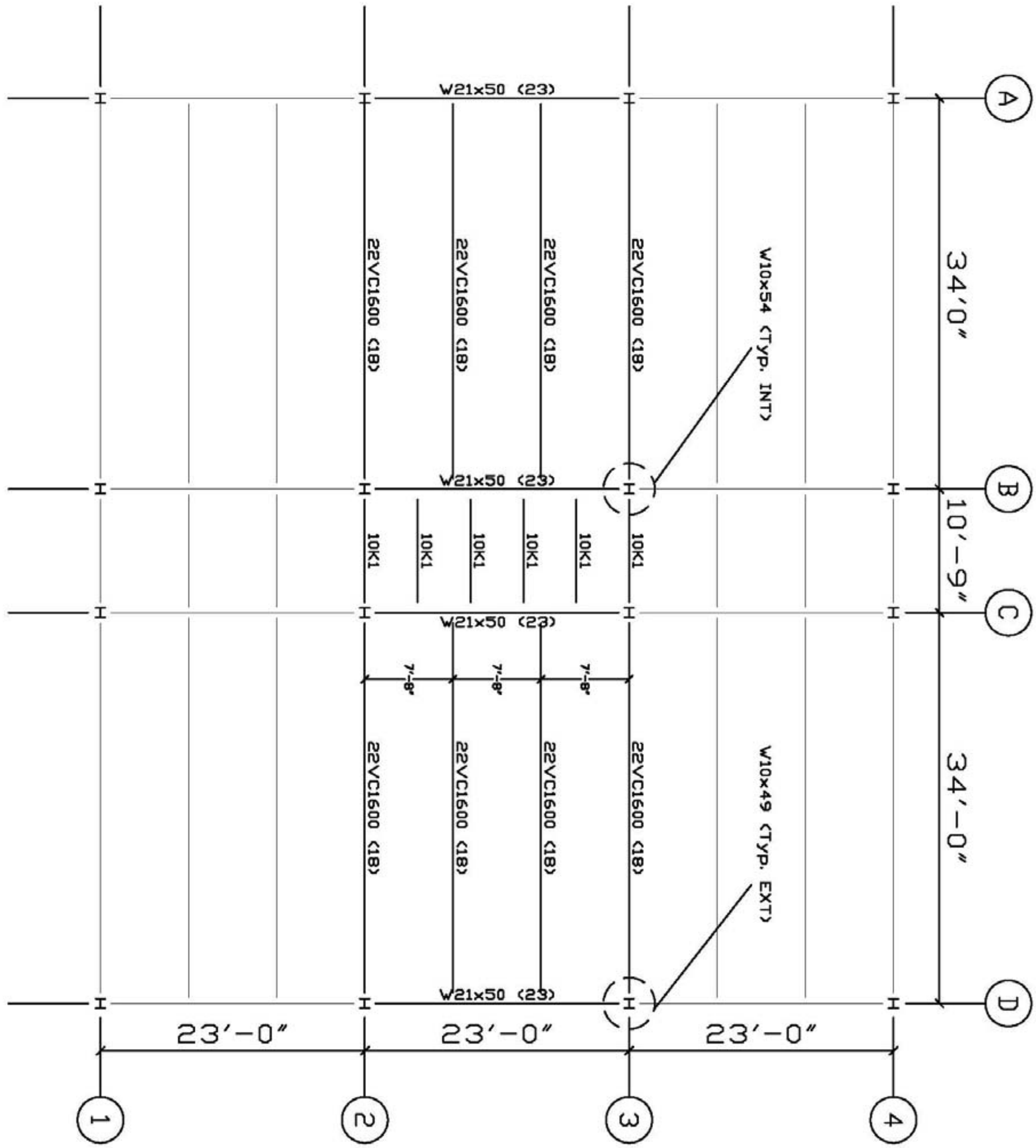


Figure 20 - New Structure Typical Bay Plan

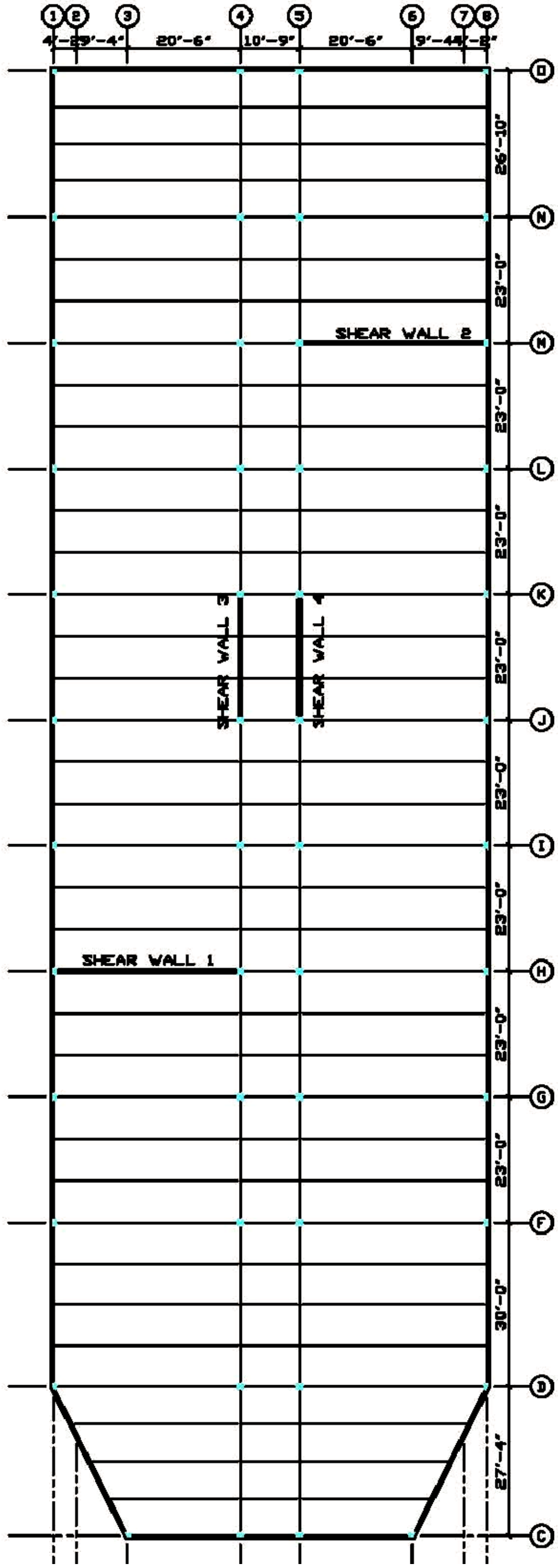


Figure 21 - New Structure Typical Floor Plan

ARCHITECTURAL BREADTH

An architectural study will be undertaken, evaluating the effects of adding two additional stories. Adding stories will have an effect on the previously designed architectural design, and considerations will need to be made to best account for the additional stories. Adding height and possibly a small amount of volume will impact the MEP sizes, locations, and main distribution ducts, as well as impact the floor plan for column sizes.

FLOOR PLANS

With the addition of two floors to the building, the architectural floor plans would obviously have to change. During the redesign of the plans, special consideration was made to keep certain groups of rooms together. For instance, all faculty offices, and guidance centers were kept towards the lower half of the classroom wings, on the first 3 floors. Other rooms such as the television studio, was kept close to the television production, workroom, and editing rooms. Normal classrooms are located on the third floor and up. In order to account for proper egress, stairways remained in their normal positioning. The restrooms were also stacked for ease of construction and simplicity.

Another design consideration was the stacking of shear walls. It's critical that at least two or three walls stack all the way up the building. These walls will be used to resist the lateral forces on the building.

ROOF PLAN

With the classroom wings getting thinner, a problem with the mechanical systems on the roof arises. Originally these mechanical systems were hidden from site, and were placed in between the two clearstories on the roof. The clearstories used to each reside over the two corridors. When the building was made thinner, one corridor was removed, and with it, one clearstory. Without any further changes, these mechanical systems would be visible from the ground. It was decided to create a new roof system that would hide the mechanical systems from site, from ground level. A sloped roof was designed to cover up the mechanical systems. On the roof is a standing seam metal roof that will match the other standing seam roofs on the front of the classroom wings.

These roof plan strips show the general layout of the clearstories to the mechanical systems. There is five feet of walking space between the mechanical systems and its adjacent obstacles. A section was also created to better show the relationship with the new roof.

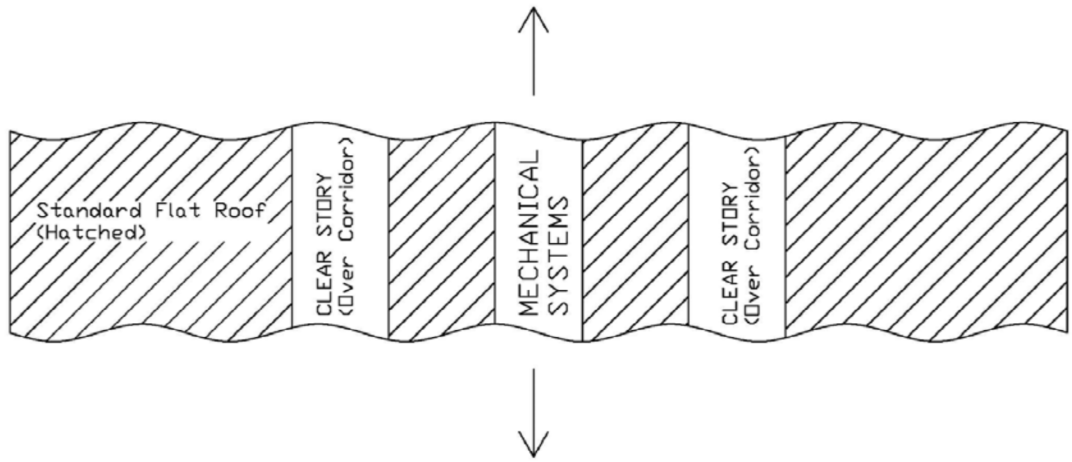


Figure 5 - Existing Roof Plan Strip

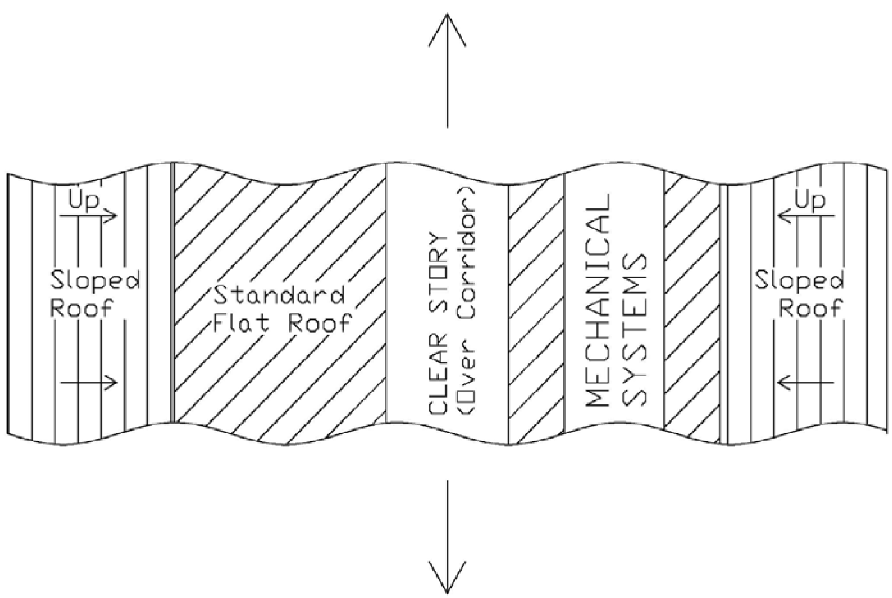


Figure 6 - New Designed Roof Plan Strip

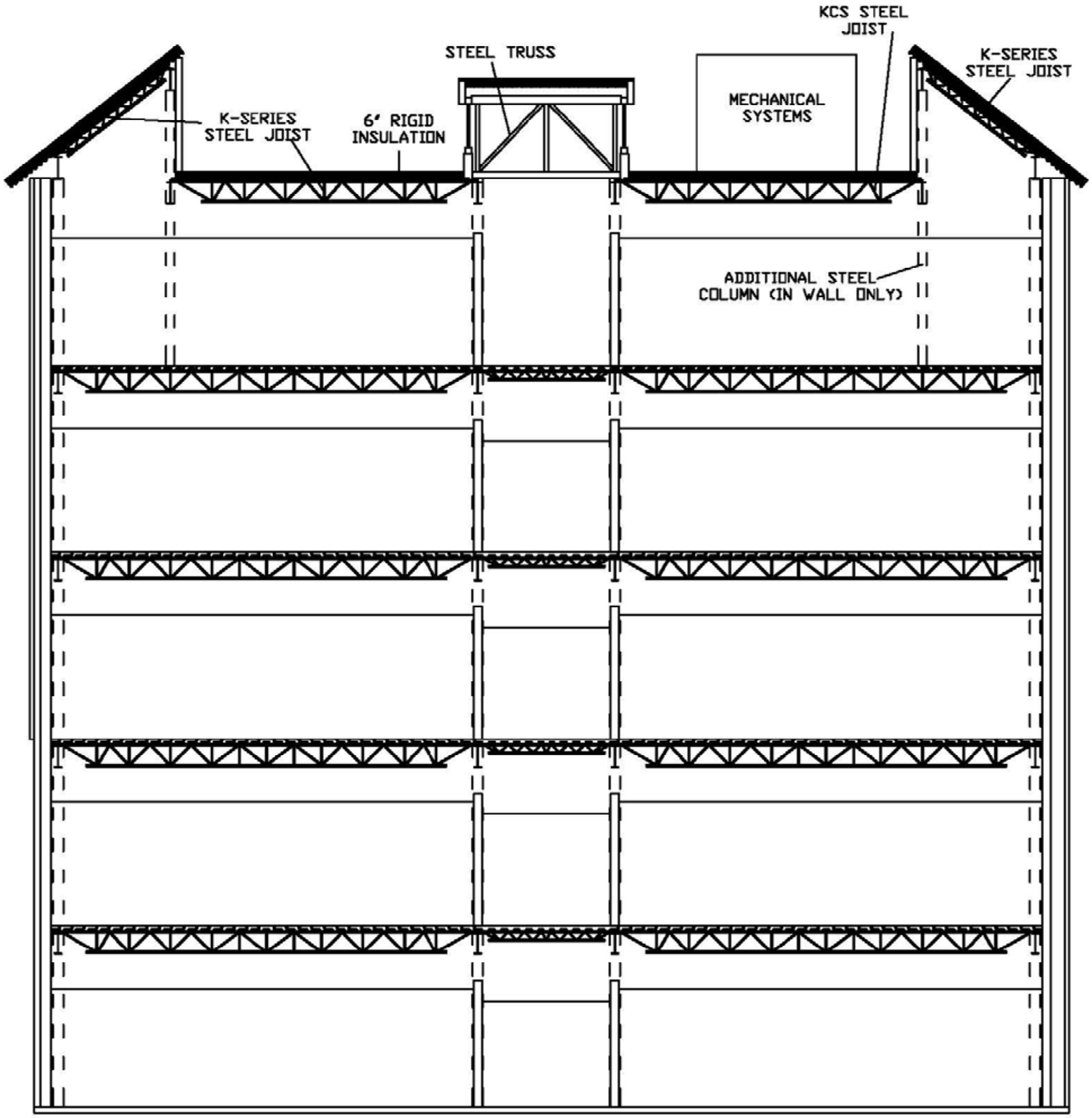


Figure 22 - Architectural Section Cut

STRUCTURAL SIZES

Also seen in the section is the relation of the structural elements to the ceiling height. In all cases, special attention was paid to the depth of the structural joists. It was decided that the joists depth would not exceed that of the original girder depth. After setting the minimum joist depth I went back and made sure the mechanical equipment had enough room to clear under the joists. Further investigation may allow the mechanical equipment to pass through the steel joists, which would actually allow a decrease in floor to floor height. However without that further investigation it is uncertain whether this would be the case or not.

The structural steel W-Shaped columns, found in the classroom wings were kept 10 inches wide to match the existing columns, and placement did not change. Additionally, the additional columns added to support the new roofing system are all found in interior partitions, so they do not affect the current floor plan.

ADDITIONAL ARCHITECTURAL FEATURES

Considering the school as a whole, there were originally 70% of rooms with an outside view. Just considering the classroom wings of the building, only 67% of these rooms had an outside view. However with the redesign, 91% of these rooms will receive natural light. This is a significant increase, and large advantage of a redesign.

The exterior façade will not change, except for its height. The additional 30 feet of height will be the same window to wall pattern as the wall below it. The building was also inspected for massing purposes, to see how the new shape would affect the rest of the building.

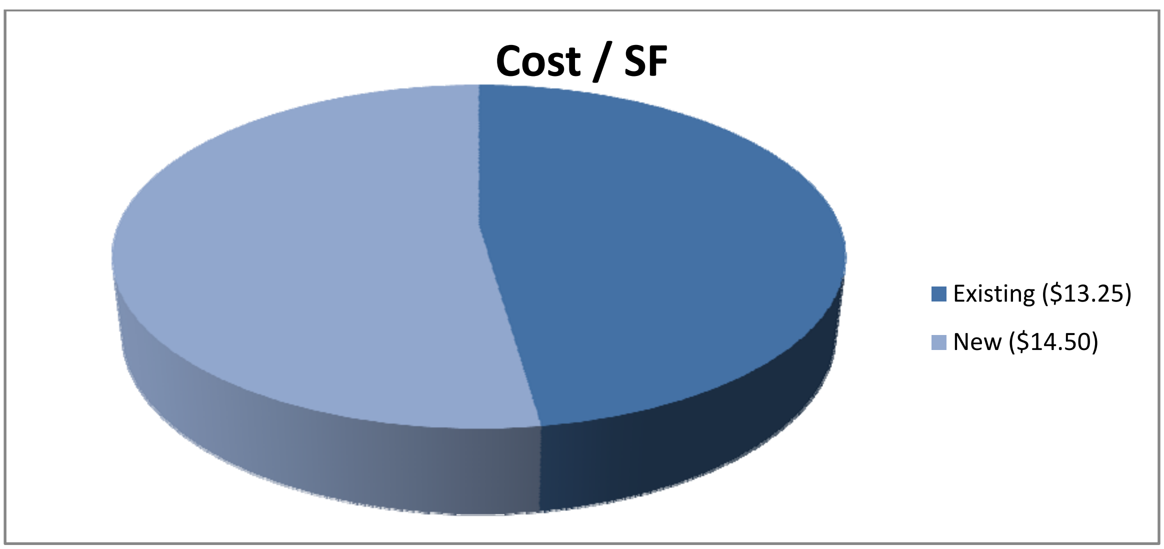
CONSTRUCTION MANAGEMENT BREADTH

A Construction Management study will examine a cost analysis and the schedule impact between the existing and alternative structural systems. Both buildings will be assumed to be the same square footage, (approximately 108,000 SF), but the existing building will only be 3 stories in height, and the new building will be 5 stories in height. With the addition of two stories, cost would be much more of an impact on the redesign than what it was with the original design. RS Means and Microsoft Project will be the primary tools used in the new scheduling and design process in order to minimize costs as best as possible.

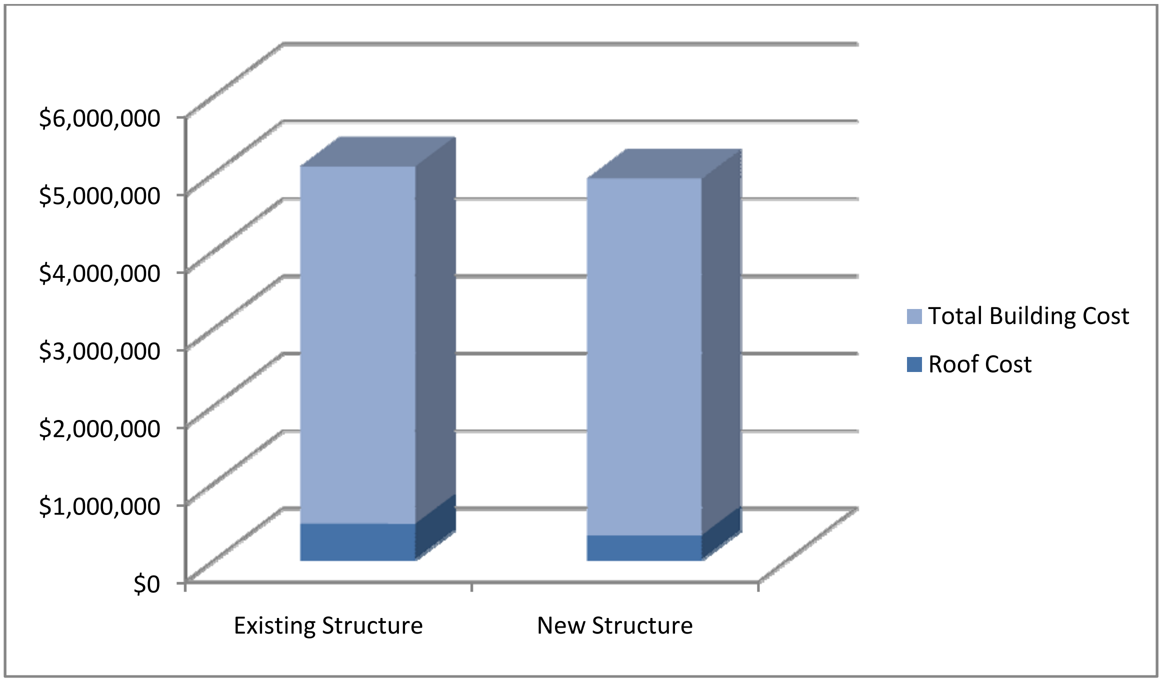
COST IMPACTS

ROOF SYSTEM

In order to satisfy an architectural requirement, the roof system needed to be redone. With a more complicated roof system, comes a higher cost. Sizes were optimized as much as possible to keep costs down, but with the addition extra columns and girders, costs / square foot are expected to rise. The total calculated cost using RS Means of the existing structural roof system was $463,568, which is approximately $13.25 / SF. The total calculated cost using RS Means of the new structural roof system was $313,061, which is approximately $14.50 / SF. This is a total difference of $1.25 / SF. Considering the roof is such a small part of the overall cost of the structure, this may turn out to be negligible.

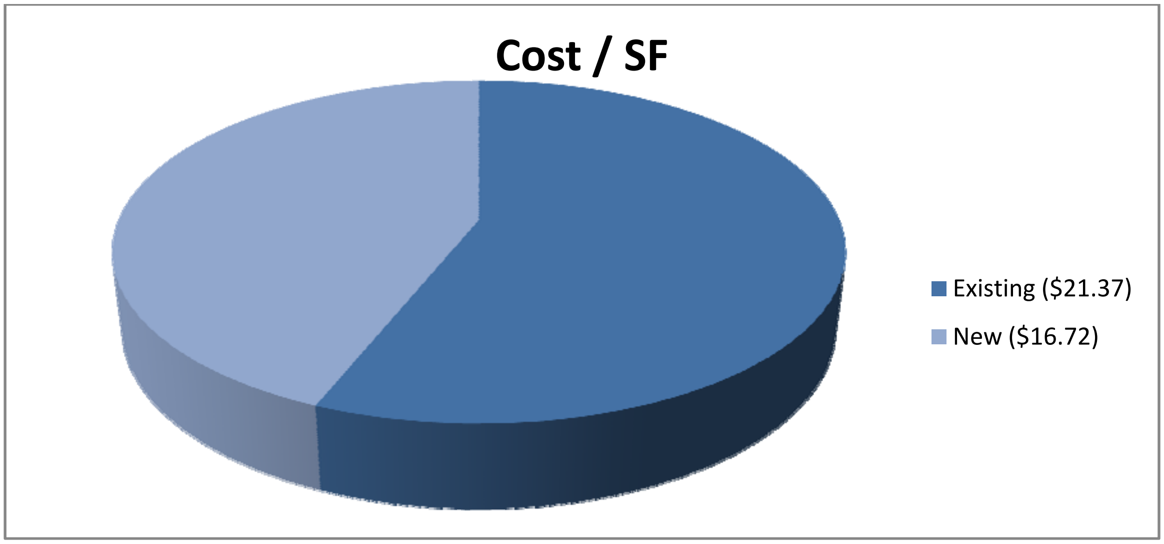


Roof - % Cost of Whole Structure

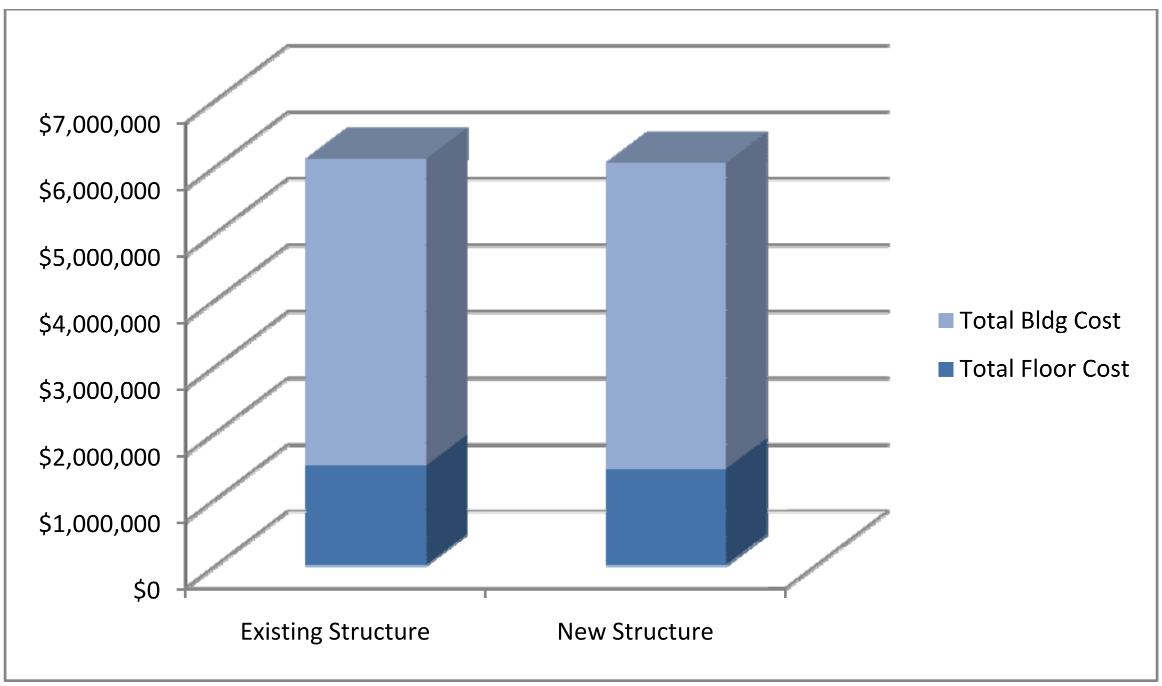


FLOOR SYSTEM

In an attempt to reduce the cost per square foot of the floor system, a composite joist system was chosen. A joist system was chosen to try and limit the slab thickness, and composite action was chosen to limit the number of joists required and thereby reducing the cost of fireproofing. However, vibration issues forced the use of larger joist and girder sizes, raising the cost of the new system. Using RS Means the existing floor system was calculated to cost $748,000 per floor, or $1,496,000 for the total floor cost. The new floor system, using RS Means, was calculated to cost $361,100 per floor, or $1,444,500 for the total floor cost of the building. Cost per square foot of the existing system was computed to be approximately $21.37 per square foot, compared to the new system which was computed to cost approximately $16.72 per square foot. The difference is nearly $4.65 per square foot, but with the increase of overall floor area above grade, the total costs of the floor systems are about even.

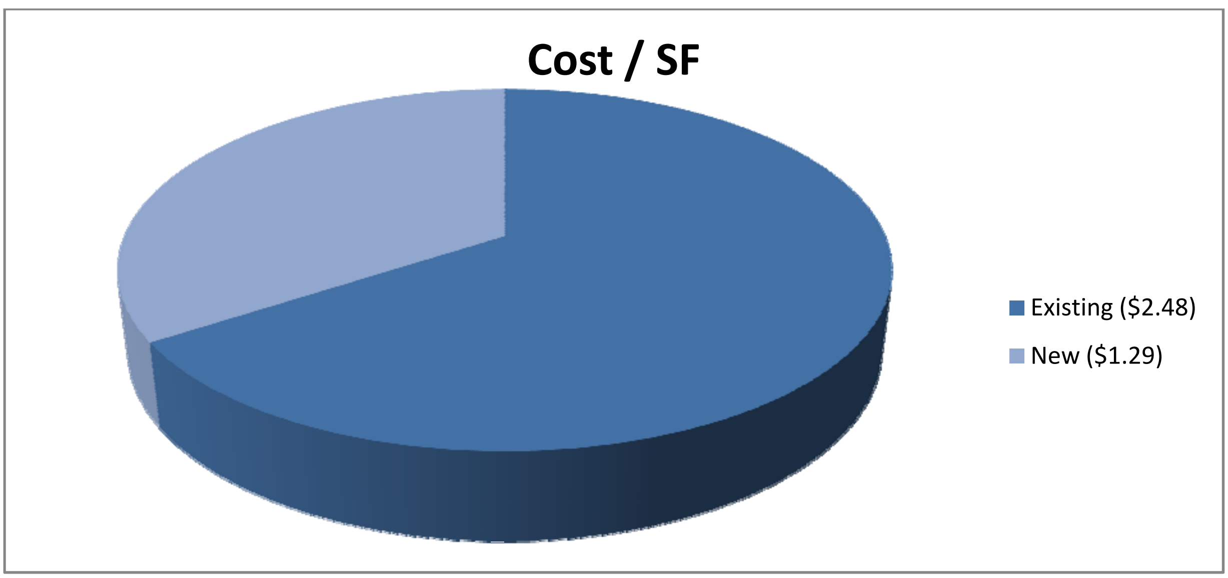


Floor - % Cost of Whole Structure

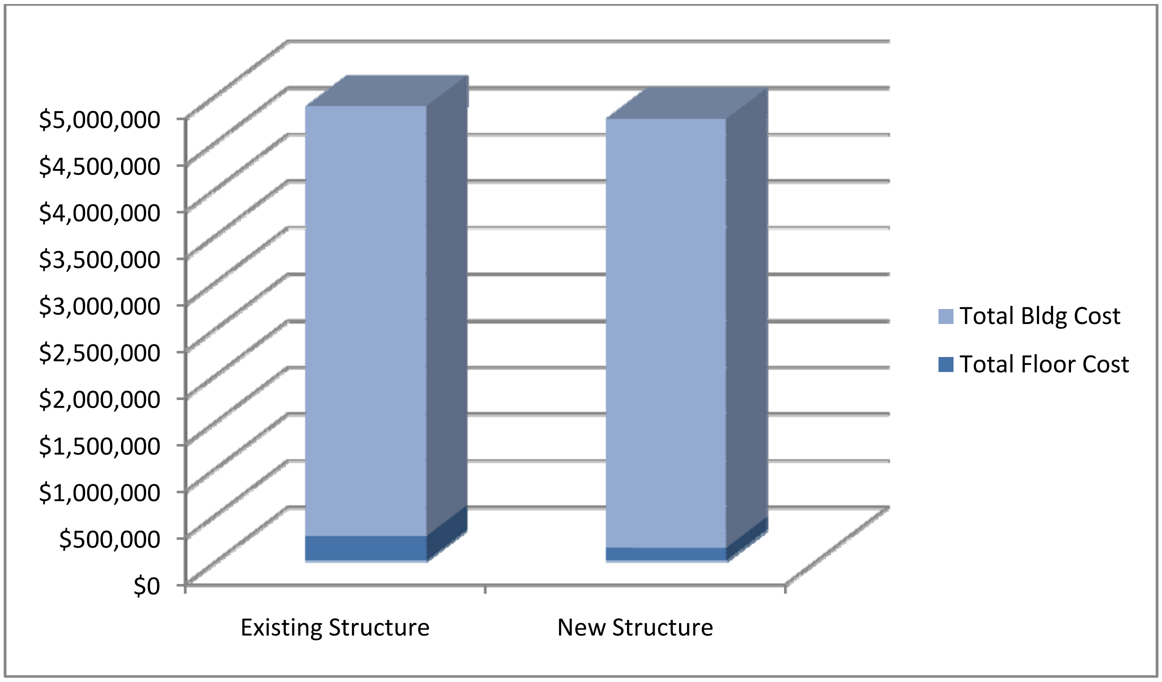


LATERAL RESISTING SYSTEM

In an attempt to use a material already present as a partition, masonry shear walls were chosen as the material of choice for the redesign of the lateral force resisting system. These will replace the steel braced frames, which required a total of 4 in each direction, and will aim to reducing the cost of the structure. It was determined that 2 reinforced masonry shear walls in each direction was the minimum number to resist the required loads. RS Means was used to calculate the both systems. The existing system was found to cost $267,500, which is approximately $2.48 per square foot of the buildings floor area. The new system was found to cost $139,510, which is approximately $1.29 per square foot of the buildings floor area. These equate to approximately a $1.19 difference in cost per square foot. This is significant cost savings for a lateral resisting system.

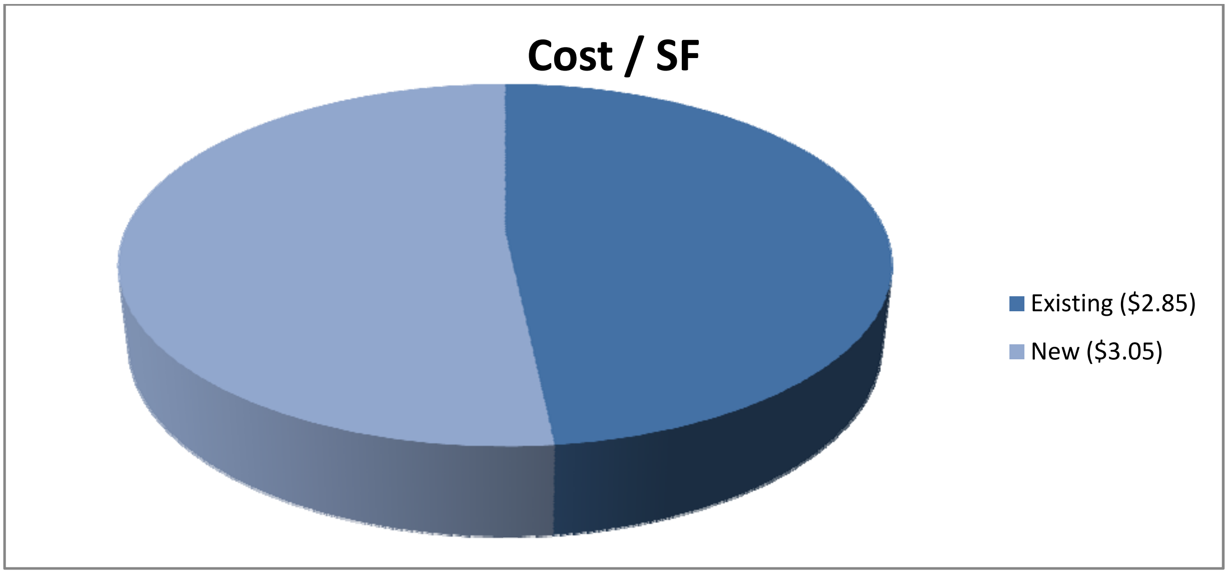


Lateral System - % Cost of Whole Structure

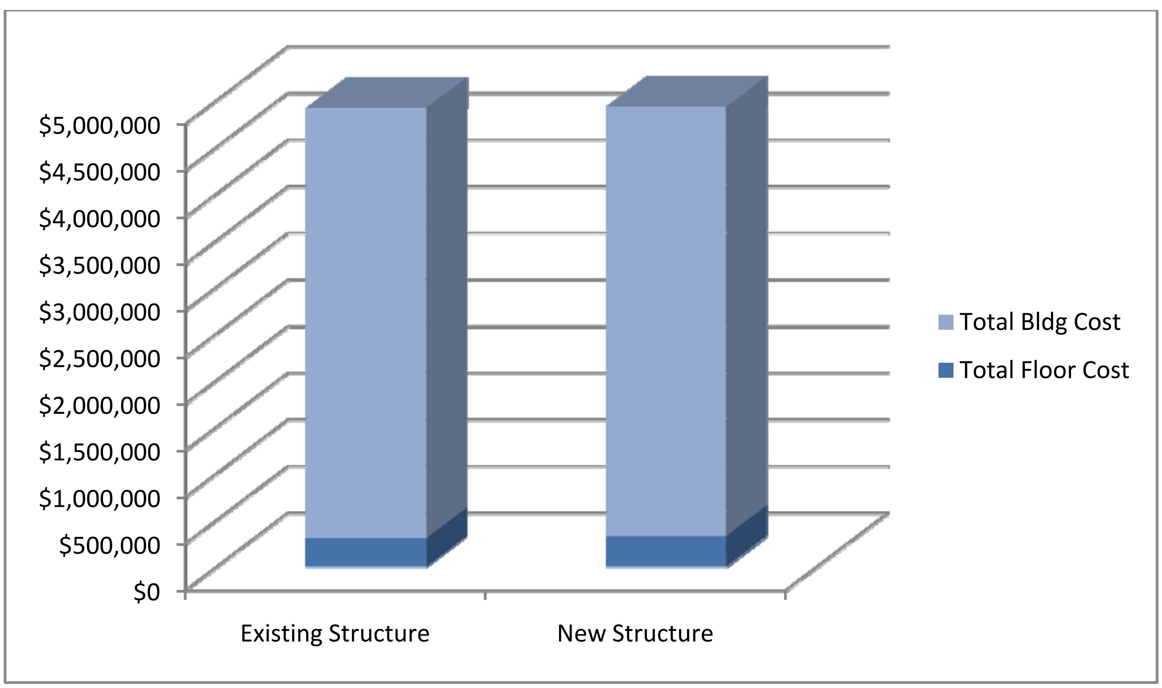


COLUMNS

With the increase in building height from 45 feet to 75 feet, the columns are expected to change. A 5 story column is also unheard of so they will need to be spliced. The splice will be taken about 5 feet above the third floor, for both ease of construction and reduction of moment. A total cost of a splice is equivalent to about 500 pounds of steel or $750 dollars. With both the increase of column sizes, along with splices, the cost per column will rise, however with a smaller building footprint; fewer columns will be needed to support the structure. The total cost of columns for the existing system, using RS Means, was calculated to cost $307,820, which equates to approximately $2.85 per square foot of building floor area. The total cost of columns for the new structural system, using RS Means, was calculated to cost $329,160, which equates to approximately $3.05 per square foot of building floor area. This difference is approximately $0.20 per square foot, and is very minimal.

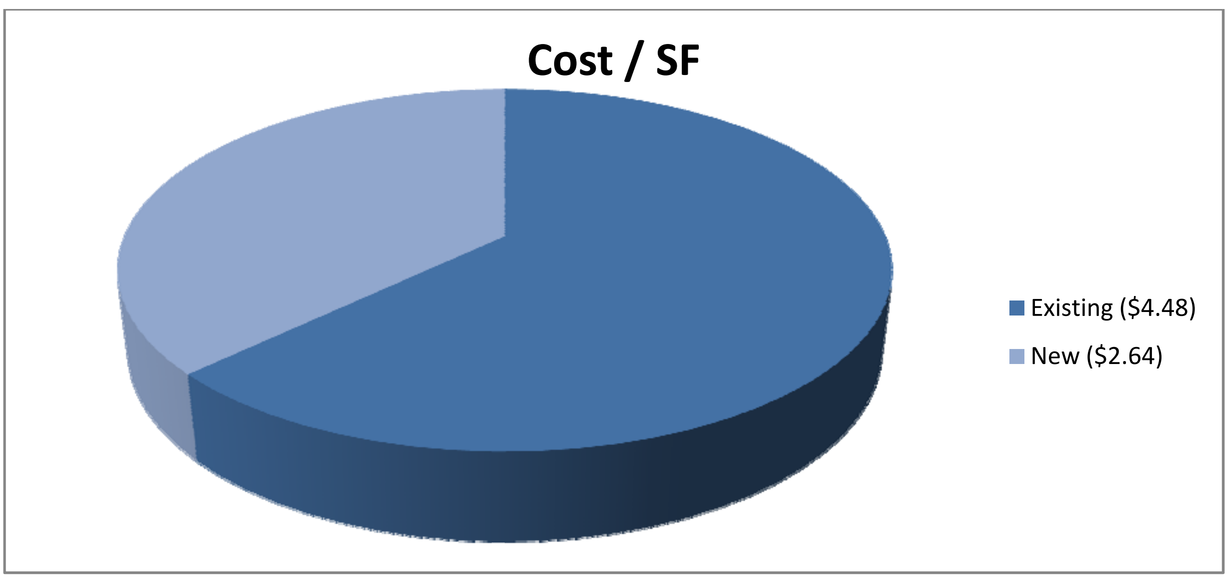


Columns - % Cost of Whole Structure

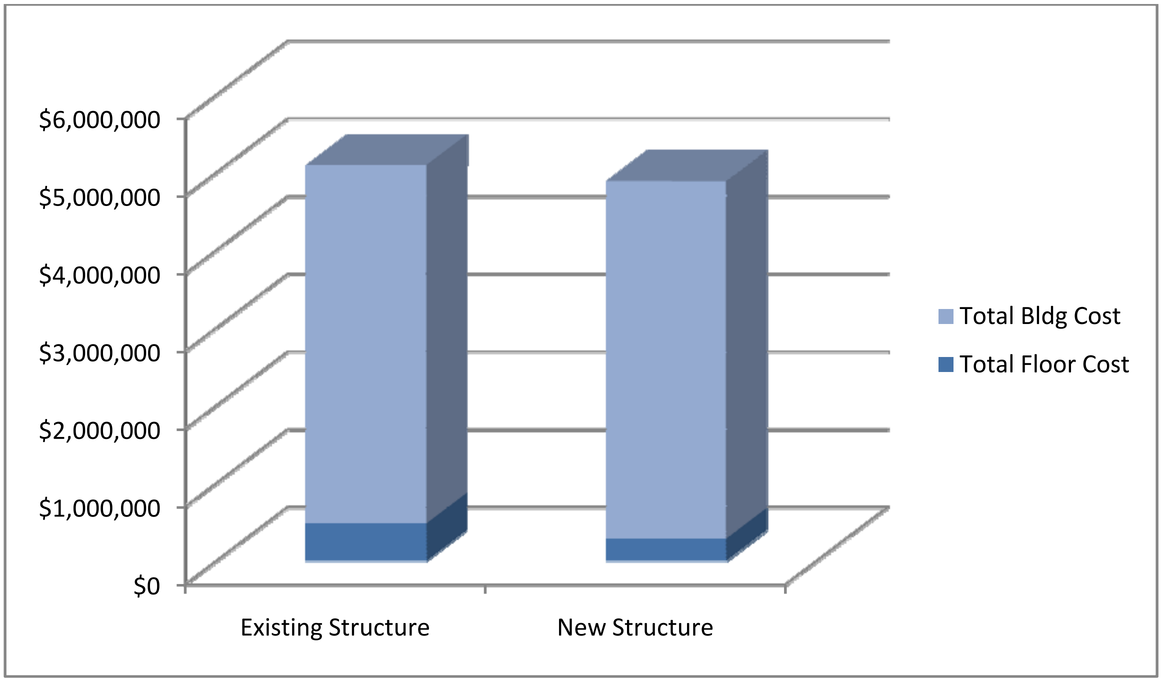


FOUNDATIONS

Geopier's 'Rammed Aggregate Pier' soil reinforcement system was used to create a soil bearing capacity of 6 KSF. The number of piers required for the existing structure was calculated to be around 425 – 12 foot deep piers, compared to the new structure which was calculated to require around 234 – 12 foot deep piers. Total increase in footing sizes turned out to be pretty minimal. The existing foundation and slab on grade system was calculated using RS Means to cost $484,120, which is about $12.57 per square foot of ground area, and $4.48 per square foot of building area. The new foundation and slab on grade system was calculated using RS Means to cost $285,466, which is about $13.22 per square foot of ground area, and $2.64 per square foot of building area. This was expected as the cost of the building footprint shrunk, reducing the overall cost of a foundation system. A difference of $1.84 per square foot of building floor area was saved.

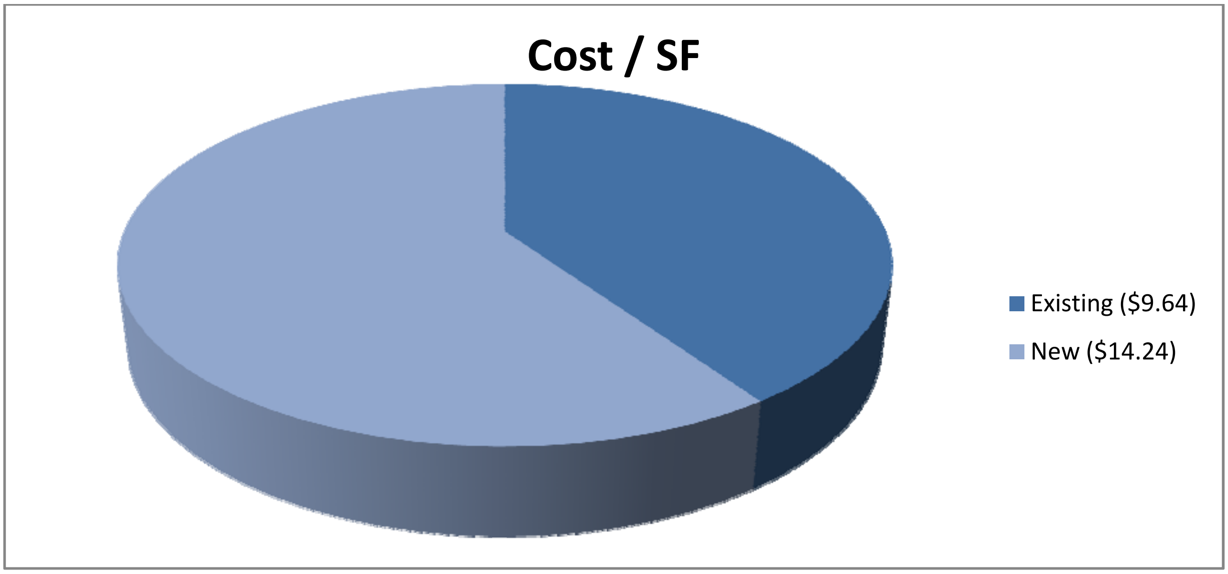


Foundations - % Cost of Whole Structure

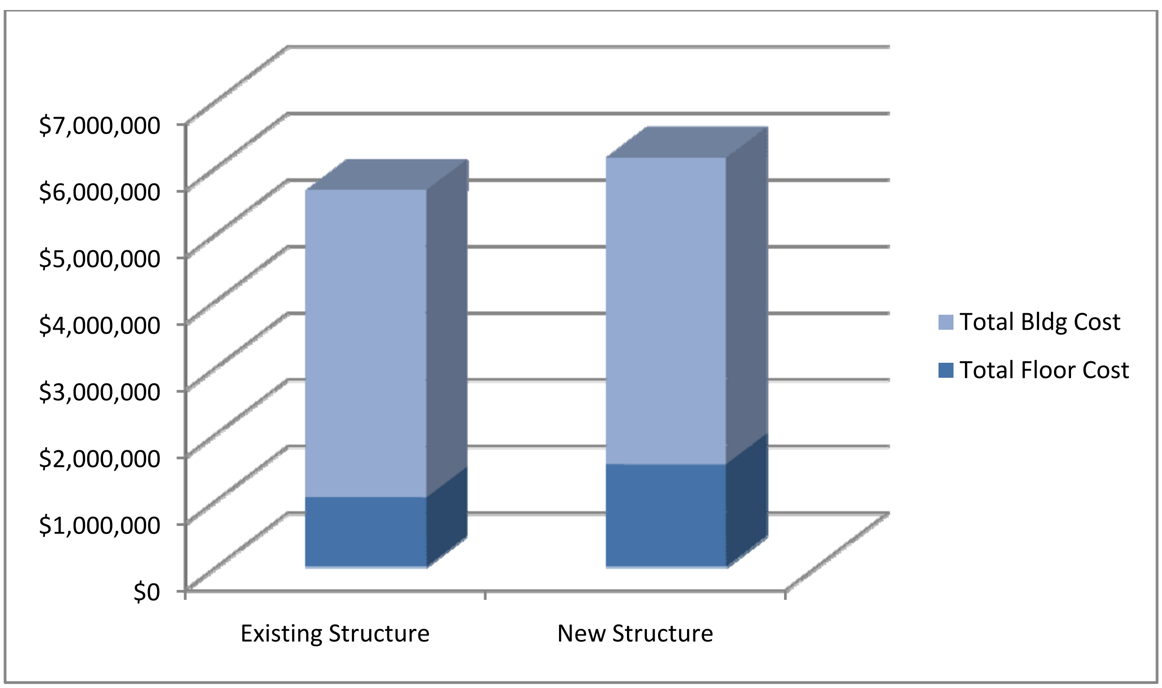


EXTERIOR WALL

With the decrease of the building footprint, and the increase of the buildings height, the overall square footage of the exterior wall was expected to change. The building materials were summed up as best as possible through the use of architectural elevations. The existing wall was calculated to cost $1,041,200, which is approximately $9.64 per square foot of building area. The new wall system was calculated to cost $1,538,300, which is approximately $14.24 per square foot of building area. This is a relatively large difference of $4.60 per square foot of floor area. Interior partitions turned out to be about the same amount of square footage, and totaled about $556,000.



Exterior Wall - % Cost of Whole Structure



NEW PROPOSED STRUCTURAL SYSTEM COST COMPARISONS

- STRUCTURAL ROOF SYSTEM
  - COST / SF ROOF AREA (+)1.25
  - COST / SF TOTAL BLDG AREA **(-)1.39**
- STRUCTURAL FLOOR SYSTEM
  - COST / SF FLOOR AREA (-4.65)
  - COST / SF TOTAL BLDG AREA **(-)0.48**
- LATERAL FORCE RESISTING SYSTEM
  - COST / SF TOTAL BLDG AREA **(-)1.19**
- COLUMNS
  - COST / SF TOTAL BLDG AREA **(+)0.20**
- FOUNDATIONS
  - COST / SF FOUNDATION AREA (+)0.65
  - COST / SF TOTAL BLDG AREA **(-)1.84**
- EXTERIOR WALLS
  - COST / SF TOTAL BLDG AREA **(+)4.60**
- INTERIOR PARTITION MASONRY
  - COST / SF TOTAL BLDG AREA **(~)0.00**

SCHEDULING IMPACTS

Both schedules start on July 02, 2004. The existing buildings schedule, using information from RS Means, was planned to finish on November 08, 2005. The new redesigned building schedule was planned to finish on November 25, 2005. This is a difference of about 2.5 weeks. The original thought was to reduce the amount of time spent on the foundation work, to decrease the total buildings schedule. In fact it is estimated that construction may begin 2.5 months earlier with the reduction in foundation work. However the main reasoning for prolonging construction with the new building schedule, is the masonry shear walls. The shear walls where a major factor in saving money, but construction couldn't be completed on the floor above the shear wall until the wall was completed, leading to much down time. Composite joists were able to be constructed twice as fast compared to the beams. However, the difference in time savings between joists and beams is pretty much negligible when compared to that of the whole schedule. If 2.5 weeks of scheduling is thought to be a problem on a project of this scale, then it would be recommended to stick with the braced frames.

APPENDICES

APPENDIX A – CONSTRUCTION MANAGEMENT

EXISTING COSTS SPREADSHEET

System	Component	Crew	Daily Output	Labor Hours	Units	No. Units	Material	Labor	Equip	Cost / Unit	Cost + O&P/Unit	**Total Cost**
Roof	Joist - 10K1	E-7	1200	0.067	LF	440	$3.78	$2.83	$1.53	$8.14	$10.80	**$4,752**
	Joist - 24k6	E-7	2200.00	0.036	LF	4,225	$7.20	$1.54	$0.83	$9.57	$11.50	**$48,588**
	Joist - 24KCS5	E-7	1800.00	0.045	LF	1,122	$15.80	$1.54	$0.83	$18.17	$21.80	**$24,460**
	Deck - 1.5" 22 GA	E-4	4900.00	0.007	SF	29,580	$1.25	$0.28	$0.03	$1.56	$1.92	**$56,794**
	Deck - 3" 18-GA	E-4	2850.00	0.011	SF	6,380	$2.29	$0.49	$0.05	$2.83	$3.45	**$22,011**
	Truss	-	-	-	Truss	20	-	-	-	-	$1,925	**$38,500**
	Beam - W16x26	E-2	1000.00	0.056	LF	1,715	$31.50	$2.34	$1.57	$35.41	$40.50	**$69,458**
	Girder - W21x44	E-5	1064.00	0.075	LF	1,334	$53.00	$3.19	$1.60	$57.79	$66.00	**$88,044**
	Fireproofing Joist	G-2	1200.00	0.019	SF	22,121	$0.47	$0.65	$0.08	$1.20	$1.54	**$34,066**
	Fireproofing Girder	G-2	1500.00	0.016	SF	9,242	$0.47	$0.51	$0.08	$1.06	$1.39	**$12,846**
	Fireproofing Deck	G-2	1250.00	0.019	SF	35,000	$0.71	$0.62	$0.10	$1.43	$1.83	**$64,050**
Floor	C-Beam - W18x35	E-5	960.00	0.083	LF	4,250	$42.50	$3.53	$1.77	$47.80	$54.50	**$231,625**
	C-Deck 1.5" 18-GA	E-4	3400.00	0.009	SF	35,000	$2.66	$0.41	$0.04	$3.11	$3.70	**$129,500**
	Beam - W12x14	E-2	880.00	0.064	LF	902	$16.95	$2.66	$1.78	$21.39	$25.00	**$22,550**
	Shear Studs	-	-	-	Stud	5,906	-	-	-	-	$15.00	**$88,590**
	NWC Slab	C-20	140.00	0.457	CY	416	$106.00	$14.90	$5.55	$126.45	$146.00	**$60,765**
	Girders - W21x50	E-5	1064.00	0.075	LF	1,656	$60.50	$3.19	$1.60	$65.29	$74.00	**$122,544**
	Fireproofing Beam	G-2	1500.00	0.016	SF	14,554	$0.47	$0.51	$0.08	$1.06	$1.39	**$20,230**
	Fireproofing Deck	G-2	1250.00	0.019	SF	35,000	$0.71	$0.62	$0.10	$1.43	$1.83	**$64,050**
	Fireproofing Girder	G-2	1500.00	0.016	SF	5,796	$0.47	$0.51	$0.08	$1.06	$1.39	**$8,056**
Exterior Wall	6 Inch CMU	D-8	430.00	0.093	SF	2,430	$2.10	$3.32	$0.00	$5.42	$7.35	**$17,861**
	8 Inch CMU	D-8	395.00	0.101	SF	13,524	$2.27	$3.62	$0.00	$5.89	$8.00	**$108,192**
	10 Inch CMU	D-8	320.00	0.125	SF	6,930	$3.06	$4.47	$0.00	$7.53	$10.15	**$70,340**
	14 Inch CMU	D-9	300.00	0.160	SF	5,040	$3.30	$5.60	$0.00	$8.90	$12.10	**$60,984**
	4 Inch Face Brick	D-8	310.00	0.129	SF	18,189	$4.12	$4.61	$0.00	$8.73	$11.55	**$210,083**
	8 Inch CMU Grout	D-4	680.00	0.047	SF	3,381	$1.13	$1.63	$0.19	$2.95	$3.91	**$13,220**
	Windows	H-1	195.00	0.164	SF	12,320	$31.50	$6.60	$0.00	$38.10	$45.50	**$560,560**

EXISTING COSTS SPREADSHEET

System	Component	Crew	Daily Output	Labor Hours	Units	No. Units	Material	Labor	Equip	Cost / Unit	Cost + O&P/Unit	**Total Cost**
Lateral Resisting	Beam - W18x50	E-5	912.00	0.088	LF	228	$60.50	$3.72	$1.86	$66.08	$75.00	**$17,100**
	Beam - W24x68	E-5	1110.00	0.072	LF	456	$82.50	$3.06	$1.53	$87.09	$97.50	**$44,460**
	Brace - HSS 14x16x.5	E-2	46.00	1.189	EA	16	$1,848	$75.50	$50.00	$1,973	$2,210	**$35,360**
	Brace - HSS 12x6x.5	E-2	48.00	1.167	EA	16	$1,680	$68.50	$45.50	$1,794	$2,010	**$32,160**
	Brace - HSS 7x5x3/8	E-2	50.00	1.120	EA	16	$1,209	$88.00	$59.00	$1,356	$1,520	**$24,320**
	Column - W10x68	E-2	984.00	0.057	LF	720	$82.50	$2.38	$1.59	$86.47	$96.50	**$69,480**
	Connection	-	-	-	20% Mat	8	-	-	-	-	$5,572	**$44,576**
Columns	Steel Col. - W10x54	E-2	550.00	0.102	LF	3,780	$59.50	$4.26	$2.85	$66.61	$75.50	**$285,390**
	Fireproofing - 1-1/8"	G-2	1100.00	0.022	SF	12,600	$0.53	$0.70	$0.12	$1.35	$1.78	**$22,428**
	Column Splice	-	-	-	Splice	0	-	-	-	-	$750.00	**$0**
Found-ations	Spread Footings	C-14C	75.00	1.493	CY	203	$176.00	$54.50	$0.33	$230.83	$280.00	**$56,913**
	Strip Footings	C-14C	60.00	1.867	CY	202	$128.00	$68.50	$0.41	$196.91	$248.00	**$50,213**
	6" Slab On Grade	C-14E	92.00	0.957	CY	722	$117.00	$36.00	$0.27	$153.27	$187.00	**$135,014**
	6x6 - W2.9xW2.9 WWF	2 Rodm	29.00	0.552	CSF	390	$20.00	$23.50	$0.00	$43.50	$61.00	**$23,790**
	Geopier Soil Reinf	-	120.00	-	LF	5,100	-	-	-	-	$40.00	**$204,000**
	Shear Wall Footings	C-14C	75.00	1.493	CY	51	$176.00	$54.50	$0.33	$230.83	$280.00	**$14,186**
Truss	Beam - W4x13	E-2	600.00	0.093	LF	37	$15.13	$3.91	$2.61	$21.64	$26.00	**$949**
	Beam - W6x15	E-2	600.00	0.093	LF	11	$19.35	$3.91	$2.61	$25.87	$31.00	**$341**
	Beam - W8x31	E-2	550.00	0.102	LF	11	$37.50	$4.26	$2.85	$44.61	$52.00	**$572**
	Connections	F-6	48.00	0.833	EA	1	-	$29.50	$15.95	$45.45	$63.00	**$63**
	Cost/Truss	-	-	-	EA	1	-	-	-	-	-	**$1,925**
Partitions	CMU Partitions	D-8	375.00	0.107	SF	22,869	$2.07	$3.81	$0.00	$5.88	$8.10	**$185,239**

TOTAL BUILDING COST **$4,615,735**

NEW COSTS SPREADSHEET

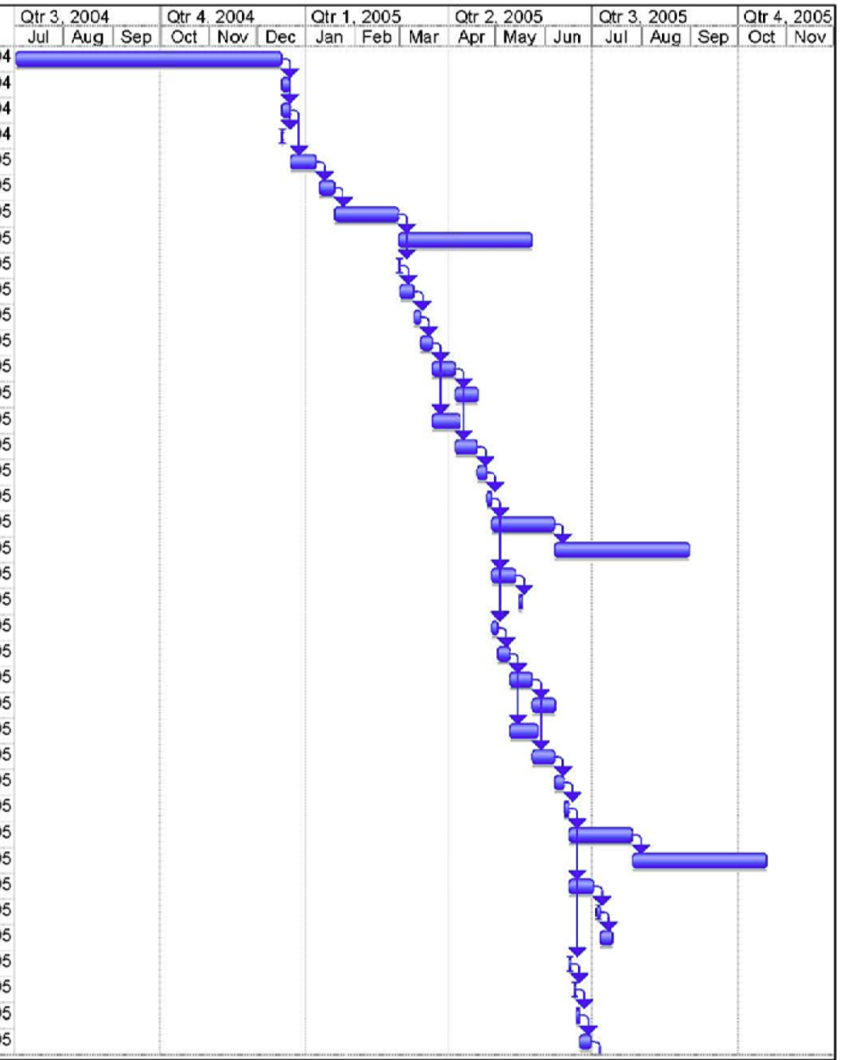
System	Component	Crew	Daily Output	Labor Hours	Units	No. Units	Material	Labor	Equip	Cost / Unit	Cost + O&P/Unit	Total Cost
Roof	Joist - 18K3	E-7	2000.00	0.040	LF	2,083	$5.28	$1.79	$0.97	$8.04	$10.00	**$20,830**
	Joist - 10K1	E-7	1200.00	0.067	LF	1,219	$3.78	$2.83	$1.53	$8.14	$10.80	**$13,165**
	Joist - 24KCS3	E-7	2200.00	0.036	LF	809	$12.80	$1.54	$0.83	$15.17	$17.65	**$14,279**
	Deck - 1.5" B 18 GA	E-4	4100.00	0.008	SF	13,230	$1.96	$0.34	$0.03	$2.33	$2.80	**$37,044**
	Deck - 1.5" B 22 GA	E-4	4900.00	0.007	SF	7,425	$1.25	$0.28	$0.03	$1.56	$1.92	**$14,256**
	Deck - 3" 18 GA	E-4	2850.00	0.011	SF	2,970	$2.29	$0.49	$0.05	$2.83	$3.45	**$10,247**
	Girder - W18x35	E-5	960.00	0.083	LF	2,160	$42.50	$3.53	$1.77	$47.80	$54.50	**$117,720**
	Truss	-	-	-	Truss	10	-	-	-	-	$1,925	**$19,250**
	Fireproofing Joist	G-2	1200.00	0.019	SF	11,517	$0.47	$0.65	$0.08	$1.20	$1.54	**$17,736**
	Fireproofing Girder	G-2	1500.00	0.016	SF	6,480	$0.47	$0.51	$0.08	$1.06	$1.39	**$9,007**
	Fireproofing Deck	G-2	1250.00	0.019	SF	21,600	$0.71	$0.62	$0.10	$1.43	$1.83	**$39,528**
Floor	C.Joist - 22VC1600	E-7	1800.00	0.044	LF	2,380	$19.25	$2.42	$1.31	$22.98	$27.00	**$64,260**
	Joist - 10K1	E-7	1200.00	0.067	LF	594	$3.78	$2.83	$1.53	$8.14	$10.80	**$6,415**
	C.Deck - 2" 18 GA	E-4	3400.00	0.009	SF	21,600	$2.66	$0.41	$0.04	$3.11	$3.70	**$79,920**
	Shear Studs	-	-	-	Stud	2,440	-	-	-	-	$15.00	**$36,600**
	NWC Slab	C-20	140.00	0.457	CY	233	$106.00	$14.90	$5.55	$126.45	$146.00	**$34,062**
	Girders - W21x50	E-5	1064.00	0.075	LF	1,180	$60.50	$3.19	$1.60	$65.29	$74.00	**$87,320**
	Fireproofing Joist	G-2	1200.00	0.019	SF	9,717	$0.47	$0.65	$0.08	$1.20	$1.54	**$14,964**
	Fireproofing Deck	G-2	1500.00	0.016	SF	21,600	$0.47	$0.51	$0.08	$1.06	$1.39	**$30,024**
	Fireproofing Girder	G-2	1250.00	0.019	SF	4,130	$0.71	$0.62	$0.10	$1.43	$1.83	**$7,558**
Exterior Wall	6 Inch CMU	D-8	430.00	0.093	SF	3,105	$2.10	$3.32	$0.00	$5.42	$7.35	**$22,822**
	8 Inch CMU	D-8	395.00	0.101	SF	15,300	$2.27	$3.62	$0.00	$5.89	$8.00	**$122,400**
	10 Inch CMU	D-8	320.00	0.125	SF	10,818	$3.06	$4.47	$0.00	$7.53	$10.15	**$109,803**
	14 Inch CMU	D-9	300.00	0.160	SF	7,860	$3.30	$5.60	$0.00	$8.90	$12.10	**$95,106**
	4 Inch Face Brick	D-8	310.00	0.129	SF	21,803	$4.12	$4.61	$0.00	$8.73	$11.55	**$251,825**
	Grout - 8" CMU	D-4	680.00	0.047	SF	15,300	$1.13	$1.63	$0.19	$2.95	$3.91	**$59,823**
	Windows	H-1	195.00	0.164	SF	19,264	$31.50	$6.60	$0.00	$38.10	$45.50	**$876,512**

NEW COSTS SPREADSHEET

System	Component	Crew	Daily Output	Labor Hours	Units	No. Units	Material	Labor	Equip	Cost / Unit	Cost + O&P/Unit	Total Cost
Lateral Resisting	8 Inch CMU	D-8	360.00	0.111	SF	1,710	$3.37	$3.97	$0.00	$7.34	$9.75	**$16,673**
	Grout - 8 Inch CMU	D-4	680.00	0.047	SF	1,710	$1.13	$1.63	$0.19	$2.95	$3.91	**$6,686**
	#5 Reinf. Steel - Vert	1 Bric	650.00	0.012	LB	2,135	$0.47	$0.48	$0.00	$0.95	$1.24	**$2,647**
	#4 Reinf. Steel - Horiz	1 Bric	800.00	0.010	LB	1,708	$0.47	$0.39	$0.00	$0.86	$1.11	**$1,896**
Columns	Steel Col. - W10x54	E-2	550.00	0.102	LF	3,600	$59.50	$4.26	$2.85	$66.61	$75.50	**$271,800**
	Fireproofing	G-2	1100.00	0.022	SF	12,000	$0.53	$0.70	$0.12	$1.35	$1.78	**$21,360**
	Column Splice	-	-	-	SPLICE	48	-	-	-	-	$750.00	**$36,000**
Found-ations	Spread Footings	C-14C	75.00	1.493	CY	171	$176.00	$54.50	$0.33	$230.83	$280.00	**$47,786**
	Strip Footings	C-14C	60.00	1.867	CY	130	$128.00	$68.50	$0.41	$196.91	$248.00	**$32,148**
	6" Slab on Grade	C-14E	92.00	0.957	CY	400	$117.00	$36.00	$0.29	$153.27	$187.00	**$74,800**
	6x6 - W2.9xW2.9 WWF	2 Rodm	29.00	0.552	CSF	216	$20.00	$23.50	$0.00	$43.50	$61.00	**$13,176**
	Geopier Soil Reinf	-	120.00	-	LF	2,808	-	-	-	-	$40.00	**$112,320**
	Shear Wall Footings	C-14C	60.00	1.867	CY	21	$128.00	$68.50	$0.41	$196.91	$248.00	**$5,235**
Truss	Beam - W4x13	E-2	600.00	0.093	LF	37	$15.13	$3.91	$2.61	$21.64	$26.00	**$949**
	Beam - W6x15	E-2	600.00	0.093	LF	11	$19.35	$3.91	$2.61	$25.87	$31.00	**$341**
	Beam - W8x31	E-2	550.00	0.102	LF	11	$37.50	$4.26	$2.85	$44.61	$52.00	**$572**
	Connections	F-6	48.00	0.833	EA	1	-	$29.50	$15.95	$45.45	$63.00	**$63**
	Cost/Truss	-	-	-	EA	1	-	-	-	-	-	**$1,925**
Partitions	CMU Partitions - 8"	D-8	375.00	0.107	SF	13,739	$2.07	$3.81	$0.00	$5.88	$8.10	**$111,286**

TOTAL BUILDING COST	**$4,606,407**

ID	Task Name	Duration	Start	Finish
1	Geopier Soil Reinf System / Excavation	120 days	Fri 7/2/04	Thu 12/16/04
2	Spread Footings	3 days	Fri 12/17/04	Tue 12/21/04
3	Strip Footings	3.5 days	Fri 12/17/04	Wed 12/22/04
4	Braced Frame Footings	1 day	Fri 12/17/04	Fri 12/17/04
5	Slab on Grade Reinforcement	12.5 days	Wed 12/22/04	Fri 1/7/05
6	Slab on Grade Pour	7.5 days	Mon 1/10/05	Wed 1/19/05
7	Concrete Curing	28 days	Wed 1/19/05	Mon 2/28/05
8	Interior Partition Placement	61 days	Mon 2/28/05	Tue 5/24/05
9	Crane Placement	1 day	Mon 2/28/05	Tue 3/1/05
10	Column Erection	7 days	Tue 3/1/05	Thu 3/10/05
11	2nd Floor Girder placement	2 days	Thu 3/10/05	Mon 3/14/05
12	2nd Floor Comp Beam	5.5 days	Mon 3/14/05	Mon 3/21/05
13	2nd Floor Deck Placement	10.5 days	Tue 3/22/05	Tue 4/5/05
14	FireProof Deck	10.5 days	Tue 4/5/05	Tue 4/19/05
15	FireProof Beams / Girders	14 days	Tue 3/22/05	Fri 4/8/05
16	2nd Floor Shear Studs	10 days	Tue 4/5/05	Tue 4/19/05
17	1st-2nd Floor Braced Frame	4 days	Tue 4/19/05	Mon 4/25/05
18	2nd Floor Slab Pour	3 days	Mon 4/25/05	Thu 4/28/05
19	Concrete Curing	28 days	Thu 4/28/05	Tue 6/7/05
20	Interior Partition Placement	61 days	Tue 6/7/05	Wed 8/31/05
21	Ext 8" CMU - to 2nd Fl	11.5 days	Thu 4/28/05	Fri 5/13/05
22	Ext 8" CMU - to 2nd Fl - Grout	2 days	Mon 5/16/05	Tue 5/17/05
23	3rd Floor Girder Placement	2 days	Thu 4/28/05	Mon 5/2/05
24	3rd Floor Comp Beam	5.5 days	Mon 5/2/05	Mon 5/9/05
25	3rd Floor Deck Placement	10.5 days	Tue 5/10/05	Tue 5/24/05
26	FireProof Deck	10.5 days	Tue 5/24/05	Tue 6/7/05
27	FireProof Beams / Girders	14 days	Tue 5/10/05	Fri 5/27/05
28	3rd Floor Shear Studs	10 days	Tue 5/24/05	Tue 6/7/05
29	2nd-3rd Floor Braced Frame	4 days	Tue 6/7/05	Mon 6/13/05
30	3rd Floor Slab Pour	3 days	Mon 6/13/05	Thu 6/16/05
31	Concrete Curing	28 days	Thu 6/16/05	Tue 7/26/05
32	Interior Partition Placement	61 days	Tue 7/26/05	Wed 10/19/05
33	Ext 8" CMU - to 3rd Fl	11.5 days	Thu 6/16/05	Fri 7/1/05
34	Ext 8" CMU - to 3rd Fl - Grout	2 days	Mon 7/4/05	Tue 7/5/05
35	Ext 14" CMU - to 2nd Fl	6 days	Wed 7/6/05	Wed 7/13/05
36	Roof Girder Placement	1.5 days	Thu 6/16/05	Fri 6/17/05
37	Roof KCS Joist Placement	1 day	Mon 6/20/05	Mon 6/20/05
38	Roof Joist Placement	2.5 days	Tue 6/21/05	Thu 6/23/05
39	Roof Truss Placement	5 days	Thu 6/23/05	Thu 6/30/05

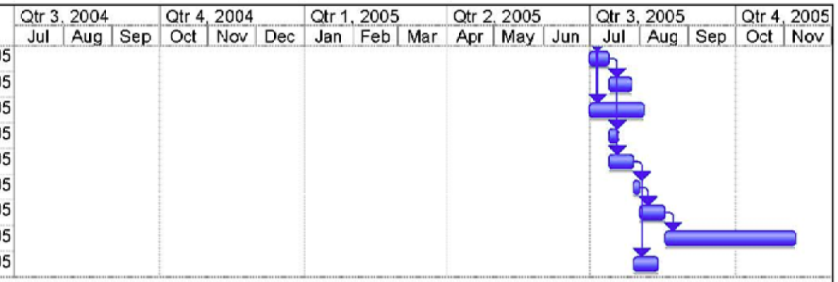


Project: Existing Building Shcedule
Date: July 2004 - November 2005

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

Page 1

ID	Task Name	Duration	Start	Finish
40	Roof Deck Placement	8.5 days	Thu 6/30/05	Tue 7/12/05
41	FireProof Deck	10.5 days	Wed 7/13/05	Wed 7/27/05
42	FireProof Joists / Girders	25 days	Thu 6/30/05	Thu 8/4/05
43	3rd-Roof Braced Frame	4 days	Wed 7/13/05	Mon 7/18/05
44	Ext 8" CMU - to Roof	11.5 days	Wed 7/13/05	Thu 7/28/05
45	Ext 8" CMU - to Roof - Grout	2 days	Thu 7/28/05	Mon 8/1/05
46	Ext 14" CMU - to Roof	12 days	Mon 8/1/05	Wed 8/17/05
47	Ext 4" Brick - to Roof	59 days	Wed 8/17/05	Tue 11/8/05
48	FireProof Columns	11.5 days	Thu 7/28/05	Fri 8/12/05

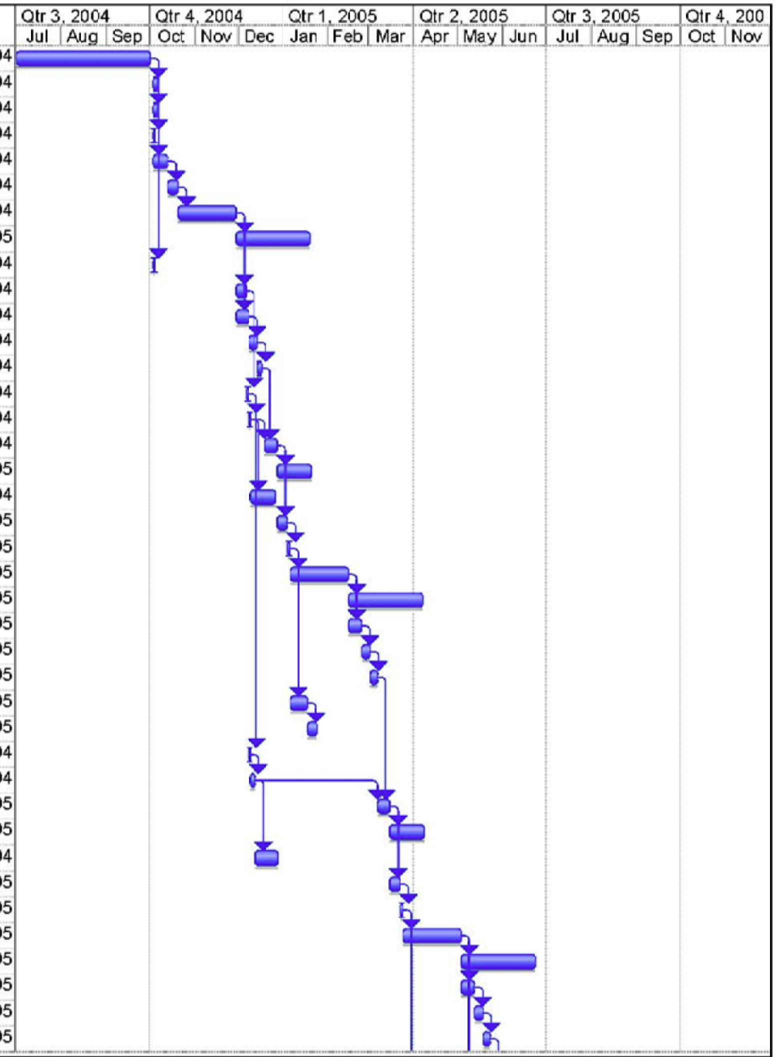


Project: Existing Building Shcedule
Date: July 2004 - November 2005

Task, Split, Progress, Milestone, Summary, Project Summary, External Tasks, External Milestone, Deadline

Page 2

ID	Task Name	Duration	Start	Finish
1	Geopier Soil Reinf System / Excavation	66 days	Fri 7/2/04	Fri 10/1/04
2	Spread Footings	3 days	Mon 10/4/04	Wed 10/6/04
3	Strip Footings	3 days	Mon 10/4/04	Wed 10/6/04
4	Shear Wall Footings	1 day	Mon 10/4/04	Mon 10/4/04
5	Slab on Grade Reinforcement	8 days	Mon 10/4/04	Wed 10/13/04
6	Slab on Grade Pour	5 days	Thu 10/14/04	Wed 10/20/04
7	Concrete Curing	28 days	Thu 10/21/04	Mon 11/29/04
8	Interior Partition Placement	37 days	Tue 11/30/04	Wed 1/19/05
9	Crane Placement	1 day	Mon 10/4/04	Mon 10/4/04
10	Column Erection	5 days	Tue 11/30/04	Mon 12/6/04
11	1st-2nd Fl Masonry Swall - CMU + Horiz Reinf	7 days	Tue 11/30/04	Wed 12/8/04
12	1st-2nd Fl Masonry Shear Wall - Vert Reinf	4 days	Thu 12/9/04	Tue 12/14/04
13	1st-2nd Fl Masonry Shear Wall Reinf - Grout	3 days	Wed 12/15/04	Fri 12/17/04
14	2nd Floor Girder placement	1.5 days	Tue 12/7/04	Wed 12/8/04
15	2nd Floor Comp Joist	1.5 days	Wed 12/8/04	Thu 12/9/04
16	2nd Floor Deck Placement	6.5 days	Mon 12/20/04	Tue 12/28/04
17	Deck Fireproofing	17.5 days	Tue 12/28/04	Thu 1/20/05
18	Joist & Girder Fireproofing	11.5 days	Fri 12/10/04	Mon 12/27/04
19	2nd Floor Shear Studs	5 days	Tue 12/28/04	Tue 1/4/05
20	2nd Floor Slab Pour	2 days	Tue 1/4/05	Thu 1/6/05
21	Concrete Curing	28 days	Thu 1/6/05	Tue 2/15/05
22	Interior Partition Placement	37 days	Tue 2/15/05	Thu 4/7/05
23	2nd-3rd Fl Masonry Swall - CMU + Horiz Reinf	7 days	Tue 2/15/05	Thu 2/24/05
24	2nd-3rd Fl Masonry Shear Wall - Vert Reinf	4 days	Thu 2/24/05	Wed 3/2/05
25	2nd-3rd Fl Masonry Shear Wall Reinf - Grout	3 days	Wed 3/2/05	Mon 3/7/05
26	Ext 8" CMU - to 2nd Fl	8 days	Thu 1/6/05	Tue 1/18/05
27	Ext 8" CMU - to 2nd Fl - Grout	4.5 days	Tue 1/18/05	Mon 1/24/05
28	3rd Floor Girder Placement	1.5 days	Wed 12/8/04	Thu 12/9/04
29	3rd Floor Comp Joist	1.5 days	Fri 12/10/04	Mon 12/13/04
30	3rd Floor Deck Placement	6.5 days	Mon 3/7/05	Tue 3/15/05
31	Deck Fireproofing	17.5 days	Wed 3/16/05	Fri 4/8/05
32	Joist & Girder Fireproofing	11.5 days	Mon 12/13/04	Tue 12/28/04
33	3rd Floor Shear Studs	5 days	Wed 3/16/05	Tue 3/22/05
34	3rd Floor Slab Pour	2 days	Wed 3/23/05	Thu 3/24/05
35	Concrete Curing	28 days	Fri 3/25/05	Tue 5/3/05
36	Interior Partition Placement	37 days	Wed 5/4/05	Thu 6/23/05
37	3rd-4th Fl Masonry Swall - CMU + Horiz Reinf	7 days	Wed 5/4/05	Thu 5/12/05
38	3rd-4th Fl Masonry Shear Wall - Vert Reinf	4 days	Fri 5/13/05	Wed 5/18/05
39	3rd-4th Fl Masonry Shear Wall Reinf - Grout	3 days	Thu 5/19/05	Mon 5/23/05

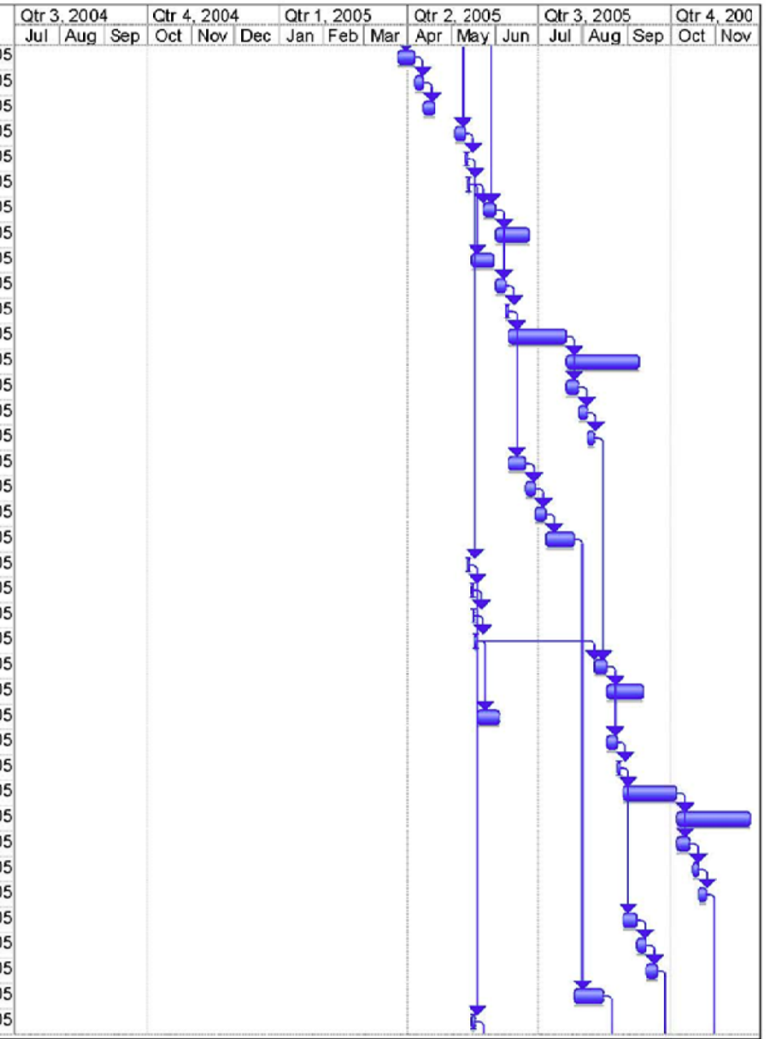


Project: New Building Schedule
Date: July 2004 -November 2005

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

Page 1

ID	Task Name	Duration	Start	Finish
40	Ext 8" CMU - to 3rd Fl	8 days	Fri 3/25/05	Tue 4/5/05
41	Ext 8" CMU - to 3rd Fl - Grout	4.5 days	Wed 4/6/05	Tue 4/12/05
42	Ext 14" CMU - to 2nd Fl	5.5 days	Tue 4/12/05	Tue 4/19/05
43	Column Splices	5 days	Wed 5/4/05	Tue 5/10/05
44	4th Floor Girder Placement	1.5 days	Wed 5/11/05	Thu 5/12/05
45	4th Floor Comp Joist	1.5 days	Thu 5/12/05	Fri 5/13/05
46	4th Floor Deck Placement	6.5 days	Tue 5/24/05	Wed 6/1/05
47	Deck Fireproofing	17.5 days	Wed 6/1/05	Fri 6/24/05
48	Joist & Girder Fireproofing	11.5 days	Mon 5/16/05	Tue 5/31/05
49	4th Floor Shear Studs	5 days	Wed 6/1/05	Wed 6/8/05
50	4th Floor Slab Pour	2 days	Wed 6/8/05	Fri 6/10/05
51	Concrete Curing	28 days	Fri 6/10/05	Wed 7/20/05
52	Interior Partition Placement	37 days	Wed 7/20/05	Fri 9/9/05
53	4th-5th Fl Masonry Swall - CMU + Horiz Reinf	7 days	Wed 7/20/05	Fri 7/29/05
54	4th-5th Fl Masonry Shear Wall - Vert Reinf	4 days	Fri 7/29/05	Thu 8/4/05
55	4th-5th Fl Masonry Shear Wall Reinf - Grout	3 days	Thu 8/4/05	Tue 8/9/05
56	Ext 8" CMU - to 4th Fl	8 days	Fri 6/10/05	Wed 6/22/05
57	Ext 8" CMU - to 4th Fl - Grout	4.5 days	Wed 6/22/05	Tue 6/28/05
58	Ext 14" CMU - to 3rd Fl	5.5 days	Wed 6/29/05	Wed 7/6/05
59	Ext 4" Brick - to 2nd Fl	14 days	Wed 7/6/05	Tue 7/26/05
60	5th Floor Girder Placement	1.5 days	Thu 5/12/05	Fri 5/13/05
61	5th Floor Beam Placement	1 day	Mon 5/16/05	Mon 5/16/05
62	Roof Column Placement	1 day	Tue 5/17/05	Tue 5/17/05
63	5th Floor Comp Joist	1.5 days	Wed 5/18/05	Thu 5/19/05
64	5th Floor Deck Placement	6.5 days	Tue 8/9/05	Wed 8/17/05
65	Deck Fireproofing	17.5 days	Thu 8/18/05	Mon 9/12/05
66	Joist & Girder Fireproofing	11.5 days	Thu 5/19/05	Fri 6/3/05
67	5th Floor Shear Studs	5 days	Thu 8/18/05	Wed 8/24/05
68	5th Floor Slab Pour	2 days	Thu 8/25/05	Fri 8/26/05
69	Concrete Curing	28 days	Mon 8/29/05	Wed 10/5/05
70	Interior Partition Placement	37 days	Thu 10/6/05	Fri 11/25/05
71	5th-Roof Fl Masonry Swall - CMU + Horiz Reinf	7 days	Thu 10/6/05	Fri 10/14/05
72	5th-Roof Fl Masonry Shear Wall - Vert Reinf	4 days	Mon 10/17/05	Thu 10/20/05
73	5th-Roof Fl Masonry Shear Wall Reinf - Grout	3 days	Fri 10/21/05	Tue 10/25/05
74	Ext 8" CMU - to 5th Fl	8 days	Mon 8/29/05	Wed 9/7/05
75	Ext 8" CMU - to 5th Fl - Grout	4.5 days	Thu 9/8/05	Wed 9/14/05
76	Ext 14" CMU - to 4th Fl	5.5 days	Wed 9/14/05	Wed 9/21/05
77	Ext 4" Brick - to 3rd Fl	14 days	Tue 7/26/05	Mon 8/15/05
78	Roof Girder Placement	2.5 days	Mon 5/16/05	Wed 5/18/05

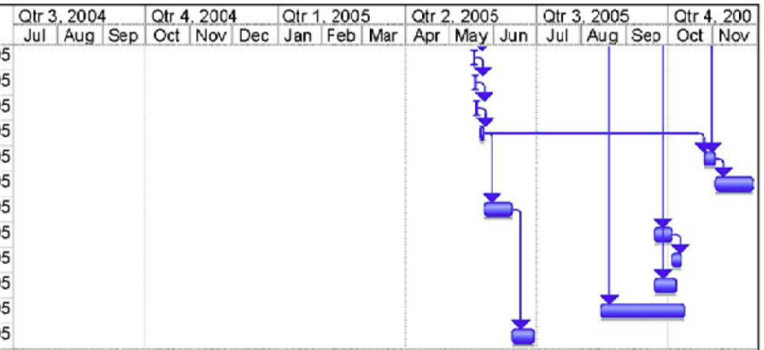


Project: New Building Schedule
Date: July 2004 -November 2005

Task | Milestone | External Tasks
Split | Summary | External Milestone
Progress | Project Summary | Deadline

Page 2

ID	Task Name	Duration	Start	Finish
79	Roof KCS Joist Placement	0.5 days	Wed 5/18/05	Wed 5/18/05
80	Roof 18k3 Joist Placement	1 day	Thu 5/19/05	Thu 5/19/05
81	Roof 10k1 Joist Placement	1 day	Fri 5/20/05	Fri 5/20/05
82	Roof Truss Placement	2.5 days	Mon 5/23/05	Wed 5/25/05
83	Roof Deck Placement	6 days	Wed 10/26/05	Wed 11/2/05
84	Deck Fireproofing	18 days	Thu 11/3/05	Mon 11/28/05
85	Joist & Girder Fireproofing	14 days	Wed 5/25/05	Tue 6/14/05
86	Ext 8"CMU - to Roof	8 days	Thu 9/22/05	Mon 10/3/05
87	Ext 8" CMU - to Roof - Grout	4.5 days	Tue 10/4/05	Mon 10/10/05
88	Ext 14" CMU - to Roof	11 days	Thu 9/22/05	Thu 10/6/05
89	Ext 4" Brick - Roof	42 days	Mon 8/15/05	Wed 10/12/05
90	FireProof Columns	11 days	Tue 6/14/05	Wed 6/29/05

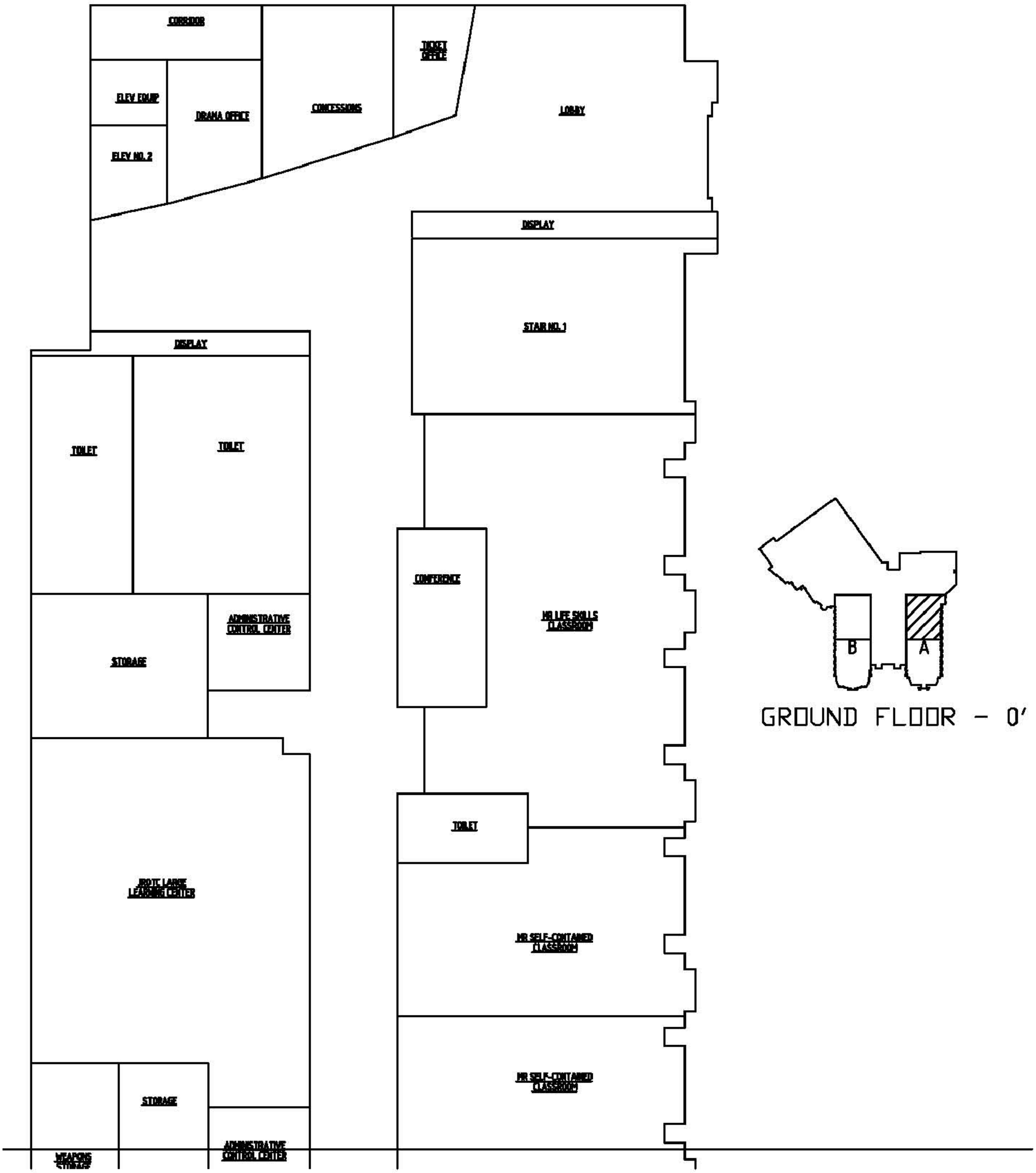


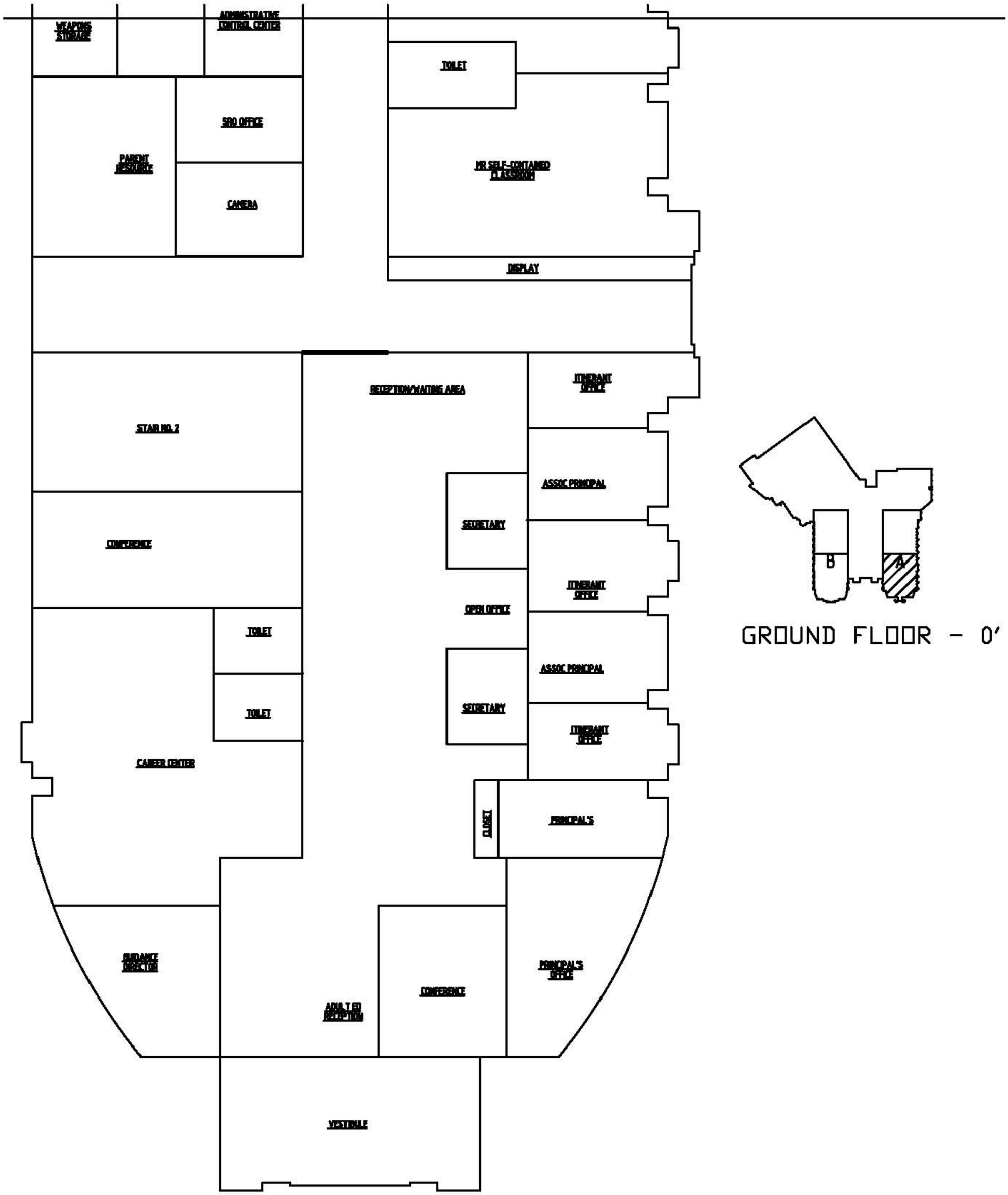
Project: New Building Schedule
Date: July 2004 -November 2005

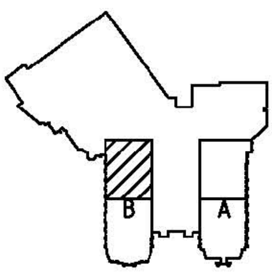
Task	Milestone	External Tasks
Split	Summary	External Milestone
Progress	Project Summary	Deadline

Page 3

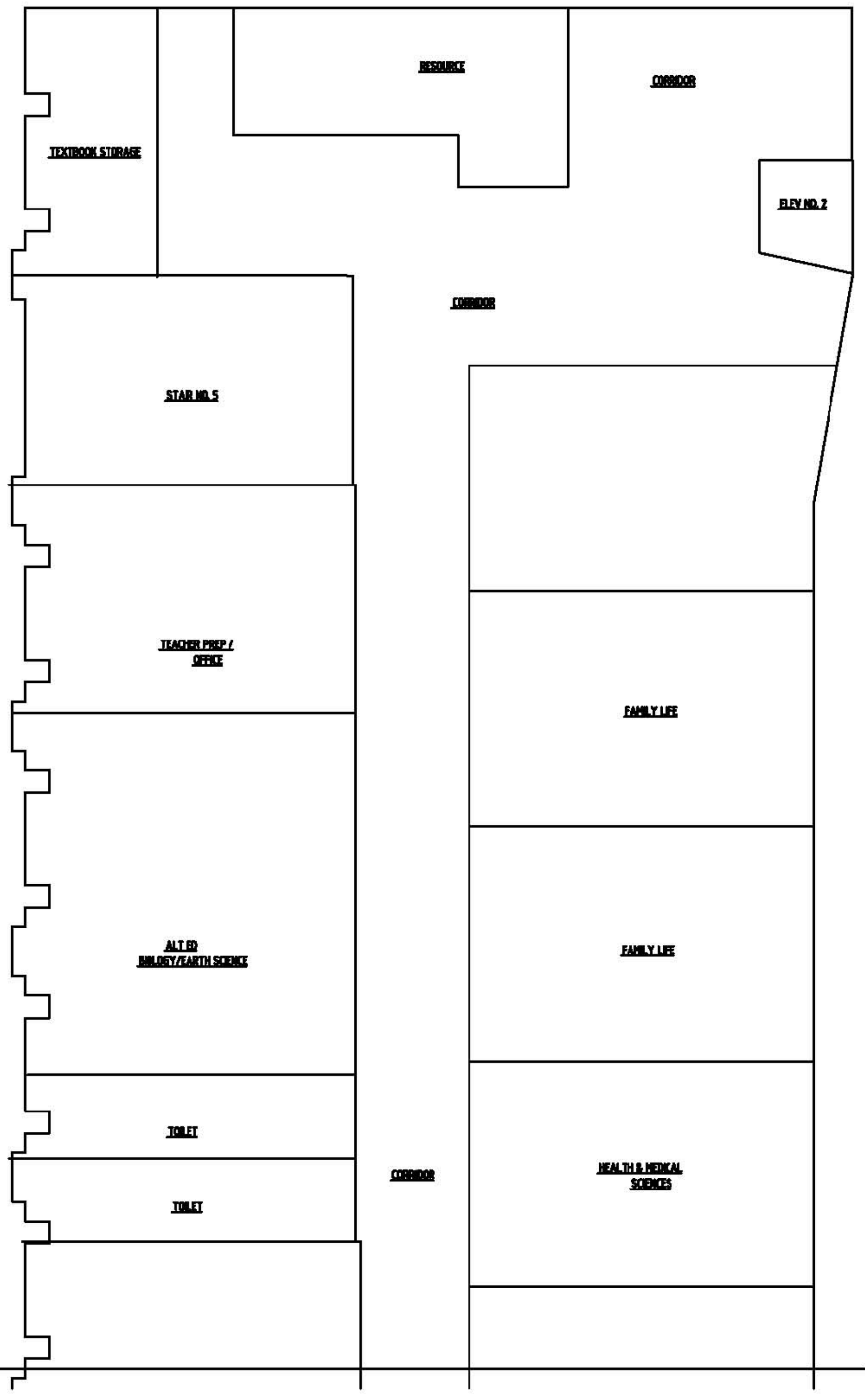
APPENDIX B – ARCHITECTURE

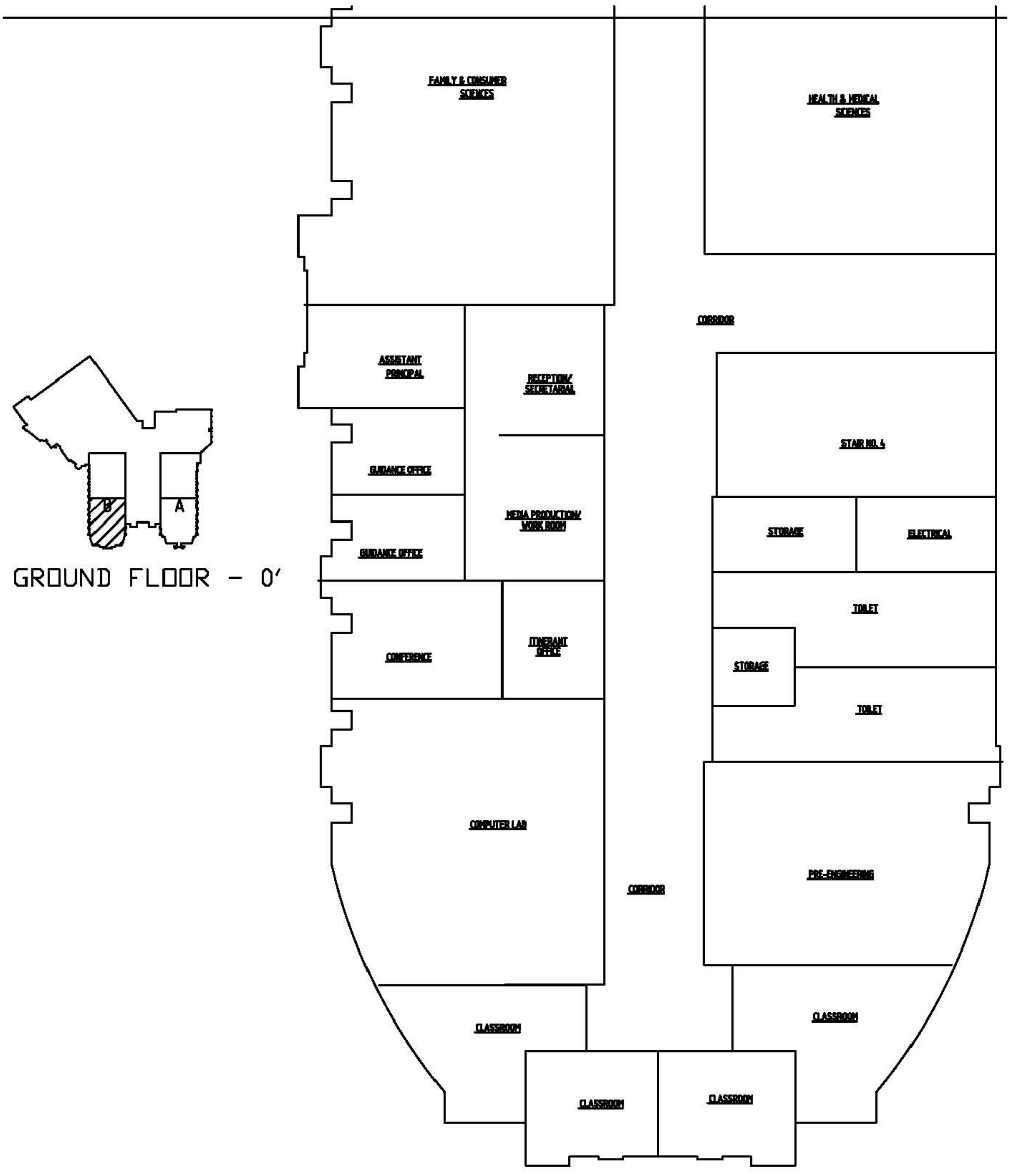

CORRIDOR
TICKET OFFICE
ELEV EQUIP
DRAMA OFFICE
CONCESSIONS
LOBBY
ELEV NO. 2
DISPLAY
STAIR NO. 1
DISPLAY
TOILET
TOILET
CONFERENCE
MR LIFE SKILLS CLASSROOM
ADMINISTRATIVE CONTROL CENTER
STORAGE
TOILET
JROTC LARGE LEARNING CENTER
MR SELF-CONTAINED CLASSROOM
MR SELF-CONTAINED CLASSROOM
STORAGE
ADMINISTRATIVE CONTROL CENTER
WEAPONS STORAGE
B
A
GROUND FLOOR - 0'

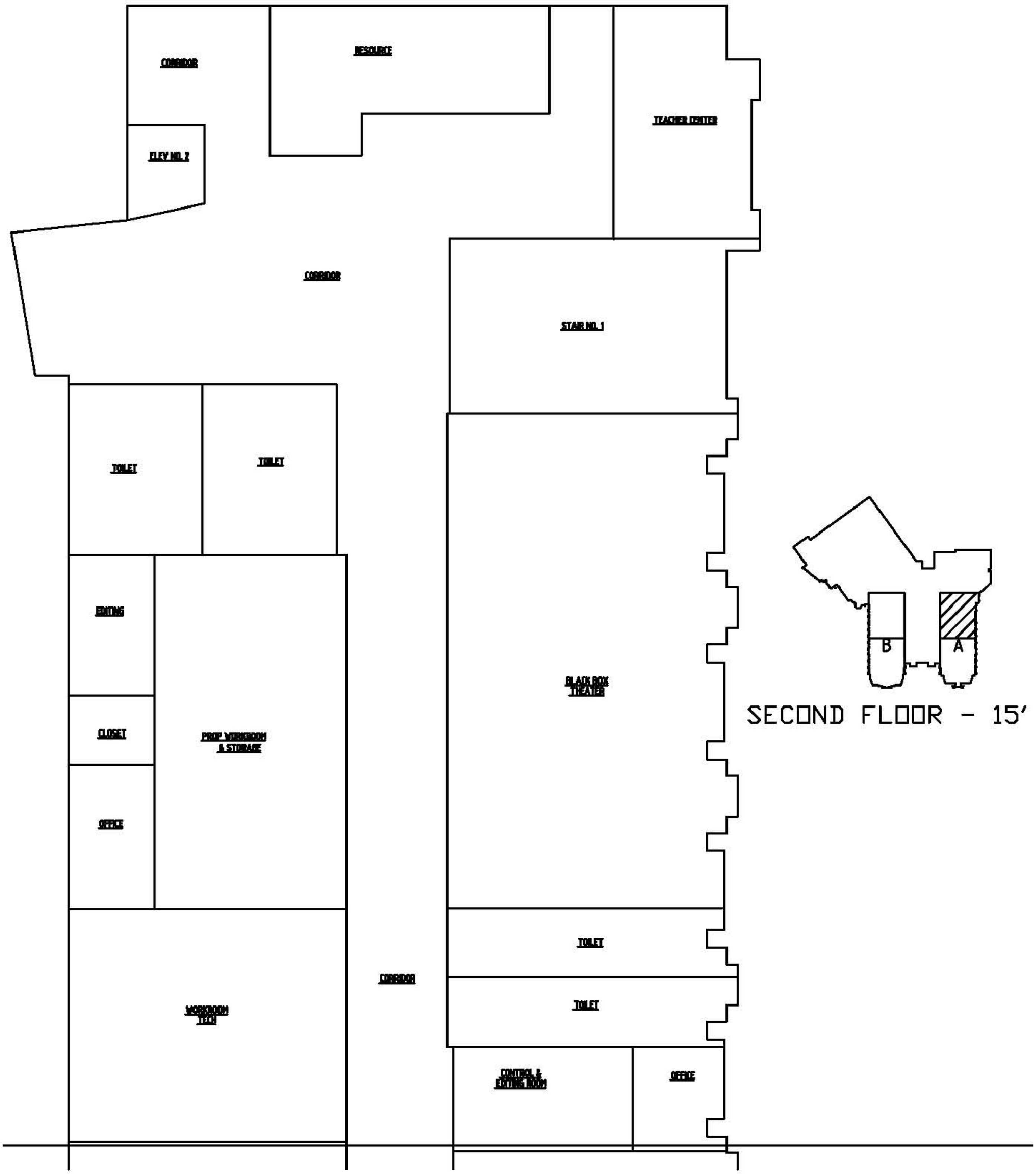

WEAPONS STORAGE
ADMINISTRATIVE CONTROL CENTER
TOILET
SRO OFFICE
PARENT RESOURCE
CAMERA
MR SELF-CONTAINED CLASSROOM
DISPLAY
RECEPTION/WAITING AREA
ITINERANT OFFICE
STAIR NO. 2
ASSOC PRINCIPAL
SECRETARY
CONFERENCE
ITINERANT OFFICE
OPEN OFFICE
TOILET
ASSOC PRINCIPAL
TOILET
SECRETARY
ITINERANT OFFICE
CAREER CENTER
CLOSET
PRINCIPAL'S
GUIDANCE DIRECTOR
PRINCIPAL'S OFFICE
CONFERENCE
ADULT ED RECEPTION
VESTIBULE
B
A
GROUND FLOOR - 0'

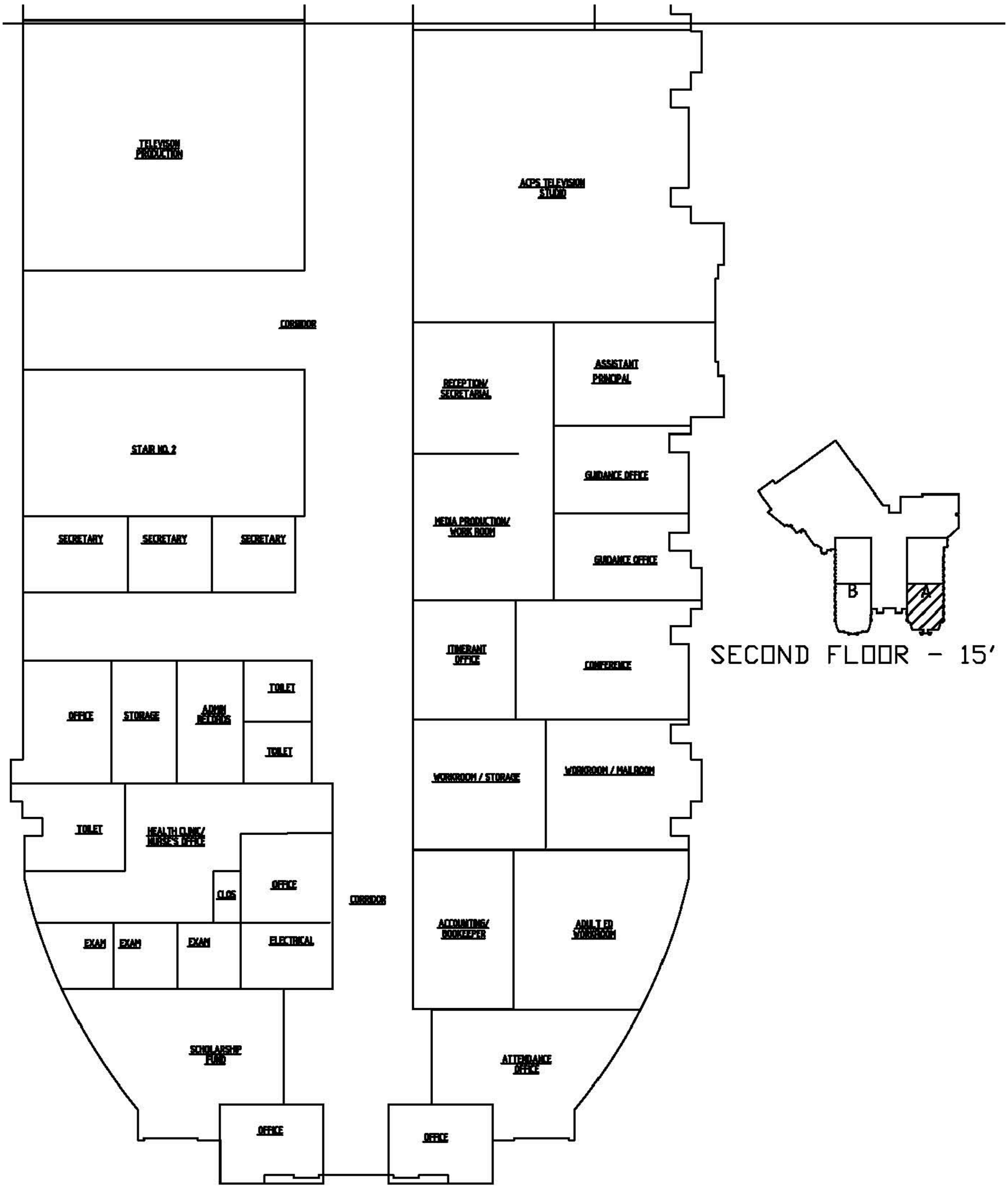


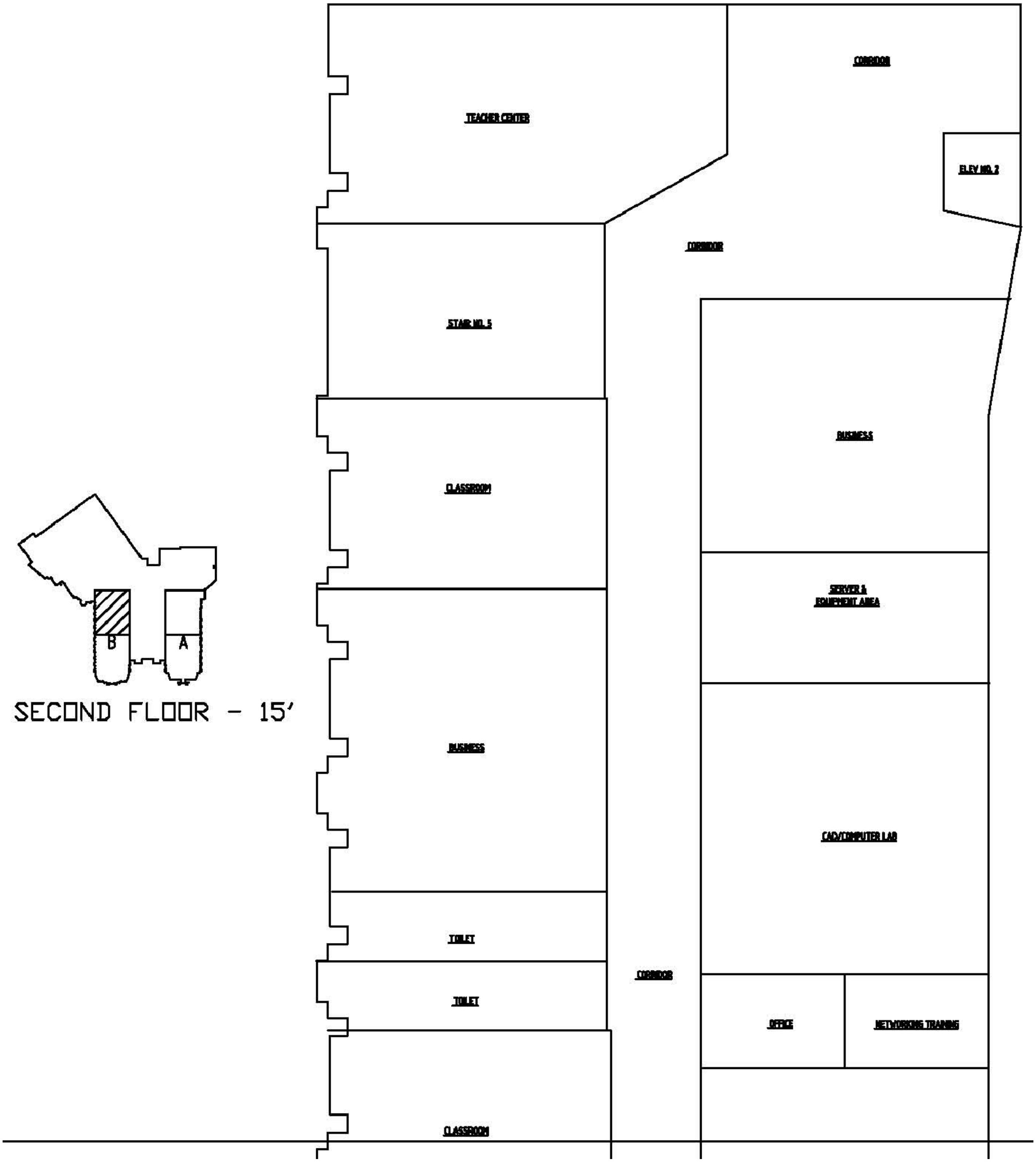
GROUND FLOOR – 0'

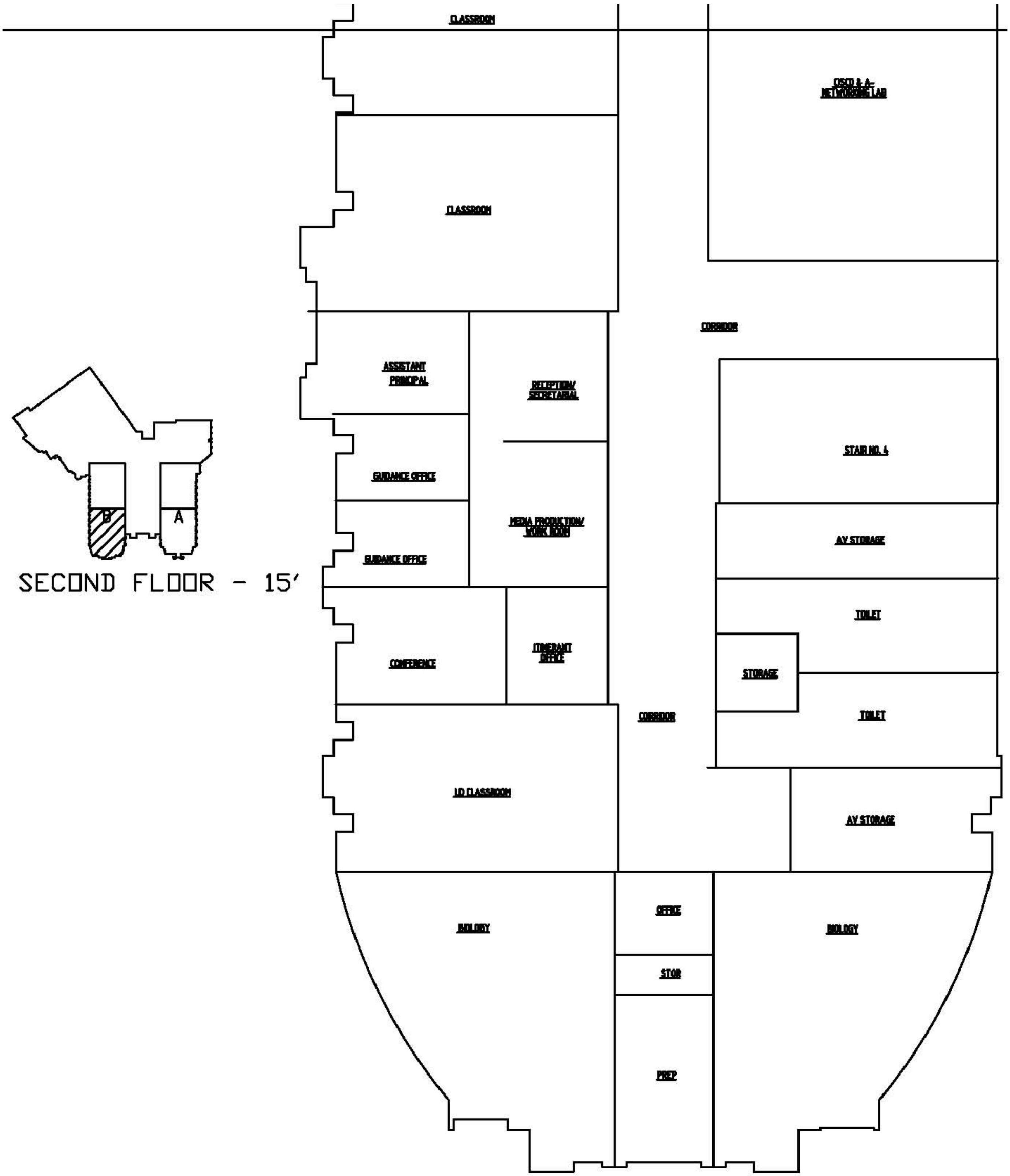


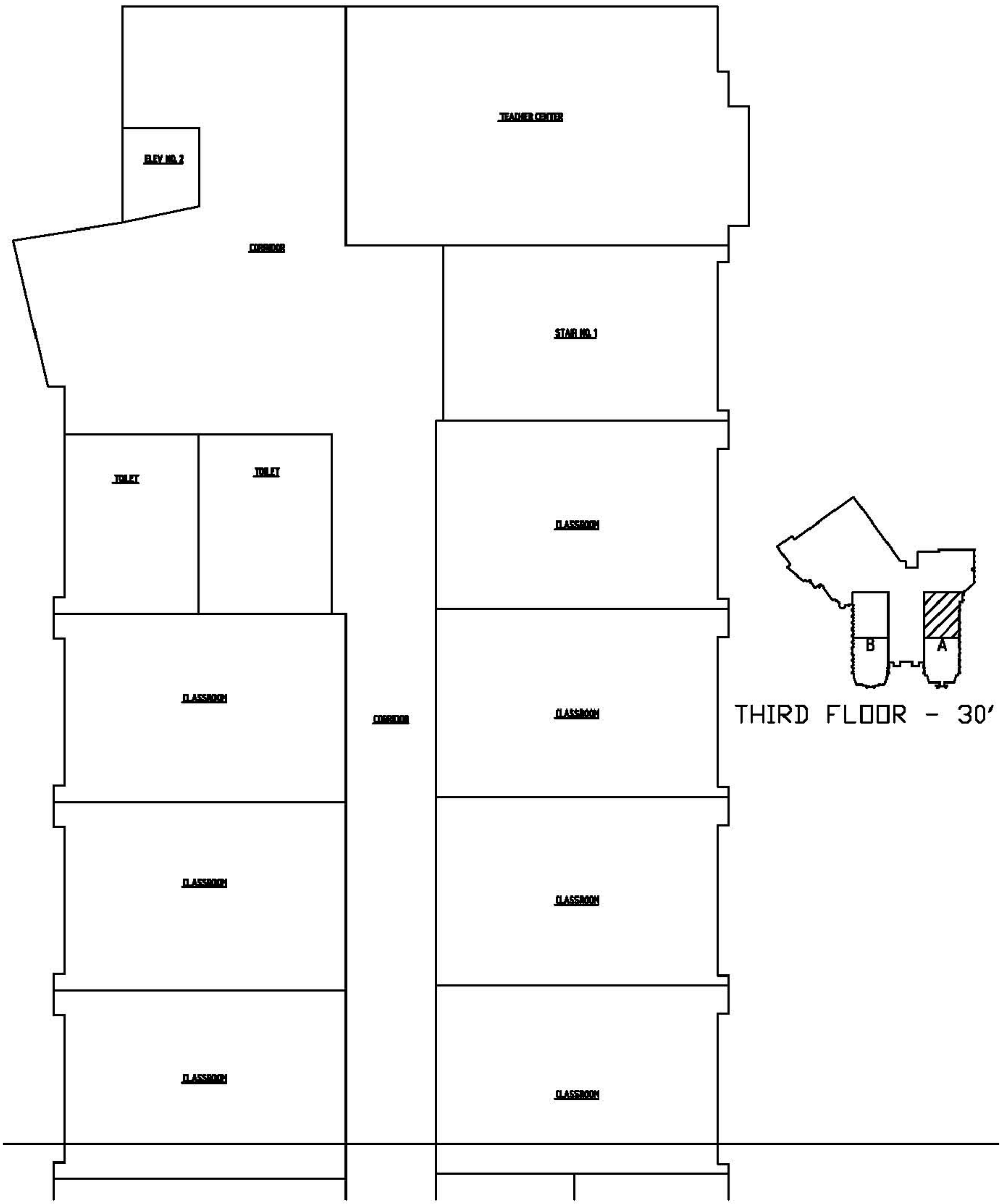

FAMILY & CONSUMER SCIENCES
HEALTH & MEDICAL SCIENCES
CORRIDOR
ASSISTANT PRINCIPAL
RECEPTION/ SECRETARIAL
STAIR NO. 4
GUIDANCE OFFICE
MEDIA PRODUCTION/ WORK ROOM
STORAGE
ELECTRICAL
GUIDANCE OFFICE
B
A
GROUND FLOOR – 0'
TOILET
CONFERENCE
ITINERANT OFFICE
STORAGE
TOILET
COMPUTER LAB
PRE-ENGINEERING
CORRIDOR
CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM

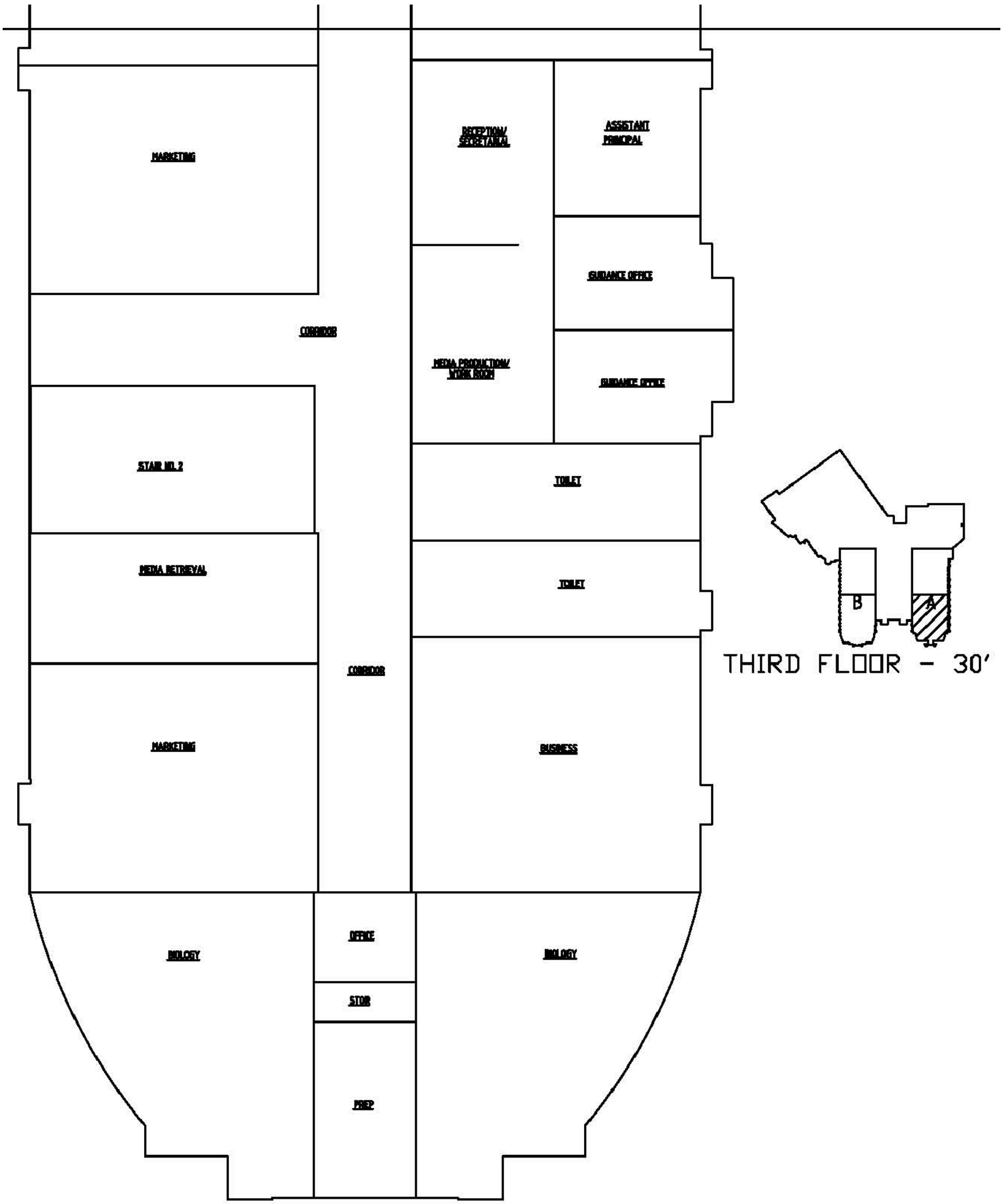

CORRIDOR
RESOURCE
TEACHER CENTER
ELEV NO. 2
CORRIDOR
STAIR NO. 1
TOILET
TOILET
EDITING
BLACK BOX THEATER
CLOSET
PROP WORKROOM & STORAGE
OFFICE
TOILET
CORRIDOR
TOILET
WORKROOM TECH
CONTROL & EDITING ROOM
OFFICE
B
A
SECOND FLOOR - 15'

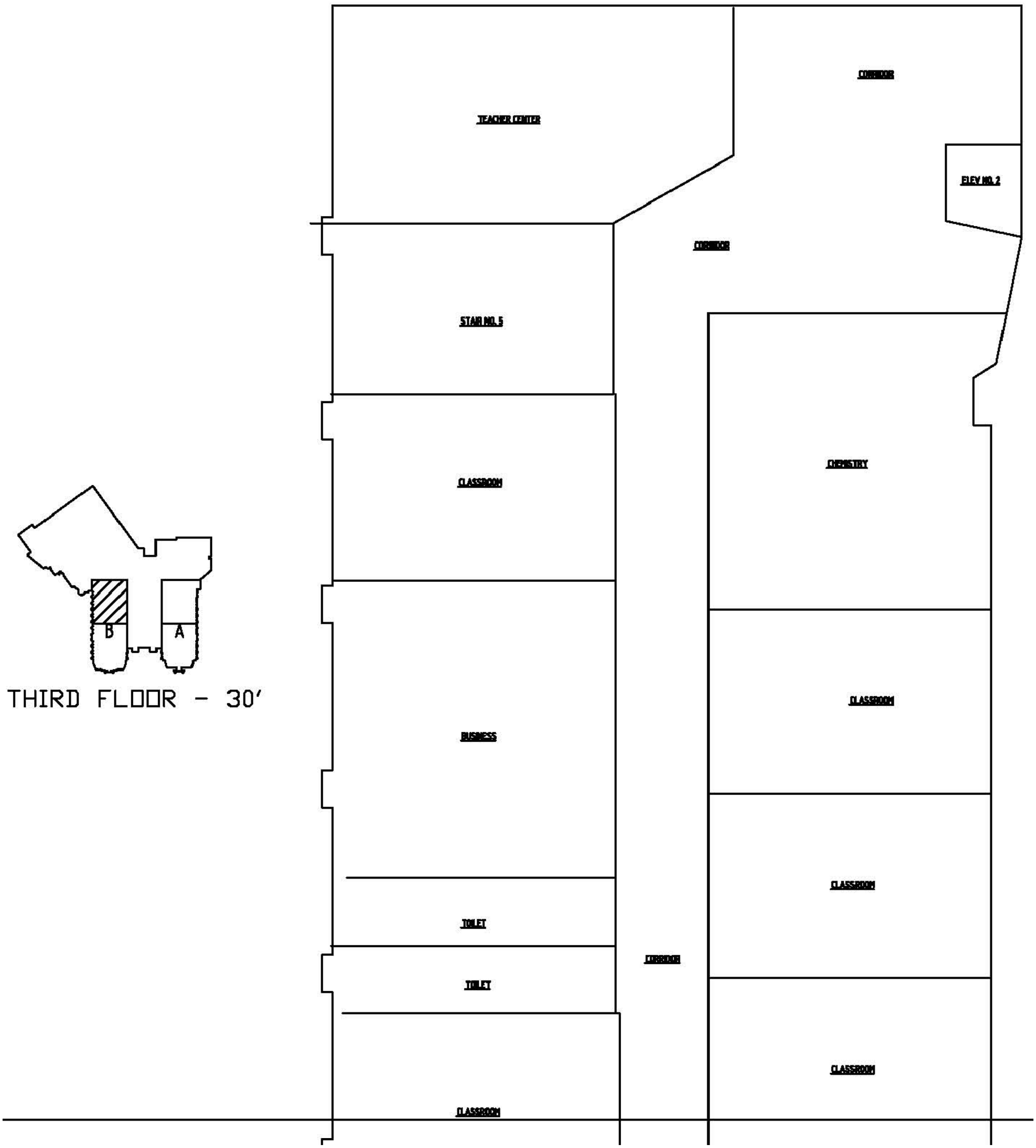

TELEVISON PRODUCTION
ACPS TELEVISION STUDIO
CORRIDOR
ASSISTANT PRINCIPAL
RECEPTION/ SECRETARIAL
STAIR NO. 2
GUIDANCE OFFICE
MEDIA PRODUCTION/ WORK ROOM
GUIDANCE OFFICE
SECRETARY
SECRETARY
SECRETARY
ITINERANT OFFICE
CONFERENCE
TOILET
OFFICE
STORAGE
ADMIN RECORDS
TOILET
WORKROOM / STORAGE
WORKROOM / MAILROOM
TOILET
HEALTH CLINIC/ NURSE'S OFFICE
OFFICE
CLOS
CORRIDOR
ACCOUNTING/ BOOKKEEPER
ADULT ED WORKROOM
EXAM
EXAM
EXAM
ELECTRICAL
SCHOLARSHIP FUND
ATTENDANCE OFFICE
OFFICE
OFFICE
B
A
SECOND FLOOR - 15'


CORRIDOR
TEACHER CENTER
ELEV NO. 2
CORRIDOR
STAIR NO. 5
BUSINESS
CLASSROOM
SERVER &
EQUIPMENT AREA
B
A
SECOND FLOOR - 15'
BUSINESS
CAD/COMPUTER LAB
TOILET
CORRIDOR
TOILET
OFFICE
NETWORKING TRAINING
CLASSROOM

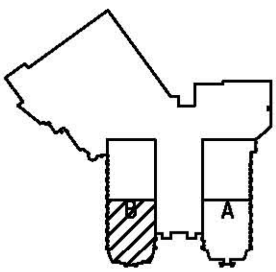

CLASSROOM
CISCO & A+ NETWORKING LAB
CLASSROOM
CORRIDOR
ASSISTANT PRINCIPAL
RECEPTION/ SECRETARIAL
STAIR NO. 4
GUIDANCE OFFICE
MEDIA PRODUCTION/ WORK ROOM
AV STORAGE
GUIDANCE OFFICE
SECOND FLOOR - 15'
B
A
TOILET
ITINERANT OFFICE
CONFERENCE
STORAGE
CORRIDOR
TOILET
LD CLASSROOM
AV STORAGE
OFFICE
BIOLOGY
BIOLOGY
STOR
PREP


TEACHER CENTER
ELEV NO. 2
CORRIDOR
STAIR NO. 1
TOILET
TOILET
CLASSROOM
CLASSROOM
CORRIDOR
CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM
B
A
THIRD FLOOR - 30'

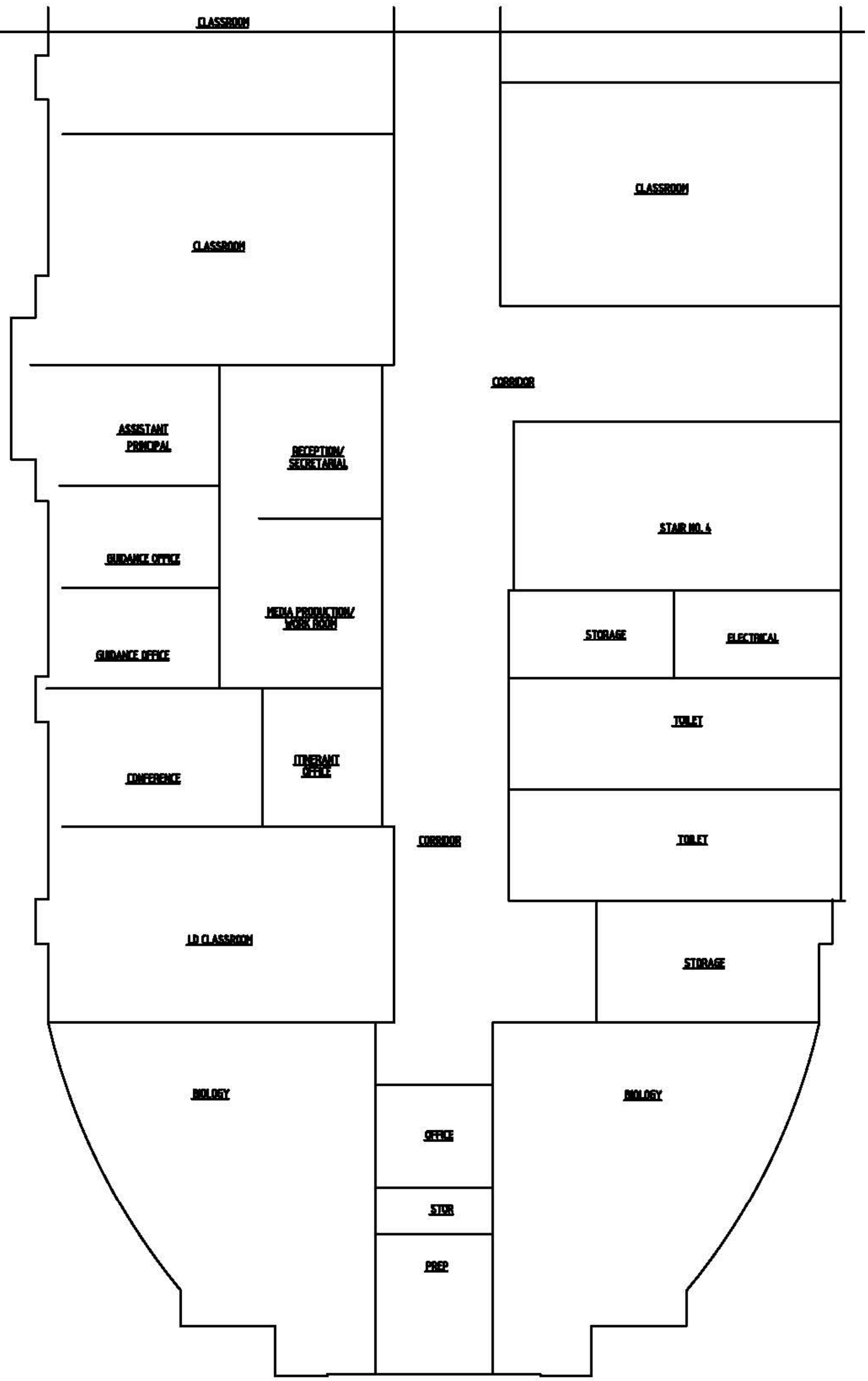

MARKETING
RECEPTION/ SECRETARIAL
ASSISTANT PRINCIPAL
GUIDANCE OFFICE
CORRIDOR
MEDIA PRODUCTION/ WORK ROOM
GUIDANCE OFFICE
STAIR NO. 2
TOILET
MEDIA RETRIEVAL
TOILET
CORRIDOR
MARKETING
BUSINESS
BIOLOGY
OFFICE
BIOLOGY
STAIR
PREP
B
A
THIRD FLOOR - 30'

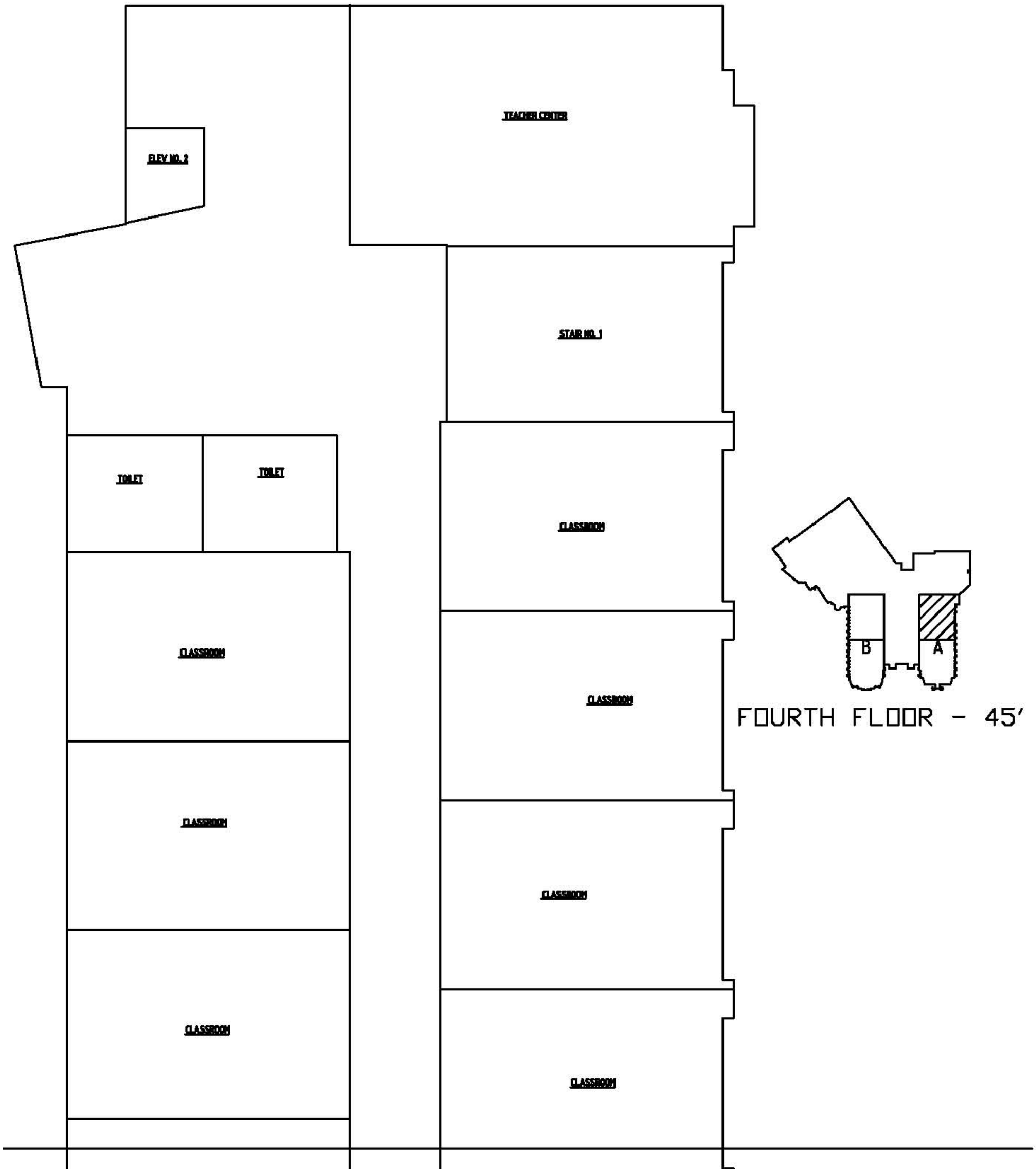


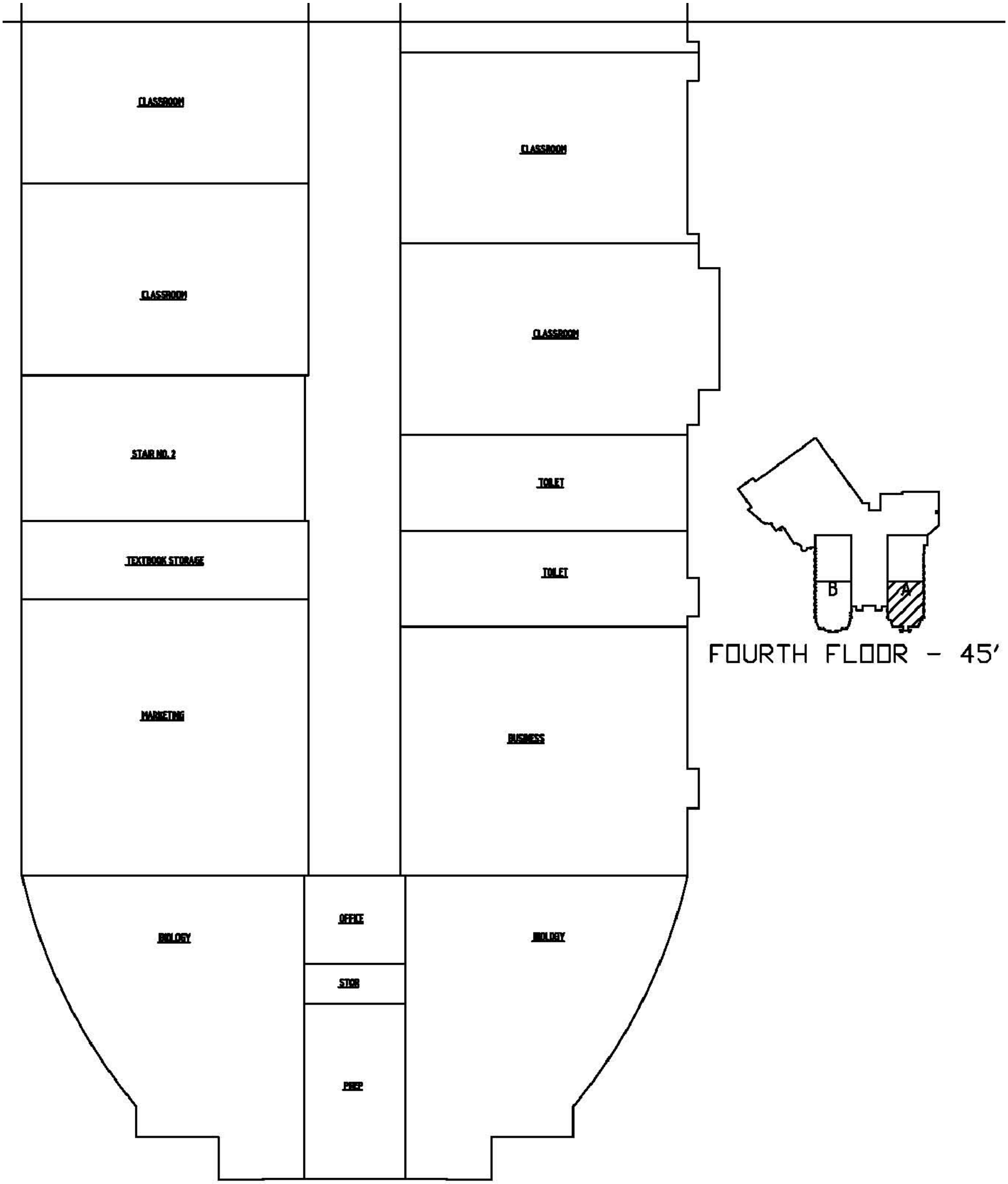
TEACHER CENTER
CORRIDOR
ELEV NO. 2
CORRIDOR
STAIR NO. 5
CLASSROOM
CHEMISTRY
B
A
THIRD FLOOR - 30'
CLASSROOM
BUSINESS
CLASSROOM
TOILET
TOILET
CORRIDOR
CLASSROOM
CLASSROOM

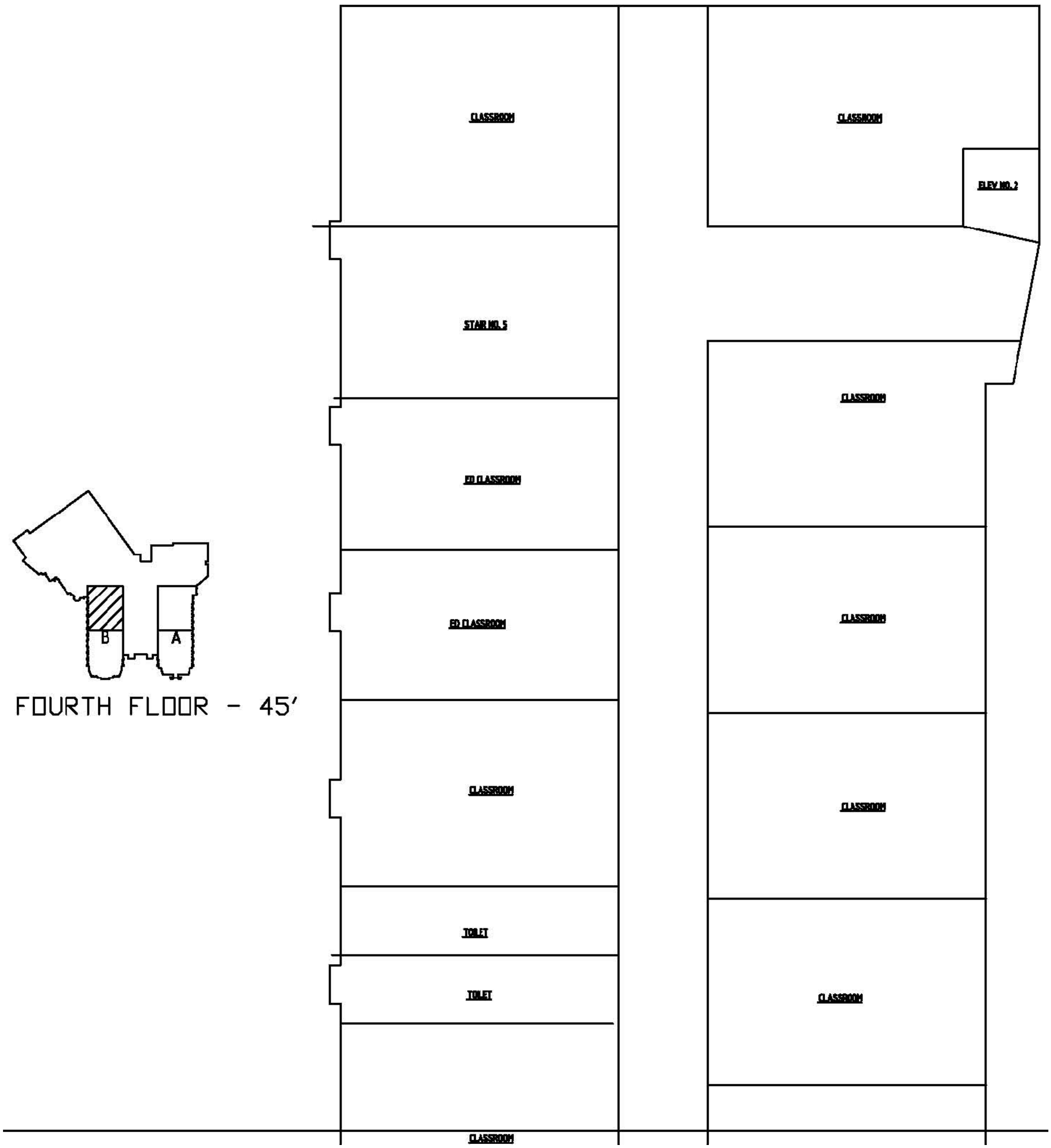


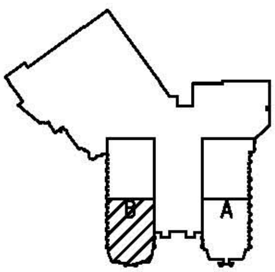
THIRD FLOOR - 30'

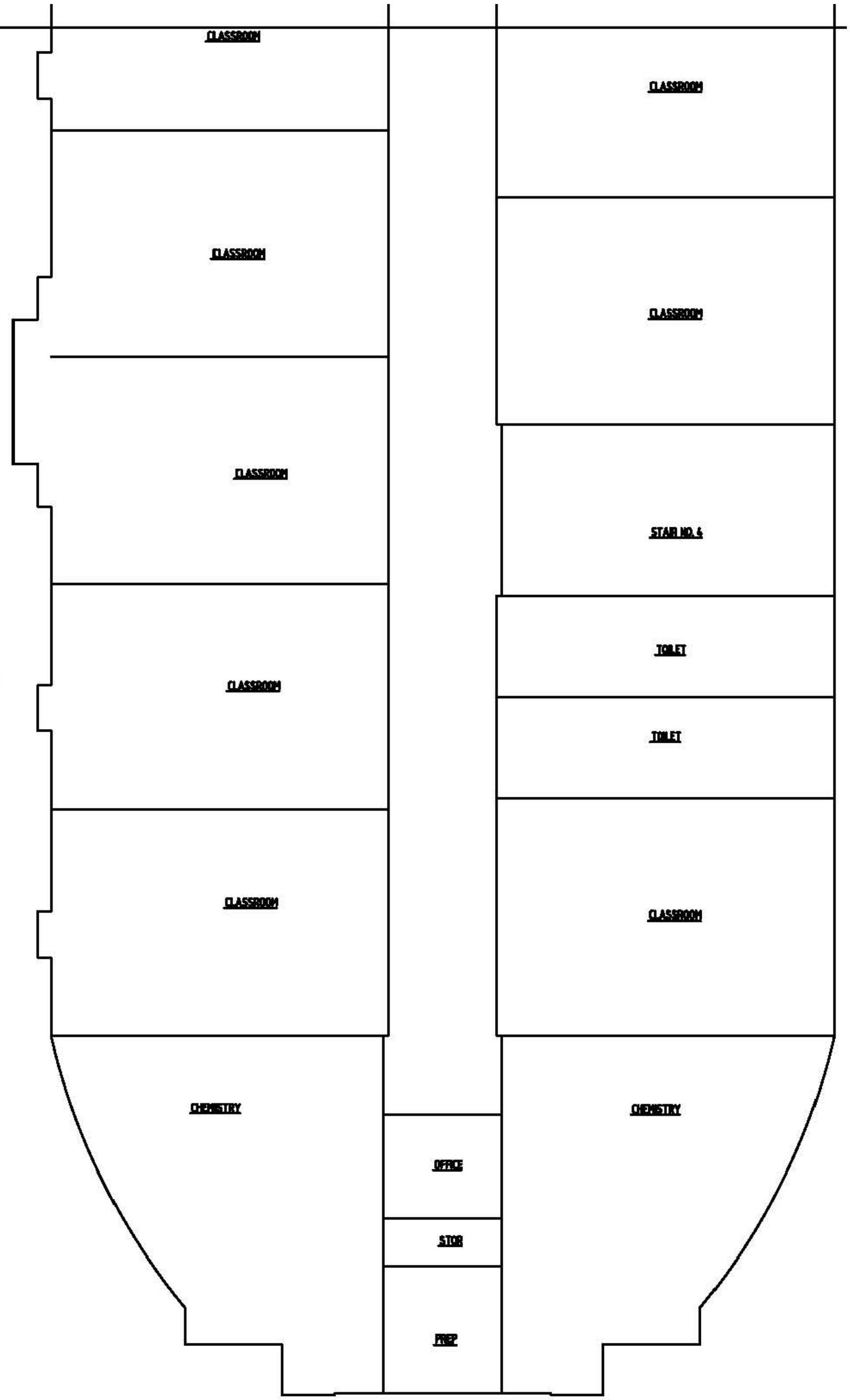


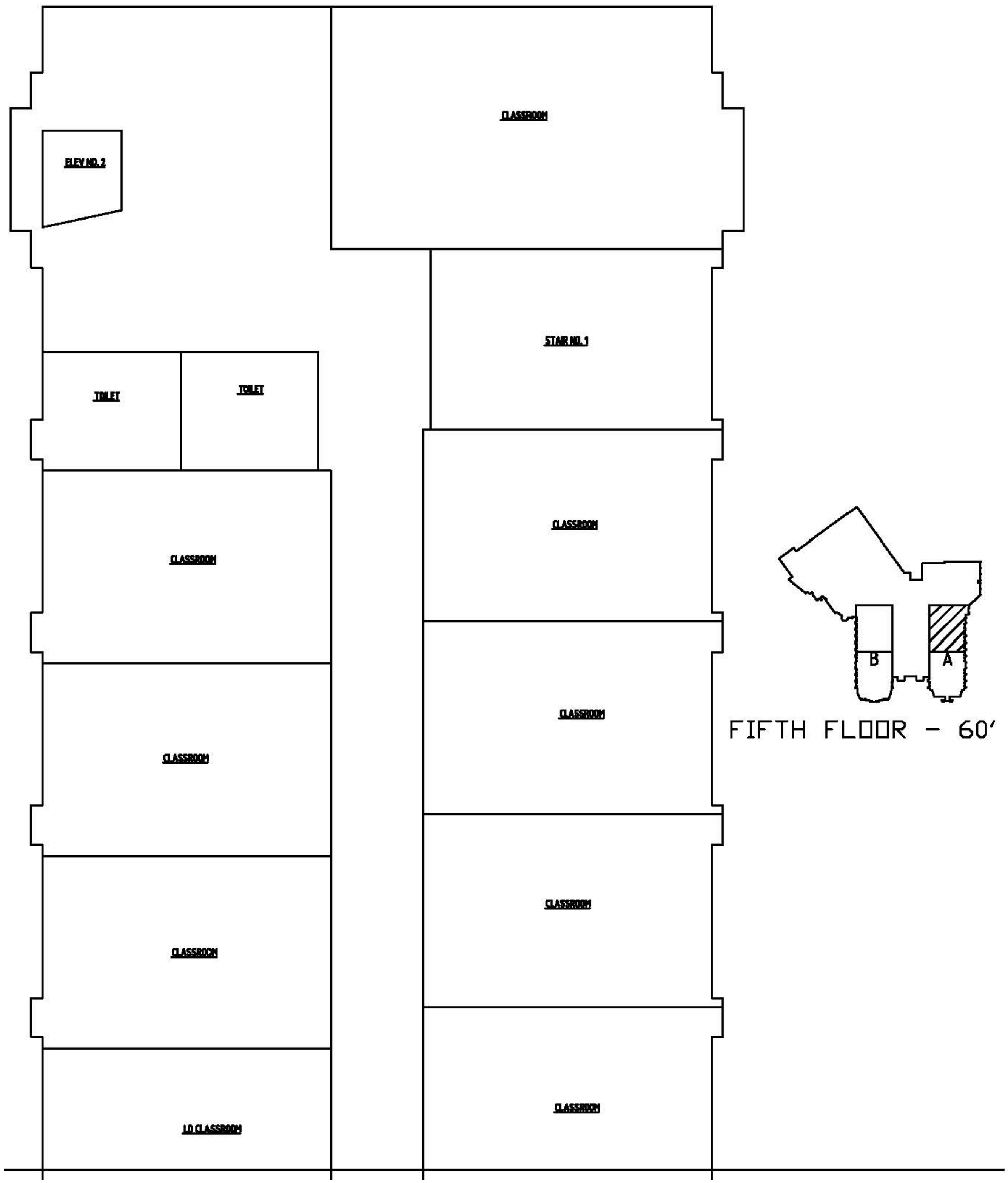

TEACHER CENTER
ELEV NO. 2
STAIR NO. 1
TOILET
TOILET
CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM
B
A
FOURTH FLOOR - 45'

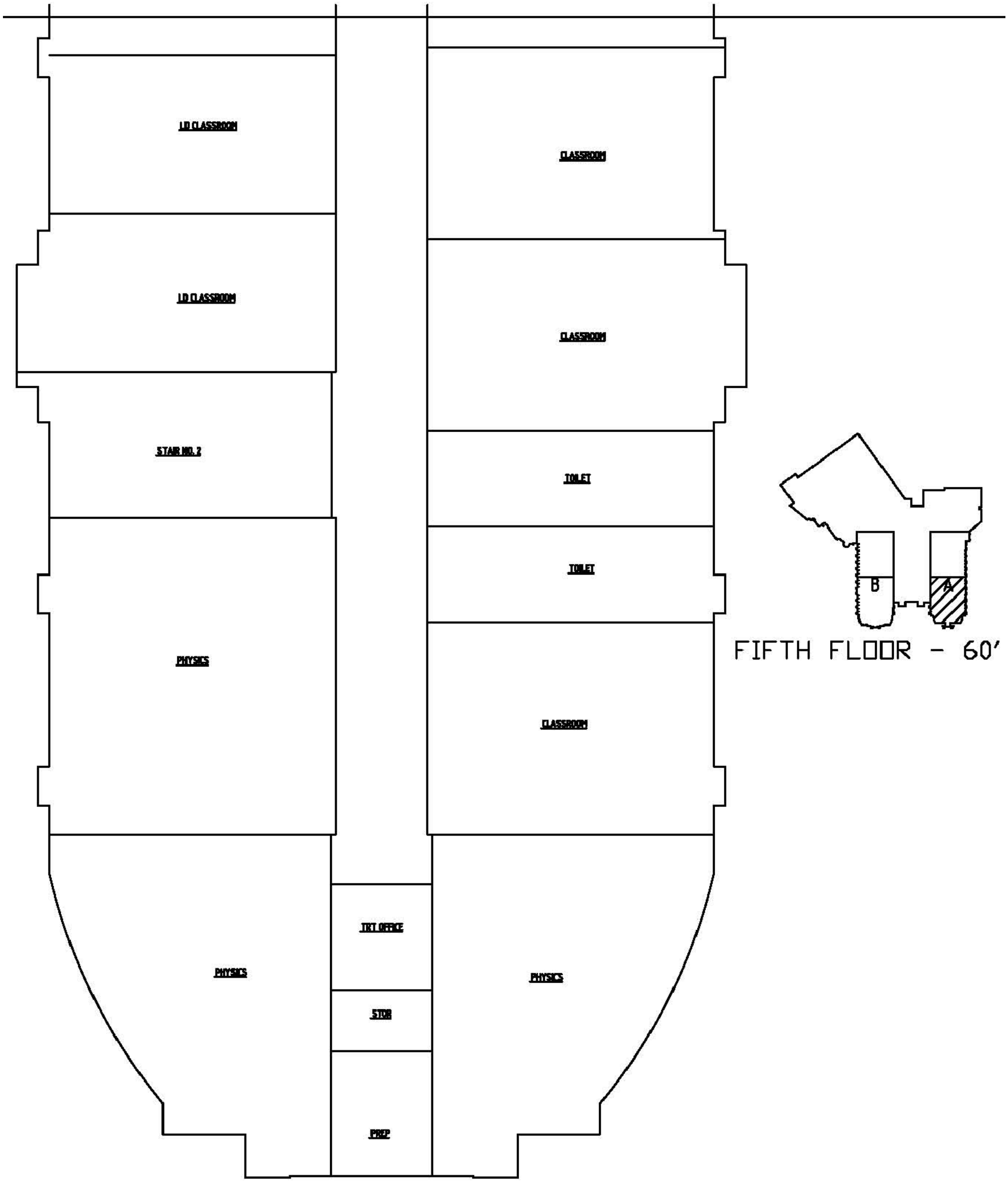

CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM
STAIR NO. 2
TOILET
TEXTBOOK STORAGE
TOILET
MARKETING
BUSINESS
BIOLOGY
OFFICE
BIOLOGY
STOR
PREP
B
A
FOURTH FLOOR - 45'

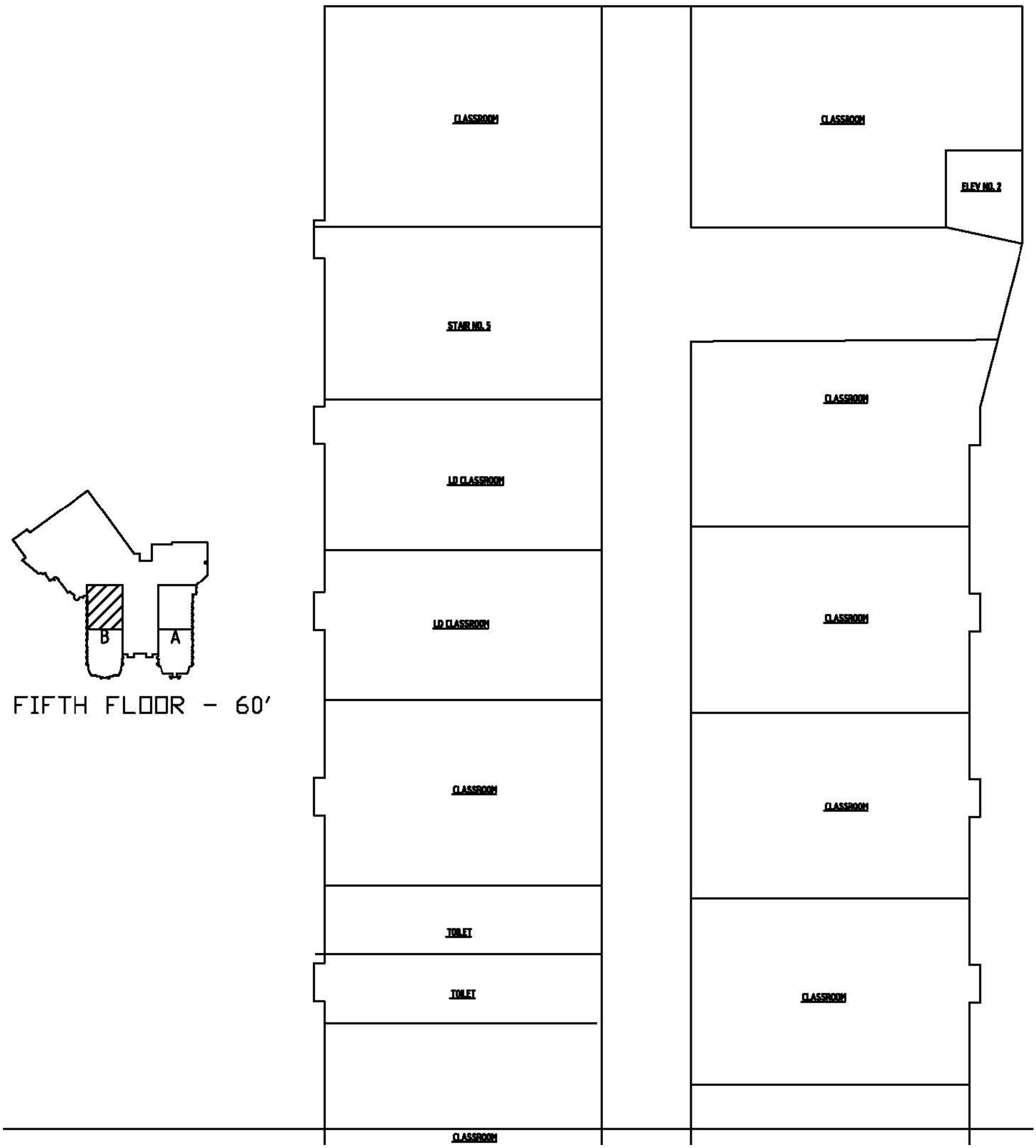

CLASSROOM
CLASSROOM
ELEV NO. 2
STAIR NO. 5
CLASSROOM
ED CLASSROOM
ED CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM
TOILET
TOILET
CLASSROOM
CLASSROOM
B
A
FOURTH FLOOR - 45'

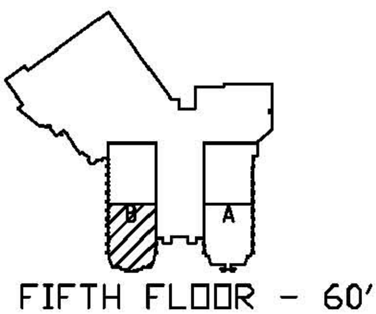

B
A
FOURTH FLOOR - 45'

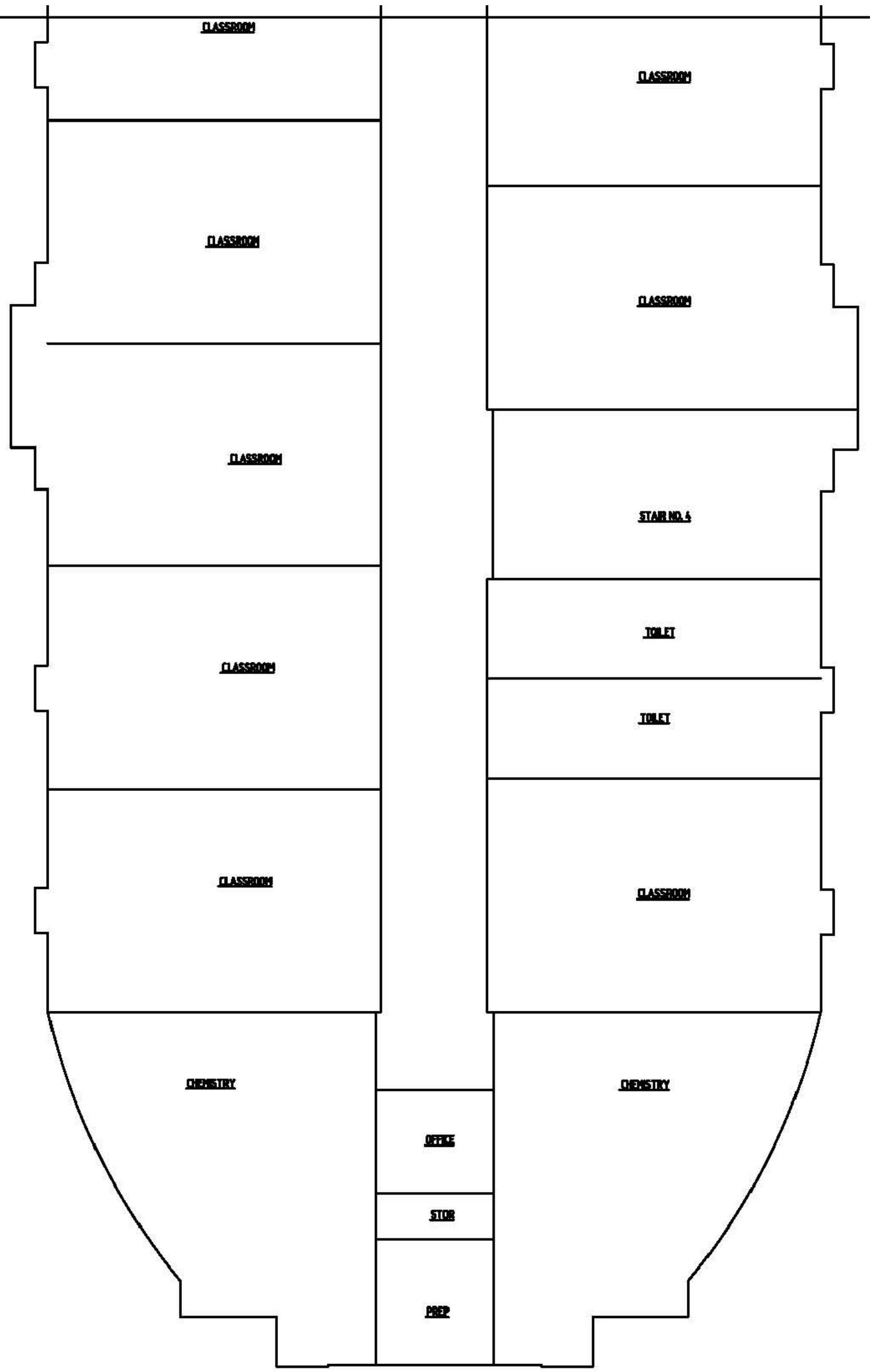

CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM
STAIR NO. 6
TOILET
TOILET
CLASSROOM
CHEMISTRY
CHEMISTRY
OFFICE
STOR
PREP


CLASSROOM
ELEV NO. 2
STAIR NO. 1
TOILET
TOILET
CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM
LD CLASSROOM
CLASSROOM
B
A
FIFTH FLOOR - 60'


LD CLASSROOM
LD CLASSROOM
STAIR NO. 2
PHYSICS
PHYSICS
CLASSROOM
CLASSROOM
TOILET
TOILET
CLASSROOM
PHYSICS
TRT OFFICE
STOR
PREP
B
A
FIFTH FLOOR - 60'


CLASSROOM
CLASSROOM
ELEV NO. 2
STAIR NO. 5
CLASSROOM
LD CLASSROOM
LD CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM
TOILET
TOILET
CLASSROOM
CLASSROOM
B
A
FIFTH FLOOR - 60'

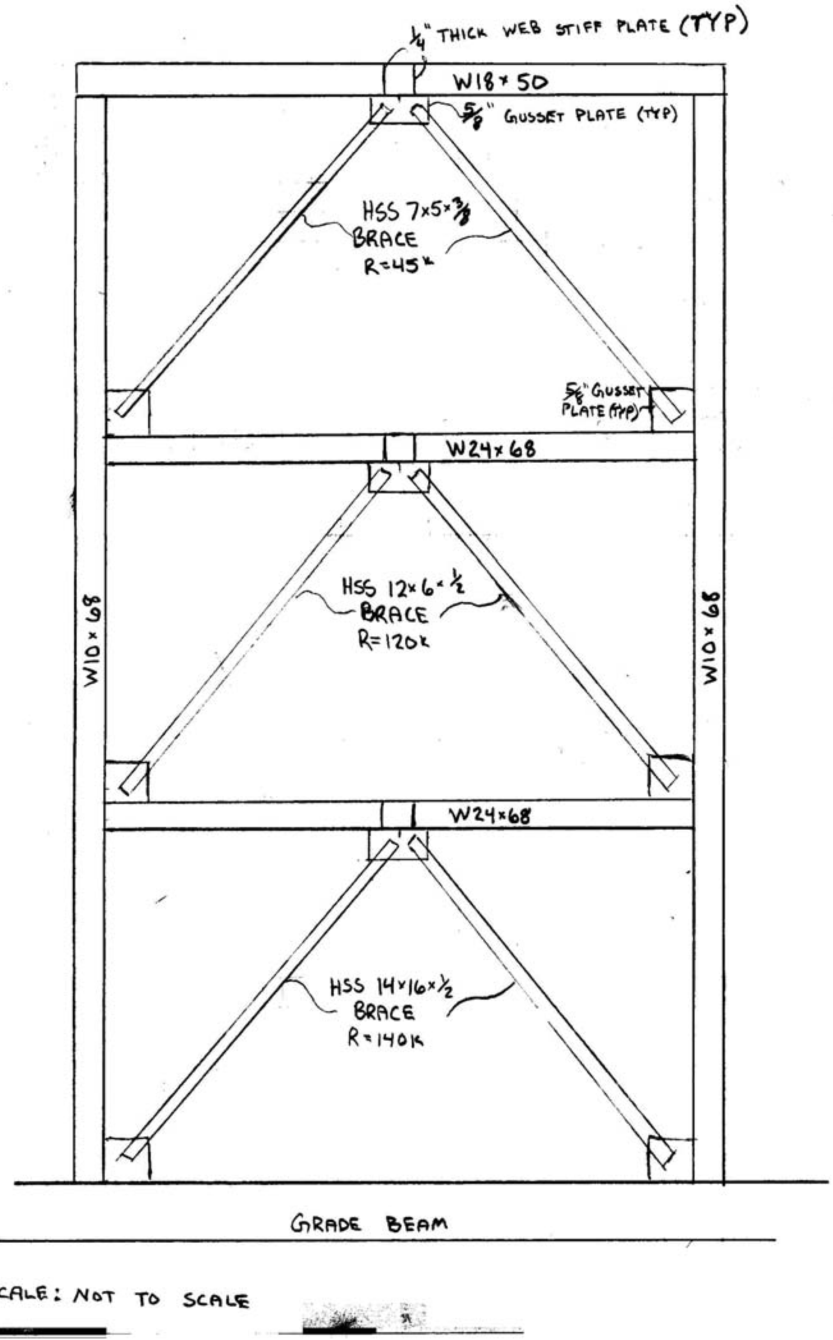

B
A
FIFTH FLOOR - 60'


CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM
STAIR NO. 4
TOILET
TOILET
CLASSROOM
CHEMISTRY
CHEMISTRY
OFFICE
STOR
PREP

APPENDIX C – STRUCTURAL CALCULATIONS

SPOT CHECK - BRACED FRAME

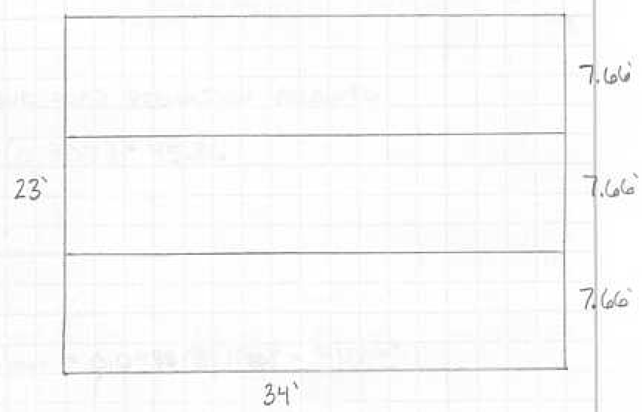
BRACE 1 DETAILS



SCALE: NOT TO SCALE

COMPOSITE JOIST DESIGN - FOR STRENGTH

JOIST GEOMETRY
1) JOIST DEPTH ~ 20"
2) JOIST SPAN ~ 34'0"
3 JOICE SPACING ~ 7.67'



DESIGN LOADS
1) NONCOMPOSITE DL
a) CONCRETE ~ 43 PSF
b) JOIST (EST) ~ 4.5 PSF
c) DECK ~ 2.5 PSF
TOTAL = 50 PSF = 383 PLF

2) CONSTRUCTION LL ~ 20.0 PSF

3) COMPISITE DL
a) MECHANICAL ~ 7 PSF
b) ELECTRICAL ~ 4 PSF
c) FIREPROOFING ~ 2 PSF
d) CEILING MISC ~ 3 PSF
TOTAL = 16 PSF = 123 PLF

4) COMPOSITE LL
a) DESIGN LL ~ 50.0 PSF
b) REDUCTION FACTOR ~ 0.907
c) REDUCED DESIGN LL ~ 46 PSF
TOTAL = 46 PSF = 353 PLF

TOTAL LOADING = 859 PLF
COMPOSITE = 476 PLF

JOIST DESIGN SUMMARY

$\boxed{\text{20 VC 1200 / 353 / 123}}$

JOIST WEIGHT = 21 PLF
USE 18 - 3/4" SHEAR STUDS
USE 2 ROWS BRIDGING
W360 = 1210 > 353 PLF ✓ OK
TL = 1200 > 859 PLF ✓ OK

CONCRETE AND DECK
1) DECK ~ 2VLI - 19 GAUGE
2) CONCRETE UNIT WEIGHT ~ 145 PSF
3) CONCRETE COMPRESSIVE STRENGTH ~ 4 KSI
4) SLAB THICKNESS ABOVE DECK ~ 2 1/2 IN

DEFLECTION
1) LIVE LOAD = $(34)(12)/360 = 1.13"$
2) TOTAL LOAD = $(34)(12)/240 = 1.70"$

LIVE LOAD REDUCTION

$L = L_o(0.25 + 15/\sqrt{A_I})$

$L_o = 50$ PSF
$A_T = 7.67' \times 34' = 260$ SF
$A_I = 521$ SF > 400 SF MIN ∴ LIVE LOAD REDUCTION ALLOWED

$L = 50^{PSF}(0.25 + 15/\sqrt{521}) = 50(0.907) = 45.36$

$L = 46$ PSF

DEFLECTIONS

$I_{EST\ NONCOMP} = 0.0488(W_{SJ})\, d^2_{JOIST} = 0.0488(21)(20)^2 = \underline{410\ IN^4}$
$W_{SJ} = 21$ PLF
$d_{JOIST} = 20"$

$\Delta_{EST\ NON\ COMP\ DL} = \dfrac{1.15(5)\, W_{NON\ COMP\ DL}\,(SPAN)^4(1728)}{384\, E_s\, I_{EST\ NONCOMP}} = \dfrac{1.15(5)(383)(\overset{33.667'}{\cancel{34'}})^4(1728)}{384(29{,}000{,}000)(410)}$

$\underline{\Delta_{ESTNC\ DL} = 1.07" = L/381}$

$\Delta_{COMP\ DL} = \dfrac{W_{C\ DL}}{W_{L/360}} \cdot \left[\dfrac{L}{360}\right] = \dfrac{123}{1210} \cdot \left(\dfrac{33.667(12")}{360}\right) = \underline{0.114"} = L/3579$

$\Delta_{COMP\ LL} = \dfrac{W_{C\ LL}}{W_{L/360}} \cdot \left[\dfrac{L}{360}\right] = \dfrac{353}{1210} \cdot \left(\dfrac{33.667'(12")}{360}\right) = \underline{0.327"} = L/1246$

$\Delta_{TL} = \Delta_{EST\ NC\ DL} + \Delta_{CDL} + \Delta_{CLL} = 1.07" + 0.114" + 0.327" = \underline{1.51"}$

$\boxed{\Delta_{TL} = 1.51" < \Delta_{TL\ MAX} = 1.70"\ \checkmark\ OK}$

SUMMARY

20 VC 1200 / 353 / 123

VC SERIES STEEL JOIST DEPTH — TOTAL LOAD ALLOWED — COMP LL ACTUAL — COMP DL ACTUAL

JOIST WEIGHT = 21 PLF JOIST BEARING DEPTH = 5"
USE 18 - 3/4" SHEAR STUDS
USE 2 ROWS BRIDGING

$\Delta_{EST\ NC\ DL} = 1.07"$
$\Delta_{COMP\ DL} = 0.114"$
$\Delta_{COMP\ LL} = 0.327"$

VULCRAFT

WEIGHT TABLE AND DESIGN GUIDE
VULCRAFT COMPOSITE STEEL JOISTS, VC SERIES

Based on Allowable Tensile Stress of 30,000 psi

Joist Span	Joist Depth	Slab Design																		
		Normal Weight Concrete (145 pcf) f 'c = 3.0 ksi																		
		tc (in)	2.00	2.00	2.00	2.00	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	3.00	3.00	3.00	3.00
		hr (in)	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0
		Js (ft)	3.5	4.0	4.0	4.5	5.0	6.0	6.5	7.0	8.0	8.5	9.0	10.0	10.0	10.0	10.0	11.0	12.0	12.0	12.0
		Total Uniformly Distributed Joist Load in Pounds Per Linear Foot																		
(ft)	(in)	TL	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1800	2000	2200	2400	2700	3000
32	12	Wtj (plf)	10	11	13	15	16	18	20	23	25	27	28	30	33	37	41	43	46	59	71
		W360 (plf)	271	348	389	452	580	657	724	766	890	957	1022	1021	1112	1245	1365	1712	1706	1916	2202
		N-ds	20-1/2	24-1/2	26-1/2	30-1/2	32-1/2	34-1/2	36-1/2	32-5/8	24-3/4	26-3/4	30-3/4	30-3/4	34-3/4	40-3/4	48-3/4	48-3/4	50-3/4	60-3/4	60-3/4
	14	Wtj (plf)	9	11	12	13	14	17	18	19	23	24	26	27	29	34	37	39	40	46	57
		W360 (plf)	304	374	442	506	635	753	838	916	982	1037	1107	1191	1273	1406	1560	1905	1910	2094	2384
		N-ds	20-1/2	22-1/2	26-1/2	28-1/2	28-1/2	32-1/2	34-1/2	38-1/2	20-3/4	20-3/4	24-3/4	26-3/4	26-3/4	34-3/4	40-3/4	42-3/4	44-3/4	50-3/4	60-3/4
	16	Wtj (plf)	9	10	11	13	13	15	17	19	21	23	24	26	26	29	34	36	39	46	47
		W360 (plf)	338	417	496	581	717	787	924	1029	1066	1166	1232	1334	1340	1550	1699	2053	2282	2526	2518
		N-ds	18-1/2	20-1/2	22-1/2	26-1/2	24-1/2	28-1/2	32-1/2	34-1/2	18-3/4	20-3/4	22-3/4	24-3/4	24-3/4	28-3/4	34-3/4	34-3/4	42-3/4	48-3/4	50-3/4
	18	Wtj (plf)	9	9	11	12	13	13	15	17	20	22	23	23	25	28	31	32	36	41	47
		W360 (plf)	364	438	531	611	779	854	928	1010	1124	1248	1366	1379	1452	1684	1792	2115	2340	2625	2908
		N-ds	18-1/2	20-1/2	22-1/2	24-1/2	24-1/2	26-1/2	28-1/2	30-1/2	18-3/4	18-3/4	20-3/4	20-3/4	22-3/4	26-3/4	30-3/4	32-3/4	36-3/4	42-3/4	50-3/4
	20	Wtj (plf)	8	9	10	12	12	13	14	15	20	21	22	22	23	26	28	30	34	38	43
		W360 (plf)	399	467	538	685	789	932	999	1084	1180	1282	1407	1417	1562	1796	1957	2251	2435	2701	3031
		N-ds	18-1/2	20-1/2	20-1/2	22-1/2	20-1/2	24-1/2	26-1/2	26-1/2	18-3/4	18-3/4	20-3/4	20-3/4	22-3/4	24-3/4	26-3/4	28-3/4	32-3/4	38-3/4	44-3/4
	22	Wtj (plf)	8	9	10	11	12	13	14	15	19	20	21	22	22	24	27	29	30	36	40
		W360 (plf)	395	489	570	718	880	966	1049	1138	1220	1327	1441	1579	1594	1775	2039	2304	2517	2963	3013
		N-ds	18-1/2	18-1/2	20-1/2	22-1/2	20-1/2	22-1/2	24-1/2	26-1/2	18-3/4	18-3/4	18-3/4	20-3/4	22-3/4	24-3/4	26-3/4	26-3/4	28-3/4	38-3/4	38-3/4
	24	Wtj (plf)	8	9	10	11	12	12	13	14	18	19	20	21	22	24	26	28	29	33	38
		W360 (plf)	426	513	643	693	875	1000	1079	1172	1236	1349	1466	1591	1747	1930	2091	2331	2554	2919	3241
		N-ds	18-1/2	18-1/2	20-1/2	20-1/2	20-1/2	20-1/2	24-1/2	26-1/2	16-3/4	14-3/4	16-3/4	18-3/4	20-3/4	22-3/4	24-3/4	24-3/4	26-3/4	32-3/4	38-3/4
	26	Wtj (plf)	8	9	10	11	12	12	13	14	18	18	19	20	21	23	24	27	29	32	35
		W360 (plf)	428	521	647	710	890	967	1102	1197	1240	1349	1475	1594	1736	1925	2135	2373	2731	2955	3147
		N-ds	18-1/2	18-1/2	20-1/2	20-1/2	18-1/2	20-1/2	20-1/2	24-1/2	12-3/4	16-3/4	16-3/4	16-3/4	18-3/4	22-3/4	24-3/4	24-3/4	26-3/4	28-3/4	32-3/4
	28	Wtj (plf)	8	9	9	10	12	12	13	14	18	18	19	20	21	22	24	27	29	32	34
		W360 (plf)	404	537	651	780	903	1048	1176	1280	1320	1439	1563	1599	1728	1902	2113	2533	2758	2940	3169
		N-ds	18-1/2	18-1/2	18-1/2	20-1/2	18-1/2	18-1/2	20-1/2	22-1/2	12-3/4	16-3/4	16-3/4	14-3/4	16-3/4	20-3/4	22-3/4	22-3/4	24-3/4	26-3/4	30-3/4
34	14	Wtj (plf)	10	11	13	15	16	18	20	22	25	27	28	30	33	36	42	43	45	56	67
		W360 (plf)	289	349	416	491	618	702	774	817	936	1019	1095	1086	1194	1345	1493	1803	1797	2051	2359
		N-ds	22-1/2	22-1/2	28-1/2	32-1/2	32-1/2	34-1/2	38-1/2	28-5/8	24-3/4	26-3/4	28-3/4	28-3/4	32-3/4	40-3/4	48-3/4	48-3/4	48-3/4	64-3/4	64-3/4
	16	Wtj (plf)	9	11	12	13	14	17	19	21	23	24	26	27	29	34	37	39	44	50	55
		W360 (plf)	312	384	452	526	652	773	858	948	998	1061	1149	1241	1330	1462	1651	1965	2164	2267	2490
		N-ds	20-1/2	22-1/2	24-1/2	26-1/2	29-1/2	34-1/2	34-1/2	38-1/2	22-3/4	24-3/4	24-3/4	26-3/4	28-3/4	34-3/4	40-3/4	40-3/4	48-3/4	56-3/4	64-3/4
	18	Wtj (plf)	9	10	11	13	14	16	17	19	22	23	24	26	27	30	34	37	42	47	50
		W360 (plf)	340	420	507	581	714	840	925	1029	1061	1166	1240	1339	1448	1568	1723	2046	2299	2524	2647
		N-ds	20-1/2	22-1/2	22-1/2	26-1/2	26-1/2	30-1/2	34-1/2	34-1/2	20-3/4	20-3/4	22-3/4	24-3/4	26-3/4	28-3/4	36-3/4	36-3/4	42-3/4	48-3/4	56-3/4
	20	Wtj (plf)	9	10	11	12	13	15	16	18	21	22	23	25	26	30	31	36	38	42	47
		W360 (plf)	360	456	539	643	771	900	984	1070	1210	1241	1363	1452	1545	1685	1791	2287	2323	2590	2854
		N-ds	20-1/2	22-1/2	22-1/2	24-1/2	24-1/2	26-1/2	28-1/2	34-1/2	18-3/4	18-3/4	20-3/4	22-3/4	24-3/4	28-3/4	32-3/4	36-3/4	36-3/4	44-3/4	50-3/4
	22	Wtj (plf)	9	10	11	12	13	14	15	17	20	21	22	23	24	29	30	33	38	42	44
		W360 (plf)	384	498	557	690	822	881	1031	1115	1219	1262	1396	1544	1560	1760	1889	2314	2568	2887	2910
		N-ds	20-1/2	22-1/2	22-1/2	24-1/2	22-1/2	24-1/2	26-1/2	28-1/2	18-3/4	18-3/4	18-3/4	20-3/4	22-3/4	24-3/4	28-3/4	30-3/4	36-3/4	42-3/4	44-3/4
	24	Wtj (plf)	9	10	10	11	12	14	15	16	20	21	21	22	24	28	29	31	35	40	44
		W360 (plf)	401	508	608	701	856	924	1073	1147	1240	1372	1404	1553	1721	1814	1951	2432	2563	2853	3189
		N-ds	20-1/2	22-1/2	22-1/2	22-1/2	22-1/2	22-1/2	26-1/2	28-1/2	16-3/4	18-3/4	16-3/4	18-3/4	20-3/4	22-3/4	26-3/4	28-3/4	30-3/4	36-3/4	42-3/4
	26	Wtj (plf)	9	10	10	11	12	14	15	16	19	20	21	22	22	26	28	29	33	38	42
		W360 (plf)	418	517	625	708	844	950	1079	1171	1249	1376	1521	1537	1708	1896	2003	2445	2611	2798	3087
		N-ds	20-1/2	22-1/2	22-1/2	22-1/2	20-1/2	22-1/2	18-5/8	26-1/2	16-3/4	16-3/4	18-3/4	18-3/4	18-3/4	22-3/4	24-3/4	28-3/4	28-3/4	32-3/4	36-3/4
	28	Wtj (plf)	9	10	10	11	12	14	15	16	19	19	21	22	22	26	26	28	32	38	42
		W360 (plf)	441	531	625	721	905	1006	1092	1182	1254	1382	1507	1652	1668	1937	2201	2433	2567	2977	3308
		N-ds	20-1/2	20-1/2	22-1/2	22-1/2	20-1/2	18-5/8	18-5/8	18-5/8	14-3/4	16-3/4	16-3/4	18-3/4	18-3/4	22-3/4	24-3/4	24-3/4	24-3/4	32-3/4	36-3/4
	30	Wtj (plf)	9	9	10	11	12	14	14	16	19	19	21	22	22	23	26	28	31	35	38
		W360 (plf)	440	534	667	725	897	981	1130	1136	1220	1345	1464	1585	1713	1984	2111	2354	2754	2918	3137
		N-ds	20-1/2	20-1/2	22-1/2	22-1/2	20-1/2	16-5/8	22-1/2	18-5/8	14-3/4	14-3/4	14-3/4	16-3/4	18-3/4	20-3/4	22-3/4	22-3/4	26-3/4	28-3/4	32-3/4
Bridging Rows			2					1												

Joist weights to the left of the heavy red line have 2 1/2 inch depth bearings. Joist weights between the heavy red and black lines have 5 inch depth bearings. Joist weights between the heavy black and blue lines require 7 1/2 inch depth bearings.

28

Back to Table of Contents

EXTERIOR 14" CMU

TRY UNGROUTED 14" CMU ~ 72 PSF $I = 1700 \text{ in}^4/\text{ft}$
-FULLY BEDDED $A = 64 \text{ in}^2/\text{ft}$

(3) CONDITIONS
1. STABILITY $w = 14.8$ PSF $\approx$ 15 PSF
2. COMPRESSIVE
3. TENSILE

LOAD COMBINATION: $0.9D + 1.6W$
$1.4D$ - SW ONLY

1. STABILITY

$P_u = 1.4(72 \cdot 65') = 6552$ PLF

$P_n = 0.8\left[0.8 A_n f'_m \left(\frac{70r}{h}\right)^2\right] = 13{,}124$ PLF

$r = \sqrt{I/A} = \sqrt{1700/64} = 5.15$

$h/r = 65 \cdot 12 / 5.15 = 151.5$

$\phi P_n = (0.6)(13{,}124) = 7875 > P_u = 6{,}552$ ✓ OK

2. COMPRESSIVE

$f_b = \frac{P_u}{A} + \cancel{\frac{M_u c}{I}}$ ≈ 0

$= 6552/64 = 102$ PSI

$F_b = \phi\, 0.8 f'_m = 720 \text{ PSI} > f_b = 102 \text{ PSI}$ ✓ OK

3. TENSILE : $f_t = -\frac{P_u}{A} + \frac{M_u c}{I}$

$P_u = 0.9D = 0.9(72 \times (50 + 15/2)) = 3726$ lb

$M_w^{MID} = \frac{wh^2}{8} = \frac{(15)(15)^2}{8} = 422$ lb-ft $= 5063$ in-lb

$M_u = 1.6(5063) = 8100$ in-lb

$f_t = \left(-3726/64\right) + \left(\frac{8100 \cdot 13.625/2}{1700}\right) = -58.2 + 32.5$ ✓

NO TENSION ✓ OK

$\boxed{\text{USE 14" HOLLOW UNGROUTED CMU (FULLY BEDDED)}}$

EXTERIOR 8" CMU

TRY 8" FULLY GROUTED CMU w/ #5@16" O.C.

$f'_m = 1500^{PSI}$

$f_y = 40{,}000^{PSI} \Rightarrow F_s = 20{,}000^{PSI}$

1) $P_0 = 0.25 f'_m A_n$

$= 0.25(1500)(7.63 \times 16" - 0.31")$

$= 45{,}634^{lb}$ PER 16" $\Rightarrow$ 34,225 lb/FT

2) PURE FLEX

$d = 7.625/2 = 3.81"$

$jd = d - kd/3 \approx \frac{7}{8}d = 3.33"$

$M = A_s F_s jd = (0.31)(20{,}000)(3.33) = 20{,}646$ IN-lb/16"

$M = 15{,}485$ IN-lb/FT

3) BALANCE POINT

$n = E_s/E_m$

$E_m = 900 f'_m = 900(1500) = 1{,}350{,}000^{PSI}$

$n = \frac{29000000}{1350000} = 21.48$

$k_b = n/(F_s/F_b) + n = \frac{21.48}{\left(\frac{20{,}000}{500} + 21.48\right)} = 0.349$

$T = A_s F_s = (0.31)(20{,}000) = 6200^{lb}$

$C = \frac{1}{2} F_b k_b d b = \frac{1}{2}(500)(0.349)(3.81)(16) = 5{,}319^{lb}$

$P = C - T = 5{,}319 - 6{,}200 = -881$ lb/16"

$P_b = -661$ lb/FT

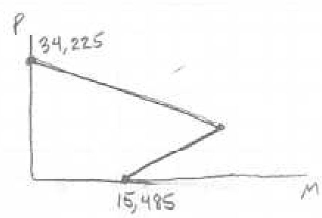
$M = T(d - h/2) + C(h/2 - k_b d/3)$

$= 6{,}200(0) + 5319\left(\frac{7.63}{2} - \frac{0.349 \times 3.81}{3}\right) = 17{,}934$ IN-lb/16"

$M_b = 13{,}450$ IN-lb/FT

$P_b = 661$ lb/FT

$M_b = 13{,}450$ IN-lb/FT



EXTERIOR 8" CMU

DETERMINE (P,M) @ MID HT
LOAD = 0.6D + W

$P = 0.6(80 \times (60 + 15/2)) = 3240$ lb/FT

$M = wh^2/8 = (15)(15)^2/8 = 422$ ft·lb $= 5063$ IN·lb/FT

$(P,M) = (3240, 5063)$ ✓OK

$\boxed{\text{USE 8" CMU FULLY GROUTED REINFORCED 16" O.C.}}$

ROOF JOISTS
NOT SUPPORTING MECH UNITS .

$l = 25'$
$DL = 25$ PSF
$LL = 20$ PSF
SPACING $= 5'$

$L = 1.6(20)(5) = 160^{PLF}$
$T = 1.2(25)(5) + 1.6(20)(5) = 310^{PLF}$

USE 18K3
$TL = 441 > 310^{PLF}$ ✓ ok
$LL = 214 > 160^{PLF}$ ✓ ok

CHECK DEFLECTION

$I_j = 26.767(W_{LL})(L^3)(10^{-6})$
$W_{LL} = 214$
$L = 24.67'$

$I_j = 86 \text{ IN}^4$

$\Delta_L = L/360 = 0.88"$
$\Delta_T = L/240 = 1.25"$

$$\Delta_L = \frac{5(0.160)(25)^4(1728)}{384(29000)(86)} = 0.57" < 0.83" \checkmark \text{ ok}$$

$$\Delta_T = \frac{5(0.310)(25)^4(1728)}{384(29000)(86)} = 1.09" < 1.25" \checkmark \text{ ok}$$

USE 18K3 SPACED 5' O.C. (SPAN = 25')

USE TYPE B 1.5" 18 GAGE DECKING

ROOF JOISTS SUPPORTING MECHANICAL UNITS

SPAN = 25'
DL = 25 PSF
LL = 150 PSF - (CONS. FOR MECH UNITS)
SPACING = 3'

$TL = 1.2(25) + 1.6(150) = 270^{PSF}$
$TL = 810^{PLF} < 825^{PLF}$ MAX

$V_{MAX} = w(\frac{l}{2}) = 810(\frac{25}{2}) = 10{,}125^{lb}$

$M_{MAX} = \frac{wl^2}{8} = \frac{810(25)^2}{8} = 759.4^{IN \cdot K}$

TRY 24 KCS 3
$I = 301 \, IN^4$

$V = 10{,}800 > 10{,}125^{lbs}$ ✓ OK
$M = 1080 > 759^{IN \cdot K}$ ✓ OK

CHECK DEFLECTION

$\Delta_L = \frac{L}{360} = 0.83''$
$\Delta_T = \frac{L}{240} = 1.25''$

$$\Delta_L = \frac{5(\overset{1.6(150)(3')}{0.720})(25)^4(1728)}{384(29000)(301)} = 0.73'' < 0.83'' \text{ ✓ OK}$$

$$\Delta_T = \frac{5(0.810)(25)^4(1728)}{384(29000)(301)} = 0.82'' < 1.25'' \text{ ✓ OK}$$

$\boxed{\text{USE 24 KCS 3 SPACED 3' O.C.}}$ (SPAN = 25')

$\boxed{\text{USE TYPE B 1.5'' 18 GAGE DECKING}}$

ROOF
JOISTS - SLOPPED

$l = 12'$
DL = 25 PSF
LL = 20 PSF
SPACING = 5'

$L = 1.6 \times 20 \times 5 = 160^{PLF}$
$T = 1.2(25)(5) + 1.6(20)(5) = 310^{PLF}$

USE 10K1
$TL = 825 > 310^{PLF}$ ✓ ok
$LL = 455 > 160^{PLF}$ ✓ ok

CHECK DEFLECTION

$I_j = 26.767(W_{LL})(L^3)(10^{-6})$
$W_{LL} = 455$
$L = 11.67$

$I_j = 19.36 \, IN^4$

$\Delta_{LIVE} = L/360 = 0.40"$
$\Delta_{TOTAL} = L/240 = 0.60"$

$$\Delta_T = \frac{5(0.310)(12)^4(1728)}{384(29000)(19.36)} = 0.26" < 0.60" \checkmark \text{ ok}$$

$$\Delta_L = \frac{5(0.160)(12)^4(1728)}{384(29000)(19.36)} = 0.14" < 0.40" \checkmark \text{ ok}$$

$\boxed{\text{USE 10K1 SPACED 6' O.C.}}$ (SPAN = 12')

$\boxed{\text{USE TYPE B 1.5" - 22 GAGE DECKING}}$

SEISMIC

IMP CAT III - $I_E = 1.25$

SEIS CAT II - SUG = II

SITE CLASS - D

ALEXANDRIA, VA 22302

$S_S = 15.3\%$ $F_a = 1.6$
$S_1 = 5.0\%$ $F_v = 2.4$

$S_{MS} = F_a S_S = (1.6)(0.153) = 0.2448$

$S_{M1} = F_v S_1 = (2.4)(0.05) = 0.120$

$S_{DS} = \frac{2}{3} S_{MS} = (\frac{2}{3})(0.2448) = \underline{0.1632}$

$S_{D1} = \frac{2}{3} S_{M1} = (\frac{2}{3})(0.120) = \underline{0.080}$

FOR $S_{DS} = 0.1632$ & SUG II $\Rightarrow$ SDC = A
FOR $S_{D1} = 0.80$ & SUG II $\Rightarrow$ SDC = B - CONTROLS

SEIS. DES. CAT. B

USE INTERMEDIATE REINFORCED SHEAR WALLS (REINF SPACING $\leq 48"$)
$\underline{R = 4.0}$

BUILDING HEIGHT - 75'

DETERMINE T
$S_{D1} = 0.80 \leq 0.1 \Rightarrow C_u = 1.7$

$T_a = C_T h_n^x = 0.02 (75)^{0.75} = 0.51$

$T = C_u T_a = 1.7(0.51) = \underline{0.867 s}$

DETERMINE C_S

$C_S \leq S_{D1} / (\frac{R}{I} \times T) = 0.08 / (\frac{4.0}{1.25} \times 0.867) = 0.029$ - CONTROLS

$C_S \geq 0.044 S_{DS} I = 0.044 (0.1632)(1.25) = 0.009$

$C_S = SDS / (\frac{R}{I}) = 0.1632 / (4.0/1.25) = 0.051$

$\boxed{C_S = 0.029}$

BUILDING WEIGHT

DEAD LOAD
- SLAB + DECK - 45 PSF
- JOISTS - 2 PSF
- MECHANICAL - 7 PSF
- ELECTRICAL - 4 PSF
- FIRE PROOFING - 2 PSF

TOTAL = 60 PSF

NO STORAGE
ROOF SNOW (FLAT) < 30 PSF

EXT WALLS - 80 PSF

INT WALLS - 35 PSF

FLOOR 2, 3, 4, 5
AREA = 20,830 SF / FL
EXT WALLS = (15')(380') = 5700 SF/FL
INT WALLS = (10'8")(1288') = 13,740 SF/FL

WEIGHT = (20,830)(60 PSF) + (5700)(80 PSF) + (13,740)(35 PSF)
= 2,200 K / FLOOR

ROOF
AREA = 20,830 SF
EXT WALLS = (7.5')(380') = 2850 SF
INT WALLS = (3.167')(1288') = 4080 SF

WEIGHT = (20,830)(60 PSF) + (2850)(80 PSF) + (4080)(35 PSF)
= 1,620 K

TOTAL WEIGHT = 10,420 K
C_s = 0.029

$V = C_s \cdot W = 302^k$

BASE SHEAR

$\boxed{V = 302^k}$

VERT DIST OF FORCES

$F_x = C_{vx} \cdot V$

$C_{vx} = \frac{w_x h_x^k}{\Sigma w_i h_i^k}$; $T = 0.867s \Rightarrow k = 1.18$

$\Sigma w_i h_i^k = 2200(15)^{1.18} + 2200(30)^{1.18} + 2200(45)^{1.18} + 2200(60)^{1.18} + 1620(75)^{1.18}$

$\Sigma w_i h_i^k = 912{,}000$ 'K

$C_2 = \frac{2200(15)^{1.18}}{912{,}000} = 0.059$

$C_3 = \frac{2200(30)^{1.18}}{912{,}000} = 0.133$

$C_4 = \frac{2200(45)^{1.18}}{912{,}000} = 0.215$

$C_5 = \frac{2200(60)^{1.18}}{912{,}000} = 0.302$

$C_{RF} = \frac{1620(75)^{1.18}}{912{,}000} = 0.290$

$F_2 = (0.059)(302^k)$

$F_3 = (0.133)(302^k)$

$F_4 = (0.215)(302^k)$

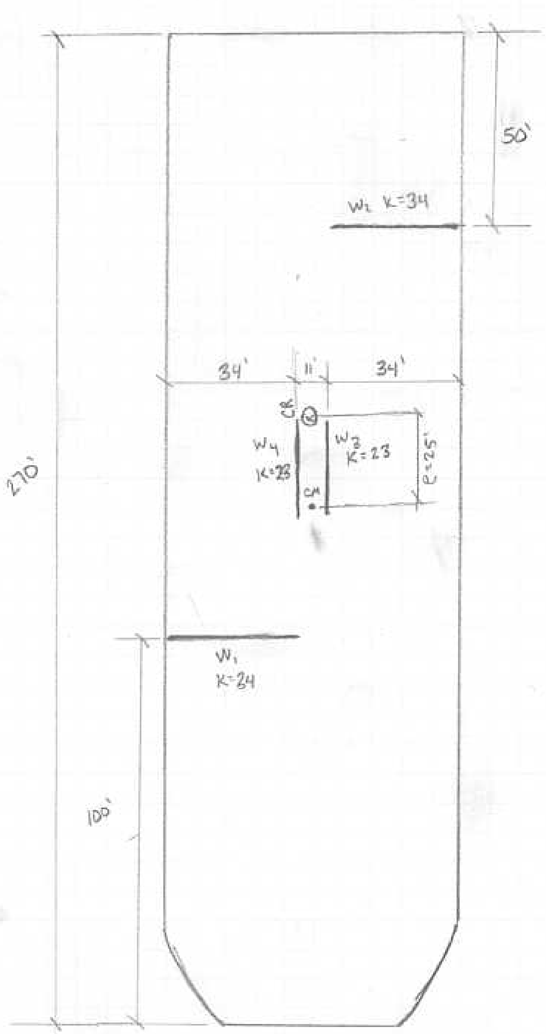
$F_5 = (0.302)(302^k)$

$F_{RF} = (0.290)(302^k)$

$F_2 = 17.8^k$
$F_3 = 40.3^k$
$F_4 = 65.0^k$
$F_5 = 91.3^k$
$F_{RF} = 87.5^k$

MASONRY SHEAR WALLS

TORSION DESIGN



MASONRY SHEAR WALLS

TORSION

LOCATE CR

$$\bar{X} = \frac{\Sigma x_i L_i}{\Sigma L_i} = \frac{(100')(34') + (220')(34')}{34' + 34'} = 160'$$

$\bar{X} = 160'$

ECCENTRICITY

$e = 135' - 160' = 25'$

$e_x = 25'$

$e_y = 0'$

POLAR MOMENTS OF INERTIA

$J = \Sigma k_i y_i^2 + \Sigma k_i x_i^2$ x_i, y_i MEASURED FROM CR

$J = (2)(23)(5.5)^2 + (34)(60)^2 + (34)(60)^2$

$\underline{J = 246{,}192 \text{ FT·K}}$

TORSIONAL SHEAR

$F_{wi} = k_i x_i \cdot \frac{V_{DIAPH} \cdot e_x}{J}$

$F_{w1} = (34)(60) \frac{V(25')}{246{,}192} = 0.207 V_{DIAPH}$

$F_{w2} = 0.207 V_{DIAPH}$

$F_{w3} = (23)(5.5) \frac{V(25')}{246{,}192} = 0.0128 V_{DIAPH}$

$F_{w4} = 0.0128 V_{DIAPH}$

$V_{D2} = 75.2^k$

$V_{D3} = 86.8^k$

$V_{D4} = 94.6^k$

$V_{D5} = 100.4^k$

$V_{DR} = 52.8^k$

$F_{w1,2\,F2} = 15.58^k$

$F_{w1,2\,F3} = 17.98^k$

$F_{w1,2\,F4} = 19.60^k$

$F_{w1,2\,F5} = 20.80^k$

$F_{w1,2\,RF} = 10.94^k$

$$\left.\begin{array}{l} F_{w34\,F2} = \\ F_{w34\,F3} = \\ F_{w34\,F4} = \\ F_{w34\,F5} = \\ F_{w34\,RF} = \end{array}\right\} \approx 1^k \text{ EACH (NEGLIGABLE)}$$

DIRECT SHEAR

$V_{w1} = V_{w2} = V_{DIAPH} \cdot \frac{k_1}{k_1 + k_2} = 0.5 V_{DIAPH}$

$V_{w1\,F2} = 37.6^k$

$V_{w1\,F3} = 43.4^k$

$V_{w1\,F4} = 47.3^k$

$V_{w1\,F5} = 50.2^k$

$V_{w1\,RF} = 26.4^k$

TOTAL SHEARS

MAX SHEARS:

$$\boxed{\begin{array}{l} V_{F2} = 53.2^k \\ V_{F3} = 61.4^k \\ V_{F4} = 66.9^k \\ V_{F5} = 71.0^k \\ V_{RF} = 37.3^k \end{array}}$$

MASONRY SHEAR WALLS

FLOORS 2, 3, 4, 5 - FORCES DIST ON STIFFNESS

ROOF - FORCES DIST BY TRIB AREA

E-W RESISTING WALLS

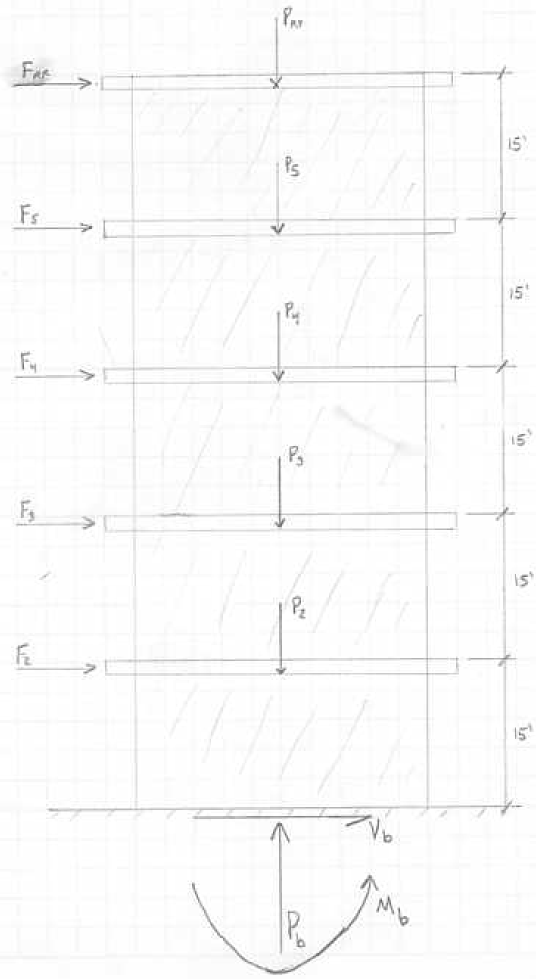
- 2 EQUAL WALLS W/ 2 EQUAL TRIB AREAS
- EACH WALL TAKES $\frac{1}{2}$ TH LOAD
- WIND CONROLS IN THIS DIRECTION

FACTORED LOAD

F_2 - 75.2^k		$F_2 = 53.2^k$
F_3 - 86.8^k	$\frac{1}{2}$	$F_3 = 61.4^k$
F_4 - 94.6^k	=>	$F_4 = 66.9^k$
F_5 - 100.4^k	+ TORSION	$F_5 = 71.0^k$
F_{RF} - 52.8^k		$F_{RF} = 37.3^k$

$V_b = 205^k$

$M_b = 8986^{FT.K}$
$= 107{,}838^{INK}$



STRENGTH DESIGN

EQUATIONS: $\varepsilon_{si} = \varepsilon_{mu}\left(\frac{d-c}{c}\right)$

$f_{si} = \varepsilon_{si} \cdot E_s \Rightarrow \le 60{,}000$

$T_{si} = A_s f_{si}$

$a = 0.80\,c$

$C_m = 0.8(f'_m)(a)(t)$

$C + T = 0$

CONSTANTS:
$f'_m = 1500^{psi}$
$f_y = 60{,}000^{psi}$
$t = 7.625''$
$l = 408''$
$\varepsilon_{mu} = 0.0025$
$E_s = 29\times10^6$
$A_s = 0.31''$
$d_v = 404''$
FULLY GROUTED

FROM EXCELL SPREADSHEET
$C = 73.024$ IN

FOR #5 REINF @ 8" O.C.
$a = 58.42''$
$C_m = -534{,}536$
$C + T = 0$

$M_n = 134{,}576{,}975^{\,in\cdot lb} \Rightarrow \underline{\phi M_n = 121{,}120^{\,in\cdot k}}$

$\underline{M_u = 107{,}838^{\,in\cdot k} \le \phi M_n = 121{,}120^{\,in\cdot k}}$ ✓ ok

$\boxed{\text{USE \#5 @ 8" O.C. VERT}}$

SHEAR DESIGN
$M_u = 107{,}838^{\,in\cdot k}$
$V_u = 205^{k}$
$d = 404''$

CHECK $\frac{M_u}{V_u d} = \frac{107{,}838}{205(404)} = 1.3 > 1.0$

$\therefore V_n \le 4 A_n \sqrt{f'_m} = 4(7.625 \times 404)\sqrt{1500}$
$V_n = 447^{k}$

$V_s = 0.5\left(\frac{A_v}{s}\right) f_y d_v$

$\frac{A_v}{s} = \frac{205{,}000}{0.5(60{,}000)(404)} = 0.0169$

USE #4 REINF, $A_s = 0.20$ IN

$S_{REQ} = \frac{0.20}{0.0169} = 11.83$ IN $\Rightarrow$ USE $\boxed{\text{\#4 @ 8" O.C. HORIZ.}}$

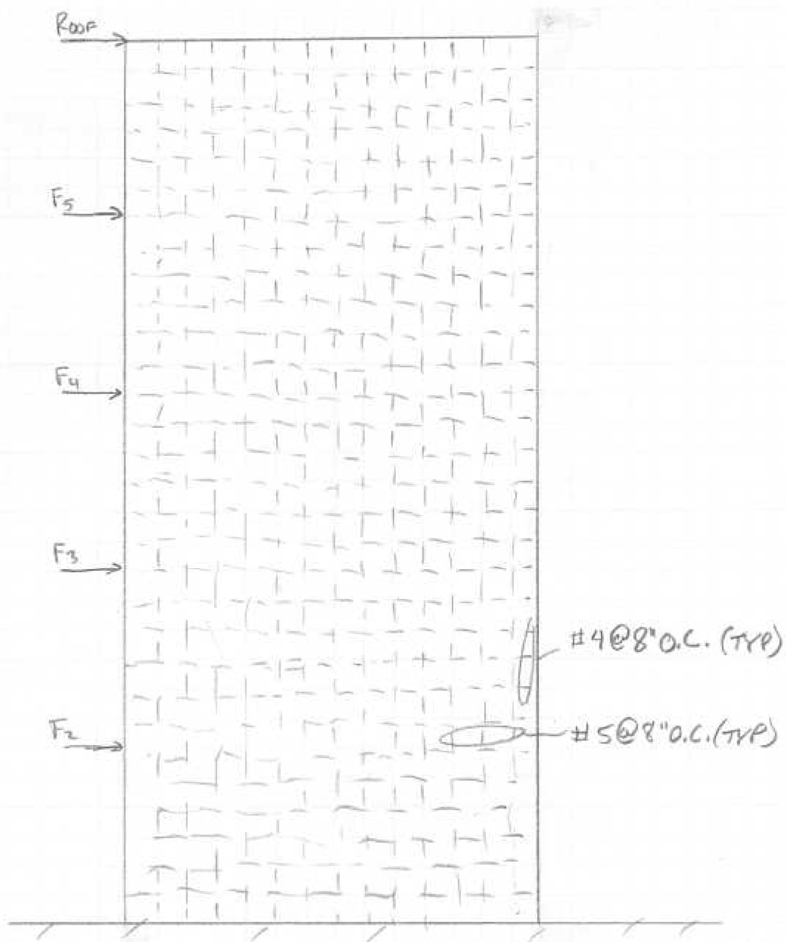
$\frac{M_n}{M_u} = \frac{134{,}577}{107{,}838} = 1.25 \Rightarrow M_n = 1.25\,M_u$

$\phi V_n \ge 1.25 \times 1.25\,V_u = 1.56 V_u$
$\phi = 0.80$

$V_n = 1.95(V_u) = 400^{k}$

$\underline{V_n = V_m = 447^{k} \ge 400^{k}}$ ✓ ok

USE 34' LENGTH FULLY GROUTED 8"CMU, TYPE S MORTAR
W/ #5@8" O.C. VERT REINF
#4@8" O.C. HORIZ REINF



SHEAR WALL DRIFT

$\Delta = \frac{Vh}{AG}$ – SHEAR

A (FULLY GROUTED) = $7.625'' \times 34' \times 12 = 3{,}111 \text{ in}^2$

$G = 0.4E_m = (0.4)(900f'_m) = (0.4)(900)(1500)$
$G = 540^{ksi}$

$V_{F2} = 53.2^k$ @ 15' ⇒ $Vh_2 = 9576^{k\cdot in}$
$V_{F3} = 61.4^k$ @ 30' ⇒ $Vh_3 = 22104^{k\cdot in}$
$V_{F4} = 66.9^k$ @ 45' ⇒ $Vh_4 = 36{,}126^{k\cdot in}$
$V_{F5} = 71.0^k$ @ 60' ⇒ $Vh_5 = 51{,}120^{k\cdot in}$
$V_{RF} = 37.3^k$ @ 75' ⇒ $Vh_R = 33{,}570^{k\cdot in}$

$AG = 1.68 \times 10^6$ KIPS

$\Delta_5 = \Sigma\Delta_i$

$\Delta_2 = 0.0057$
$\Delta_3 = 0.0132$
$\Delta_4 = 0.0215$
$\Delta_5 = 0.0304$
$\Delta_{RF} = 0.0200$

$\underline{\Delta_5 = 0.091''}$ – SHEAR

$\Delta_{BENDING} = \frac{wH^4}{8EI_w}$

$E = 900(1500) = 1.35 \times 10^6$
$I_w = \frac{7.625(34 \times 12)^3}{12} = 43.16 \times 10^6$

$W = 3866.66$ PLF
$H = 75$ FT

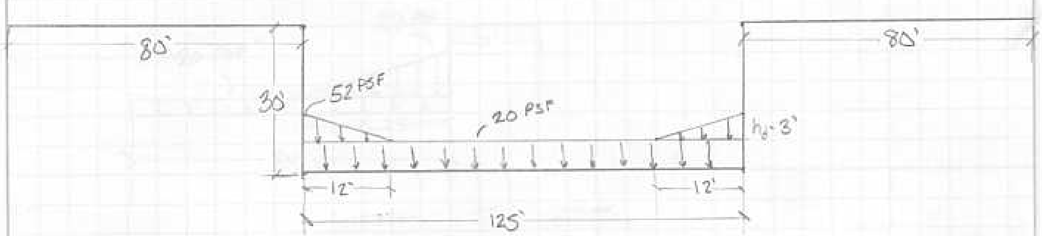
$\Delta_B = \frac{(3866.66)(75)^4(1728)}{8(1.35 \times 10^6)(43.16 \times 10^6)} = \underline{0.454''}$ – BENDING

$\Delta_{TOTAL} = 0.454'' + 0.091''$

$\boxed{\Delta_{TOTAL} = 0.55''}$

$L/400 = 75 \times 12/400 = 2.25''$ ✓ OK

SNOW DRIFT



$\gamma = 0.13 P_g + 14$
$= 0.13(25) + 14 = 17.25$

NOT TO SCALE

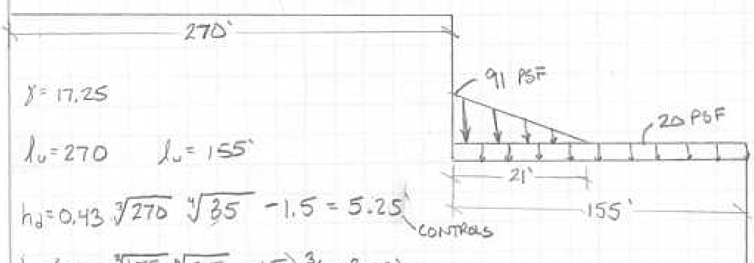
$h_d = 0.43 \sqrt[3]{l_u}\ \sqrt[4]{P_g + 10} - 1.5$
$l_u = 80'$, $P_g = 25'$

$h_d = (0.43 \sqrt[3]{125}\ \sqrt[4]{35} - 1.5)\,\frac{3}{4}$
$= 2.90'$

$h_d = 0.43 \sqrt[3]{80}\ \sqrt[4]{35} - 1.5 = 3'$ – CONTROLS

$h_d \cdot \gamma = \boxed{52\ PSF}$

$h_d = 3' < h_c = 30'$ $\therefore$ $W = 4 h_d = 12'$



$\gamma = 17.25$

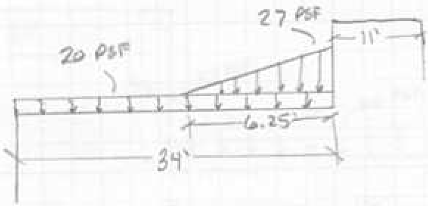
$l_u = 270$ $l_u = 155'$

$h_d = 0.43 \sqrt[3]{270}\ \sqrt[4]{35} - 1.5 = 5.25'$ CONTROLS

$h_d = (0.43 \sqrt[3]{155}\ \sqrt[4]{35} - 1.5)\,\frac{3}{4} = 3.09'$

$W = 4h_d = 21'$

$\gamma h_d = \boxed{91\ PSF}$



$\gamma = 17.25$

$l_u = 11' \rightarrow 25'$

$l_v = 34'$

$h_d = 0.43\sqrt[3]{25}\sqrt[4]{35} - 1.5 = 1.56'$ - CONTROLS

$h_d = \frac{3}{4}\left(0.43\sqrt[3]{34}\sqrt[4]{35} - 1.5\right) = 1.42'$

$W = 4h_d = 6.25'$

$\gamma h_d = \boxed{27 \text{ PSF}}$

SPREAD FOOTING (TYP)

W10x54 STEEL COLUMN
24"x 24" STEEL BASE PLATE
$f'_c = 3000$ PSI
$q_a = 6{,}000$ PSF

$P_D = 165^k$
$P_L = 130^k$
$P = P_D + P_L = 295^k$

FOOTING SIZE

$q_a \geq P/A \Rightarrow 6{,}000 \geq \frac{295^k}{B^2}$

$B = 7.01 \rightarrow$ USE $\underline{B = 8'}$ ✓ OK

$P_u = 1.2P_D + 1.6P_L$
$P_u = 406^k$

$q = P_u/A = 406^k/(8)^2 = 6.34$ KSF

$q = 44.06$ PSI

$V_c = \phi 4\sqrt{f'_c} = 0.75(4)(\sqrt{3000}) = 164$ PSI

TWO WAY SHEAR STRESS

$$d^2\left(V_c + \frac{q}{4}\right) + d\left(V_c + \frac{q}{2}\right)W = \frac{q}{4}\left(BL - W^2\right)$$

$$d^2\left(164^{PSI} + \frac{44.06}{4}\right) + d\left(164^{PSI} + \frac{44.06}{2}\right)(24") = \frac{44.06}{4}\left[(96)^2 - (24)^2\right]$$

$d = 13.82" \Rightarrow h = d + 3" + d_b = 13.82 + 3 + 0.625"$

$h = 17.5"$

USE $h = 18"$
$d = 14.375"$

CHECK WIDE BEAM SHEAR

$V_u = 6.34^{KSF}\left(\frac{8'-2'}{2} - 1.20'\right) = 11.41^k$

$\phi V_n = \phi 2\sqrt{f'_c}\, b.d$
$= 0.75(2)\sqrt{3000}(24")(14.375") = 28.34^k$

$\phi V_n > V_u$ ✓ OK

$l = \frac{8'-2'}{2} = 3'$

$M_u = \frac{q l^2}{2} = \frac{(6.34)(3')^2}{2} = 28.5'^k$

$a = \frac{A_s f_y}{0.85 f'_c b} = \frac{A_s (60)}{0.85(3ksi)(12'')}$

$a = 1.96 A_s$

$M_u = \phi M_n = \phi A_s f_y (d - a/2)$

$28.5'^k(12''/') = 0.9 A_s (60)(14.375'' - \frac{1.96 A_s}{2})$

$A_s = 0.455 \text{ IN}^2$

USE #5 @ 8" O.C. $A_s = 0.46 \text{ IN}^2$

$\rho = A_s/bh = \frac{0.46 \text{ IN}^2}{(12'')(12'')} = 0.0032 \geq 0.0018$ ✓ ok

$a = 1.96 A_s = 1.96(0.46 \text{ IN}^2) = 0.902''$

$c = \frac{a}{0.85} = \frac{0.902''}{0.85} = 1.06''$

$\varepsilon_s = \frac{0.003}{c}(d-c) = \frac{0.003}{1.06}(14.375 - 1.06) = 0.038 \text{ IN/IN} > 0.005 \text{ IN/IN}$ ✓ ok

$\therefore \phi = 0.90$

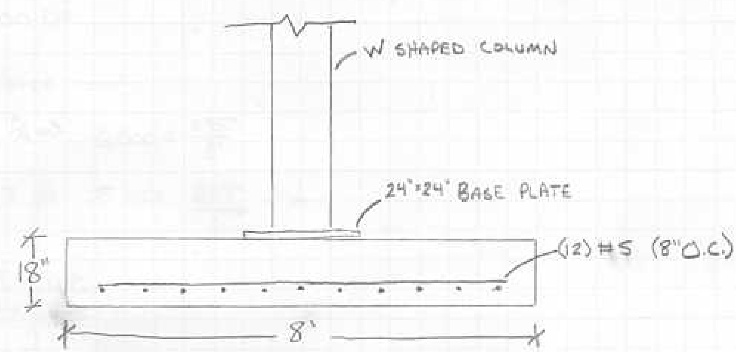
USE (12) #5 EACH DIRECTION

$\phi B_n = \phi\, 0.85 f'_c A_1 \sqrt{A_2/A_1}$

$A_1 = 24'' \times 24'' = 576 \text{ IN}^2$
$A_2 = 96'' \times 96'' = 9216 \text{ IN}^2$

$\sqrt{\frac{9216}{576}} = 4.0 > 2 \quad \therefore \sqrt{\frac{A_2}{A_1}} = 2$

$\phi B_n = 0.65(0.85)(3^{ksi})(576 \text{ IN}^2)(2)$
$\phi B_n = 1909^k \geq P_u = 406^k$ ✓ ok


W SHAPED COLUMN
24"x24" BASE PLATE
(12) #5 (8" O.C.)
18"
8'

STRIP FOUNDATION (TYP)

TOTAL WEIGHT EXT. WALL SYSTEM

WALL SYSTEM = 28"
$P = 14.325$ KLF
$f'_c = 3000$ PSI
$q_a = 6000$ PSF

8" CMU − 80 PSF
14" CMU − 72 PSF
4" BRICK − 39 PSF
TOTAL = 191 PSF

191 PSF × 75 FT = 14,325 PLF

DL = 14.325 KLF (SELF WEIGHT)

$P = 14.325$ KLF

$q_a = P/A \Rightarrow 6\text{ KSF} = \frac{14.325}{B} \Rightarrow B \geq 2.39'$

USE $B = 5'$ ← CONTROLED BY SHAPE OF WALL

$P_u = 1.4 P_D = 1.4(14.325) = 20.$ KLF

$q = P/A = 20/5 = 4.00$ KSF

REINFORCED FOOTING OPTION

WIDE BEAM SHEAR

$\phi V_c = \phi\, 2\sqrt{f'_c}\, bd$
$= 0.75(2)\sqrt{3000}\,(12")d$
$= 985.9d$

$V_u = 4.00^{\text{KSF}}(1')(2.5' - 14"(1'/12"))$
$= 5.33^{k}$

$V_u = \phi V_n$
$5333 = 985.9d$
$d = 5.4"$

$h = d + 3" + 0.5 d_b$
$= 5.4" + 3" + 0.25" = 8.65"$

USE $h = 12"$
$d = 8.75"$

$l = \frac{5' - 14"(1'/12")}{2} = 1.92'$

$M_u = \frac{q l^2}{2} = \frac{4(1.92)^2}{2} = 7.37^{1k}$

$a = \frac{A_s f_y}{0.85 f'_c b} = \frac{A_s(60^{\text{KSI}})}{0.85(3^{\text{KSI}})(12")} = 1.96 A_s$

STRIP FOUNDATION (TYP) (CONT.)

$M_u = \phi M_n = \phi A_s f_y (d - a/2)$
$7.37^{'k}(12^{in}/_{ft}) = 0.9 A_s (60^{ksi})(8.75'' - \frac{1.96 A_s}{2})$

$A_s = 0.192 \, in^2$

~~USE #4 @ 12" O.C. $A_s = 0.20 \, in^2$~~

$\rho = A_s/bh = 0.20/(12)(12) = 0.0014 < 0.0018$

$\boxed{\text{USE \#5 @ 12" O.C.} \quad A_s = 0.31 \, in^2/ft}$

$\rho = A_s/bh = 0.0022 \geq 0.0018$ ✓ OK

$a = 1.96 A_s = 1.96(0.31) = 0.608''$

$c = \frac{a}{0.85} = \frac{0.608}{0.85} = 0.715''$

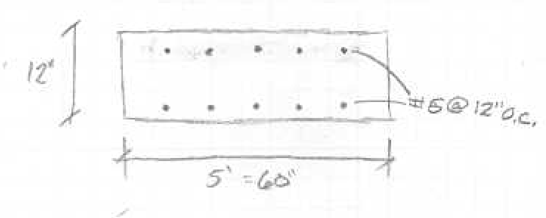
$\varepsilon_s = \frac{0.003}{c}(d - c) = \frac{0.003}{0.715}(8.75 - 0.715) = 0.0337 \geq 0.005 \, in/in$

$\therefore \phi = 0.9$

LONGITUDIAL SHRINKAGE & TEMPERATURE

$A_s = 0.0018 \, bh = 0.259 \, in^2$

$\boxed{\text{USE \#5 @ 12" O.C.} \quad A_s = 0.31 \, in^2/ft}$



VIBRATION (1 OF 3)

JOIST ~ 22 VC 1600 (34' SPAN)

JOIST SW = 24 PLF
FLOOR THICKNESS = 2½ + 2" DECK = 4½"
CONCRETE: W_c = 145 PCF
f'_c = 4,000 PSI

SLAB + DECK WEIGHT = 46.25 PSF

DETERMINE I_j
W = 1600 PLF

$$M_{ALL} = \frac{wL_n^2}{8} = (1.6)(34-0.33)^2/8 = 226.7^{\text{ 'K}}$$

$$A_{BOT} = \frac{M_{ALL}}{(d-1)f_{ALL}} = \frac{226.7(12)}{(22-1)(30)} = 4.32 \text{ IN}^2$$

$$A_{TOP} = 1.25\,A_{BOT} = 1.25\,(4.05) = 5.40 \text{ IN}^2$$

$$A_{CHORD} = 4.32 \text{ IN}^2 + 5.40 \text{ IN}^2 = 9.72 \text{ IN}^2$$

$$\bar{y}_c = 0.5 + \frac{A_{BOT}(d-1)}{A_{CHORD}} = 0.5 + \frac{4.32(22-1)}{9.72} = 9.83"$$

$$I_{CHORD} = A_{TOP}(\bar{y}_c - 0.5)^2 + A_{BOT}(d - \bar{y}_c - 0.5)^2 = 5.40(9.83-0.5)^2 + 4.32(22-9.83-0.5)^2$$
$$= 1059 \text{ IN}^4$$

$$n = E_s / 1.35E_c = \frac{29\times10^6}{1.35(145)^{1.5}(33)\sqrt{4000}} = 5.9$$

$$\bar{y}_c = \frac{\Sigma A y}{\Sigma A} = \frac{(92/5.9)(2.5)(2.0) + 9.72(4.5+9.83)}{(92/5.9)(2.5) + 9.72} = 4.46"$$

$$I_{COMP} = \Sigma I + \Sigma A d^2 = \frac{(92/5.9)(2.5)^3}{12} + 9.72(9.83+4.5-4.46)^2 + 992 + (92/5.9)(2.5)(4.46-2)^2$$

$$I_{COMP} = 2262 \text{ IN}^4$$

$$L/D = 18.55 \quad \therefore \; C_r = 0.90\left(1 - e^{-0.28(L/D)}\right)^{2.8} = 0.89$$

$$\gamma = 1/C_r - 1 = 1/0.89 - 1 = 0.12$$

$$I_j = \frac{1}{\left(\frac{\gamma}{I_{CHORD}}\right) + \left(\frac{1}{I_{COMP}}\right)} = 1801 \text{ IN}^4$$

$I_j = 1801 \text{ IN}^4$

VIBRATION (2 OF 3)

DETERMINE Δ_j

$w_j = 7.666(46.25 + 11 + 4) + 24 = 494 \text{ PLF}$

$$\Delta_j = \frac{5(0.494)(34)^4(1728)}{(384)(29\times10^3)(1801)} = \underline{0.284''}$$

DETERMINE W_j

$w_j = 494/7.666 = 64.5 \text{ PSF}$

$D_s = 12de^3/12n = (12)(3.5)^3/(12)(5.9) = 7.27$

$D_j = I_j/S = 1801/7.666 = 235$

$B_j = C_j(D_s/D_j)^{0.25} L_j = 2.0(7.27/235)^{0.25}(34') = 29.0$ $\quad 2/3(69) = 46.0$

$W_j = 64.5(29)(34) = 63{,}600^{lb}$

W21x50

DETERMINE I_g

$b = 0.4L_j = 163''$ ← CONTROLS
$= 23(12) = 276''$

$$\bar{y} = \frac{\Sigma Ay}{\Sigma A} = \frac{(14.7)(20.8/2 + 4.5 + 2.5) + (163/5.9)(2.5)(1.25) + (163/2/5.9)(2)(3.5)}{(14.7) + (163/5.9)(2.5) + (163/2/5.9)(2)} = 3.94''$$

$$I_{comp} = \Sigma I + \Sigma Ad^2 = \frac{(163/5.9)(2.5)^3}{12} + \frac{(163/2/5.9)(2.0)^3}{12} + 984 + (163/5.9)(2.5)(3.94-1.25)^2$$
$$+ (163/2/5.9)(2.0)(3.94-3.5)^2 + 14.7(20.8/2 + 2.5 + 4.5 - 3.94)^2$$

$I_{comp} = 4198 \text{ IN}^4$

$$I_g = I_{nc} + \frac{(I_{comp} - I_{nc})}{4} = 984 + \frac{(4198 - 984)}{4} = 1788 \text{ IN}^4$$

DETERMINE Δ_g

$w_g = w_j/S \, L_j + SW = (494/7.666)(34') + 50 + 373 = 2614 \text{ PLF}$ (373: WALL)

$$\Delta_g = \frac{5(2.614)(23)^4(1728)}{384(29\times10^3)(1788)} = 0.313''$$

$\Delta_g' = L_g/B_j(\Delta_g) = 23/29(0.313) = \underline{0.248''}$

VIBRATION (3 OF 3)

DETERMINE W_g

$w_g = 2583/34 = 76.0^{PSF}$

$D_j = I_j/s = 235$

$D_g = I_g/L_j = 1788/34 = 52.6$

$B_g = C_g (D_j/D_g)^{0.25}(23') = 53.5$

$C_g = 1.6$

$W_g = (76.0)(53.5)(23) = 93{,}520^{lb} = \underline{93.52^k}$

DETERMINE W

$$W = \frac{\Delta_j}{\Delta_j + \Delta_g} W_j + \frac{\Delta_g}{\Delta_j + \Delta_g} W_g = 77.55^k$$

$W = 77.55^k$

DETERMINE f_n

$$f_n = 0.18\sqrt{\frac{g}{\Delta_j + \Delta_g}} \Rightarrow f_n = 4.85^{Hz}$$

$g = 386.4$

EVALUATION

$P_o = 65$ lb

$B = 0.03$

$a_o/g = 0.005g$

$$\frac{a_o}{g} = \frac{P_o e^{(-0.35 f_n)}}{BW} = 0.0050 = 0.005g \checkmark \text{ ok}$$

CONSIDERING THE NUMBERS FOR LL & DL ARE VERY CONSERVATIVE FOR A SCHOOL, AND A SCHOOL WOULD FUNCTION MUCH DIFFERENTLY THAN AN OFFICE BUILDING, THERE SHOULD BE NO VIBRATION ISSUES.

WIND DESIGN

BUILDING HEIGHT = 75'
BUILDING WIDTH = 80'
BUILDING LENGTH = 270'

$I_w = 1.15$
CAT III
$V = 90$ MPH
$K_d = 0.85$ (W/ LOAD COMBO'S) (ELSE 1.0)
EXPOSURE: B
CASE 2
$K_{0\text{-}15} = 0.57$
$K_{30} = 0.70$
$K_{45} = 0.785$
$K_{60} = 0.85$
$K_{75} = 0.91$

$K_{zt} = 1.0$
$G_f = 0.85$
$R = 1.0$
$h = 75'$
PARTIALLY ENCLOSED
$GC_{pi} = 0.18 \pm$
$R_i = 1.0$

C_p VALUES:
WINDWARD: $C_p = 0.8$
N-S LEEWARD: $C_p = -0.24$ ~ $L/B = 3.375$
E-W LEEWARD: $C_p = -0.50$
SIDEWALLS: $C_p = -0.70$

$q_z = 0.00256\ K_z \cdot K_{zt} \cdot K_d \cdot V^2 I$ (lb/ft²)
$= 0.00256\ K_z (1.0)(1.0)(90^2)(1.15)$
$q_z = 23.85\ K_z$

WINDWARD $= q_{z\,0\text{-}15} = 13.60$
$q_{z\,30} = 16.70$
$q_{z\,45} = 18.72$
$q_{z\,60} = 20.27$
$q_{z\,75} = 21.70$

LEEWARD N-S
$P = 21.70(0.85 \times -0.50) + 3.906$
$P = -5.3$ PSF

LEEWARD E-W
$P = 21.70(0.85 \times -0.24) + 3.906$
$P = -0.5$ PSF

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

WINDWARD
$P_{0\text{-}15} = (13.60)(0.85 \times 0.80) - (21.70)(-0.18) = 13.2$ PSF
$P_{30} = (16.70)(0.68) + 3.906 = 15.8$ PSF
$P_{45} = (18.72)(0.68) + 3.906 = 16.7$ PSF
$P_{60} = (20.27)(0.68) + 3.906 = 17.7$ PSF
$P_{75} = (21.70)(0.68) + 3.906 = 18.7$ PSF

WIND FORCES TO FLOOR

$q_z = 0.00256\, K_z \cdot K_{zt} \cdot K_d\, V^2 I$

$K_{zt} = 1.0$
$K_d = 0.85$
$V = 90$
$I = 1.15$

$K_{z,15} = 0.57$
$K_{z,30} = 0.70$
$K_{z,45} = 0.785$
$K_{z,60} = 0.85$
$K_{z,75} = 0.91$

$q_z = 20.27\, K_z$

$q_{z,15} = 11.55$
$q_{z,30} = 14.19$
$q_{z,45} = 15.91$
$q_{z,60} = 17.23$
$q_{z,75} = 18.45$

$P = q_z (G_f C_p) - q_H (G_i C_{pi})$

WINDWARD

$P_{15} = (11.55)(0.85 \cdot 0.80) - (18.45)(-0.18)$
$P_{30} = (14.19)(0.68) + (3.32)$
$P_{45} = (15.91)(0.68) + (3.32)$
$P_{60} = (17.23)(0.68) + (3.32)$
$P_{75} = (18.45)(0.68) + (3.32)$

LEEWARD

$P_{N\text{-}S} = (18.45)(0.85 \cdot -0.50) - (18.45)(-0.18) = -4.52$
$P_{E\text{-}W} = (18.45)(0.85 \times -0.24) - (18.45)(-0.18) = -0.44$

TOTAL PRESSURE FORCE N-S (PSF)

$P_{15} = 15.7$
$P_{30} = 17.5$
$P_{45} = 18.7$
$P_{60} = 19.6$
$P_{75} = 20.4$

TOTAL PRESSURE FORCE E-W (PSF)

$P_{15} = 11.6$
$P_{30} = 13.4$
$P_{45} = 14.6$
$P_{60} = 15.5$
$P_{75} = 16.3$

TOTAL WIND FORCE TO FLOOR (LC: 1.6W)

N-S
WIDTH = 80'

$F_2 = (1.6)(80' \times 15')(15.7) = 30.1^k$

$F_3 = (1.6)(80' \times 15')(17.5) = 33.6^k$

$F_4 = (1.6)(80' \times 15')(18.7) = 35.9^k$

$F_5 = (1.6)(80' \times 15')(19.6) = 37.6^k$

$F_{RF} = (1.6)(80' \times 7.5')(20.4) = 19.6^k$

E-W
WIDTH = 270'

$F_2 = (1.6)(270' \times 15')(11.6) = 75.2^k$

$F_3 = (1.6)(270' \times 15')(13.4) = 86.8^k$

$F_4 = (1.6)(270' \times 15')(14.6) = 94.6^k$

$F_5 = (1.6)(270' \times 15')(15.5) = 100.4^k$

$F_{RF} = (1.6)(270' \times 7.5')(16.3) = 52.8^k$

COMPONENTS & CLADDING

$K_{15} = 0.70$ $GC_p = +0.6$ - C & C
$K_{30} = 0.70$
$K_{45} = 0.785$
$K_{60} = 0.85$
$K_{75} = 0.91$

$q_z = 20.27\,K_z$

$q_{z15} = 14.19$
$q_{z30} = 14.19$
$q_{z45} = 15.91$
$q_{z60} = 17.23$
$q_{z75} = 18.45$

$P = q_z(G_fC_p) - q_H(GC_{pi})$

$P_{15} = (14.19)(0.6) - (18.45)(-0.18) = 11.8$ PSF
$P_{30} = (14.19)(0.6) + (3.32) = 11.8$ PSF
$P_{45} = (15.91)(0.6) + (3.32) = 12.9$ PSF
$P_{60} = (17.23)(0.6) + (3.32) = 13.7$ PSF
$P_{75} = (18.45)(0.6) + (3.32) = 14.4$ PSF

$P_{15} = 11.8$ PSF
$P_{30} = 11.8$ PSF
$P_{45} = 12.9$ PSF
$P_{60} = 13.7$ PSF
$P_{75} = 14.4$ PSF

Masonry Shear Wall - Strength Design

f'm (psi) = 1500
fy (psi) = 60000
Thickness = 7.625
Length = 408
Emu = 0.0025
Es = 2.9E+07
As = 0.31

Sum = 3

Mn = 134,576,975
(0.9) Mn = 121,119,278 in lb
= 121,119 k in

c = 73.024 | a = 58.4192 | Cm = -534,536

									Mn
d1	4	Es1	-0.00236	fs1	-68,529	-60,000	Ts1	-18,600	468,899
d2	12	Es2	-0.00209	fs2	-60,586	-60,000	Ts2	-18,600	320,099
d3	20	Es3	-0.00182	fs3	-52,644	-52,644	Ts3	-16,319	150,296
d4	28	Es4	-0.00154	fs4	-44,701	-44,701	Ts4	-13,857	16,762
d5	36	Es5	-0.00127	fs5	-36,758	-36,758	Ts5	-11,395	77,377
d6	44	Es6	-0.00099	fs6	-28,816	-28,816	Ts6	-8,933	132,121
d7	52	Es7	-0.00072	fs7	-20,873	-20,873	Ts7	-6,471	147,469
d8	60	Es8	-0.00045	fs8	-12,931	-12,931	Ts8	-4,008	123,422
d9	68	Es9	-0.00017	fs9	-4,988	-4,988	Ts9	-1,546	59,980
d10	76	Es10	0.000102	fs10	2,955	2,955	Ts10	916	42,857
d11	84	Es11	0.000376	fs11	10,897	10,897	Ts11	3,378	185,090
d12	92	Es12	0.00065	fs12	18,840	18,840	Ts12	5,840	366,718
d13	100	Es13	0.000924	fs13	26,782	26,782	Ts13	8,303	587,741
d14	108	Es14	0.001197	fs14	34,725	34,725	Ts14	10,765	848,159
d15	116	Es15	0.001471	fs15	42,668	42,668	Ts15	13,227	1,147,973
d16	124	Es16	0.001745	fs16	50,610	50,610	Ts16	15,689	1,487,182
d17	132	Es17	0.002019	fs17	58,553	58,553	Ts17	18,151	1,865,787
d18	140	Es18	0.002293	fs18	66,495	60,000	Ts18	18,600	2,060,701
d19	148	Es19	0.002567	fs19	74,438	60,000	Ts19	18,600	2,209,501
d20	156	Es20	0.002841	fs20	82,381	60,000	Ts20	18,600	2,358,301
d21	164	Es21	0.003115	fs21	90,323	60,000	Ts21	18,600	2,507,101
d22	172	Es22	0.003388	fs22	98,266	60,000	Ts22	18,600	2,655,901
d23	180	Es23	0.003662	fs23	106,208	60,000	Ts23	18,600	2,804,701

d24	188
d25	196
d26	204
d27	212
d28	220
d29	228
d30	236
d31	244
d32	252
d33	260
d34	268
d35	276
d36	284
d37	292
d38	300
d39	308
d40	316
d41	324
d42	332
d43	340
d44	348
d45	356
d46	364
d47	372
d48	380
d49	388
d50	396
d51	404

Es24	0.003936
Es25	0.00421
Es26	0.004484
Es27	0.004758
Es28	0.005032
Es29	0.005306
Es30	0.00558
Es31	0.005853
Es32	0.006127
Es33	0.006401
Es34	0.006675
Es35	0.006949
Es36	0.007223
Es37	0.007497
Es38	0.007771
Es39	0.008044
Es40	0.008318
Es41	0.008592
Es42	0.008866
Es43	0.00914
Es44	0.009414
Es45	0.009688
Es46	0.009962
Es47	0.010236
Es48	0.010509
Es49	0.010783
Es50	0.011057
Es51	0.011331

fs24	114,151	60,000
fs25	122,094	60,000
fs26	130,036	60,000
fs27	137,979	60,000
fs28	145,921	60,000
fs29	153,864	60,000
fs30	161,807	60,000
fs31	169,749	60,000
fs32	177,692	60,000
fs33	185,634	60,000
fs34	193,577	60,000
fs35	201,520	60,000
fs36	209,462	60,000
fs37	217,405	60,000
fs38	225,347	60,000
fs39	233,290	60,000
fs40	241,232	60,000
fs41	249,175	60,000
fs42	257,118	60,000
fs43	265,060	60,000
fs44	273,003	60,000
fs45	280,945	60,000
fs46	288,888	60,000
fs47	296,831	60,000
fs48	304,773	60,000
fs49	312,716	60,000
fs50	320,658	60,000
fs51	328,601	60,000

Ts24	18,600	2,953,501
Ts25	18,600	3,102,301
Ts26	18,600	3,251,101
Ts27	18,600	3,399,901
Ts28	18,600	3,548,701
Ts29	18,600	3,697,501
Ts30	18,600	3,846,301
Ts31	18,600	3,995,101
Ts32	18,600	4,143,901
Ts33	18,600	4,292,701
Ts34	18,600	4,441,501
Ts35	18,600	4,590,301
Ts36	18,600	4,739,101
Ts37	18,600	4,887,901
Ts38	18,600	5,036,701
Ts39	18,600	5,185,501
Ts40	18,600	5,334,301
Ts41	18,600	5,483,101
Ts42	18,600	5,631,901
Ts43	18,600	5,780,701
Ts44	18,600	5,929,501
Ts45	18,600	6,078,301
Ts46	18,600	6,227,101
Ts47	18,600	6,375,901
Ts48	18,600	6,524,701
Ts49	18,600	6,673,501
Ts50	18,600	6,822,301
Ts51	18,600	6,971,101